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La crise, dix ans après

The Crisis, Ten Years After

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THE CRISIS, TEN YEARS AFTER

PRODUCTIVITY AND CRISIS

FISCAL AND MONETARY POLICIES IN THE EUROZONE AFTER THE CRISIS

Introduction
Ten long years of crisis

Daniel Cohen*

Abstract – The crisis celebrates its tenth anniversary, offering economists a lesson in modesty and a great opportunity to take a new look at their understanding of the world. The effect of a zero lower bound on interest rates on the efficiency of economic policies, the Keynesian multiplier measure, the issue of the growth slowdown being a cause or consequence of the crisis, the effect of rising uncertainties on households' and firms' behaviour, the effectiveness of macro-prudential stabilisation, the impact of inequalities on the functioning of the credit market, the way in which the coordination of macro-economic policies in Europe is designed and promoted: all these crucial questions are part of the economists' research programme, and this special issue offers a rich review of the progress already achieved.

Keywords: financial crisis, European crisis, productivity, inequalities, uncertainty, employment adjustment, economic policies

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Ten years long years have passed since the start of the crisis. A lot has been learned about its causes and consequences, but many factors remain mysterious. When the Queen of England had expressed her surprise that so few economists were able to predict it, she had been answered that it was because everyone was focused on managing their own risk, without anyone understanding that the threat was on the system as a whole. The securitisation of real estate investments at the origin of the crisis had certainly been analysed. What had obviously not been foreseen, in part because it was not visible, including to the regulators, was the extent to which the banks' off-balance sheet commitments were putting the whole system at risk.

When the crisis started, the comparison with the crash of 1929 appeared obvious. By some sort of intellectual miracle, the President of the U.S. Federal Reserve, Ben Bernanke, was its undisputed expert. He did everything possible to avoid the panic which followed in the 1930s, not hesitating to phenomenally increase the Central Bank's balance sheet. After the collapse of Lehman Brothers, a strategic error due, perhaps to the idea that the worst of the crisis was already over, the fall in industrial production and international trade reached almost 20% in less than nine months. It was then thought that the crash of 1929 was starting again. The collective response to the crisis, this time well aware of what was at stakes, met the challenges. Global fiscal stimulus, coordinated by the International Monetary Fund, ultra-accommodative monetary policy, like that conducted by Bernanke, and pursued in Europe, and strengthening of international cooperation, through the G20 in particular, all things which had failed in the thirties. And it worked. As early as in the second quarter of 2009, growth returned to the positive in France and in Germany. In the United States, the NBER believed that the crisis was over at the end of June 2009.

Unfortunately, when the crisis crossed the Atlantic, bringing down Greece, then Ireland and Portugal, the eurozone was not equal to the event, repeating, in this instance, the errors of the thirties: budgetary austerity too soon, monetary policy reluctant to come to the rescue of States threatened by a refinancing crisis. It would be necessary to wait for the famous speech by Mario Draghi on July 26 2012, announcing that he would do "*whatever it takes*" to save the eurozone, to get away from the sovereign debt crisis. When Mario Draghi made his speech, spreads on Italian and Spanish debt relative to Germany had already reached 536 and 638 basis points respectively! Although the restrictions coming from monetary policy were removed after this speech, the conduct of fiscal policy would remain, however, marked by a consolidation against the tide, playing an unquestionably pro-cyclical role over the entire eurozone. Ultimately, while the crisis had started in the United States, the rebound would happen much sooner in this country than in the eurozone.

Returning to the "systemic" causes of the crisis, the emphasis has rightly been put on the collective non-accountability of the international financial system. But other causes also played a decisive role upstream. The rise of inequality in the United States is one of them. The series constructed by Piketty, Saez and Zucman show a major stagnation of the income of the middle class over the past decades. This explains why borrowing, facilitated by the real estate bubble, has been the main way around this stagnation of purchasing power.

It is well established in the literature that financial crises have lasting consequences on economic growth. The slowdown observed after the crisis is therefore not surprising. But a reverse causality is also possible, namely that the slowing down of long-term growth could actually be responsible for the crisis. This is the hypothesis made by Blanchard, Cerutti and Summers at an ECB conference organised in Sintra in 2015 (Blanchard et al., 2015). On the basis of the theories of Laurence Summers and Robert Gordon on secular stagnation, they suggested analysing the crisis as the indirect consequence of the latter. Showing that post-crisis growth rates have been getting lower and lower over the last fifty years, they concluded that households and firms have consistently overestimated their growth prospects and their own solvency, sooner or later fatally hitting the wall of refinancing their debt.

The article presented in this special issue by **Gilbert Cette, Simon Corde and Rémy Lecat** offers a thorough test of this thesis according to which the slowdown in growth preceded the crisis. Is there a break in the productivity trend in France, before, during or after the crisis? By focusing here on Total Factor Productivity, measured on the basis of macroeconomic data, the answer seems indisputably affirmative. Indeed, it is quite remarkable that its growth rate has been nil since 2003, well before the crisis began. It is not surprising in these conditions that gains in labour productivity have also collapsed, at a rate of 0.5% a year. It should be noted that the United States, were a rebound in labour productivity had been recorded in the 90s following the dissemination of ICTs, also experienced a significant decline in productivity since the early 2000s. The analysis of Cette et al. allows to go a step further in the explanation of this slowdown. They note that it is concomitant with an increase in inequalities between firms. The most efficient firms' productivity, which are not necessarily the same from one year to the next, remains on a sustained trend of increase. It is the gap between the best performances and the average which pulls the average down. Richard Freeman and his co-authors' work partly corroborates these results (Barth et al., 2016). Analysing wage inequalities in the United States, they had shown that they were almost completely explained by a widening of inequalities between companies, not within them… We must therefore seek to understand the unprecedented link between slowing growth and widening inequalities, which is one of the most active directions of research underway.

The effectiveness of economic policy is the other major question that the crisis brought back to the forefront of the intellectual debate. One of the cruel surprises of the period was to discover that the Keynesian multiplier was much higher than expected. While the traditional models simulated a multiplier in the range of 0.5, the raw empirical reality estimated by Blanchard and Leigh (2013) revealed much higher levels, as high as 1.5. It should be remembered that Eichengreen and his co-authors had established a multiplier as high as 2 for the crisis of 1929 (Almunia et al., 2010). Greece falls exactly into this pattern, with a budgetary consolidation of 12 points of GDP and a 25% cumulative loss in production.

Several factors explain why the multiplier was higher than expected. When the crisis is intense, the households with the most limited borrowing capacities will have more difficulty in smoothing out their consumption. The increase in income uncertainty is documented in the article by **Pierre Pora and Lionel Wilner**, who show that there is an important distinction to be made between the volume of hours worked by the poorest, and the hourly remuneration of the richest. A

form of pessimism can also spread. As **André Masson and Luc Arrondel** also highlight in this issue, households' holdings in risky securities declined considerably after the crisis not because of a change in their intrinsic attitude toward risk, but, as the article shows, because the world appears more uncertain in the crisis.

The increase in the multiplier also owes a lot to the fact that monetary policy has lost in efficiency as a force to counterbalance fiscal consolidation. When inflation becomes too low, and interest rates drop close to the "zero lower bound", monetary policy meets limits that are difficult to get around. Ramey and Zubairy (2014) had shown that the budgetary multiplier was much higher when the interest rates are at the lower bound. The article by **Jocelyn Boussard and Benoît Campagne** in this issue takes up this theme. Budgetary consolidation in Europe took place in the worst possible conditions: it was conducted simultaneously in all eurozone countries, and under a fixed exchange rate regime that deprived the countries the most involved in the process of fiscal consolidation of the benefit of the safety valve that is the exchange rate. The fact that the eurozone's monetary policy has come up against the lower bound has limited its efficiency. The article also shows that at the lower bound on interest rates, the bigger the fiscal consolidation, the more its effect on economic activity (*i.e.* its multiplier effect) is recessive. An optimal coordinated fiscal policy, to follow this model, would have required a fiscal consolidation in the South of Europe and a stimulus in the North, whose absence heavily penalised the former.

The use of non-conventional policies was imposed upon central banks, in the United States as well as in Europe, to circumvent this obstacle of the lower bound on interest rates, and in the case of Europe, also to solve the sovereign debt crisis. The article by **Désiré Kanga and Grégory Levieuge** examines these policies, trying to distinguish their effects on the sovereign rates and on loans to the private sector. The paradox of the article is to show that non-conventional policies had more favourable effects in the countries that had the least need, Germany and Austria, than in the countries that should have been helped as a priority, Greece, Italy, Spain and Portugal. By expanding the class of assets eligible for refinancing, however, the ECB has supported the credit policy of commercial banks. According to the estimation of **Jean Barthélémy, Vincent Bignon and Benoît Nguyen**, the increase in the share of illiquid collateral has significantly helped to increase lending to the economy.

The crisis has also forced to rethink banking regulation. In Europe, the Basel 3 agreements sought to include off-balance sheet operations in prudential calculations for the first time. The banking industry was opposed to these measures on the grounds that they were going to impact the sector's profitability, and therefore have negative effects on credit supply. Using a new database, **Olivier de Bandt, Boubacar Camara, Pierre Pessarossi and Martin Rose** provide an answer to this: the increase in equity, according to this study, is in no way detrimental to the sector's profitability. Hence the argument that the banking system should be protected from does not hold.

The crisis has caused a rapid increase in unemployment. In metropolitan France, the unemployment rate, as understood by the ILO, was at a relatively low level of 6.8% at the beginning of 2008, without, in fact, showing that it was in the process of approaching a floor. The drop in economic activity had the mechanical effect of rising unemployment, which ended up exceeding 10%. One of the criticisms to

the functioning of the French labour market is its polarisation between insiders, holding permanent contracts, and outsiders, on fixed-term contracts or temporary jobs. Has the crisis widened this gap? Everything leads to think that companies first laid off workers with the least protection. **Delphine Brochard and Corinne Perraudin** offer a remarkable analysis of companies' behaviour. Their article shows that a much wider range of instruments than just the dismissal of outsiders was used to cope with the crisis. Thus, although a quarter of the establishments studied have reduced their workforce, nearly half of them also reorganised their activity, froze or decreased wages or resorted to short-time working. It is therefore not true to say that France has a preference for external adjustment, which would protect the insiders… It is particularly clear in the manufacturing sector, which was the most affected by the crisis, where the share of atypical employment does not seem correlated with workforce reduction. Unsurprisingly, the companies where social dialogue is the most active are also those who were able to combine various means of adjustment, including wage moderation, to cope with the crisis. In contrast, subcontractors and companies being majority foreign-owned were those where the decline in staff numbers was the most frequent, this leading to the obvious interpretation that decisions being made outside, social negotiation was also the least effective.

The crisis, whose tenth anniversary is marked by this special issue, has certainly made us understand a lot of new things but has most importantly made us rediscover old truths. The need for coordinated action from States, the decisive role of economic policy and the supervision of the financial system are simple ideas that had simply been forgotten. For economists, however, a huge amount of work remains to be done so that macroeconomic modelling draws all the lessons from it. Research has made significant efforts to integrate inequalities, financial markets imperfection, the dysfunctions of labour markets and agents' limited rationality, but it still lacks a canonical model able to include them into a coherent whole. It would be absurd to think that this work will provide the answer to the question that the Queen or her successor will ask during the next crisis, "*Why didn't you see anything coming this time either*?", but at least, we can hope that it will integrate the lessons of this crisis and allow a more brilliant response to the next one. □

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Stagnation of productivity in France: A legacy of the crisis or a structural slowdown?

Gilbert Cette*, Simon Corde and Rémy Lecat****

Abstract - The productivity slowdown has been analysed either as an effect of the crisis, resulting from the financial and demand shocks, or as a more structural decline. In France, using macroeconomic and microeconomic data, we identify downward breaks in the trends of labour productivity and total factor productivity in the 2000s, several years before the crisis. These breaks result in historically weak rhythms of the trends. Using data on firms located in France, we highlight that, at the technological frontier, productivity has accelerated, especially over the recent period, which contradicts the hypothesis of a decline in innovation. The most productive firms in a given year do not, however, improve their relative advantage. The convergence of firms' productivity does not seem to have slowed down in the 2000s, which does not confirm the hypothesis of a decrease in the dissemination of innovation. On the other hand, the dispersion of productivity between firms has increased, which suggests increasing difficulties in the reallocation of production factors, labour and capital, between firms.

JEL Classification: E22, L11, O47.
Keywords: labour productivity, total factor productivity, tests for breaks, dissemination of innovation.

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Productivity is the main source of gains in GDP per capita and therefore of the increase of the average living standard of a population. However, at the beginning of the 2000s, that is, before the financial crisis which began in 2007-2008, productivity slowed down in all the main developed countries, including France (on this topic see Bergeaud et al., 2016). Such a slowdown brings productivity growth to historically low levels compared to those we have been used to since the second industrial revolution which completely disrupted lifestyles and production processes in the 20th century. The third industrial revolution, associated with the production and dissemination of information and communication technologies (ICT), galvanised productivity in some countries and over short periods (for example the United States from the mid-1990s to the mid-2000s). It has not yet fulfilled the biggest expectations that many had in the "new economy".

This apparent decline of productivity growth has been largely discussed in the literature[1]. It leads certain economists (for example Summers, 2014 and 2015; or Gordon, 2016) to consider the risk of secular stagnation, in other words a long period of weak growth[2]. In fact, as Mokyr et al. (2015) have thoroughly analysed in a recent – and already much referred to – article, such a fear has been recurrent since the beginning of the first industrial revolutions. Other authors envisage considerable shake-ups in the decades to come – for example Brynjolfsson and McAfee (2014) or Pratt (2015) about robotics – which will lead to a new wave of productivity growth (see Cette, 2014 and 2015, for a literature review). The third industrial revolution, associated with ICT, might therefore lead to two successive waves of acceleration of productivity, the first having been clearly identified in the US and in a few other countries over the 1995-2005 decade, and the second still to come. Such a phenomenon of a double wave of productivity acceleration had already been observed during the first industrial revolution associated with, among other transformations, the invention and dissemination of the steam engine, with a first wave from the end of the 18th century to the first half of the 19th century with, for example, the use of this energy source in the textiles industry, and from the second half of the 19th century to the beginning of the 20th century with the development of railway transportation. In other words, and as Van Ark (2016) writes, the current pause in the productivity gains of the third industrial revolution would characterise the transition from the phase of creation and installation of new technologies to the phase of their widespread use. Since this had been the case for the preceding technological revolutions, especially electricity, this deployment phase would require time because it involves drastic changes to our institutions and our production and management processes, but now it would be close. But for certain economists, for example Branstetter and Sichel (2017), the gains in productivity brought on by the transformations associated with the digital economy could be both durable and greatly significant.

The aim of this article is not to answer all the questions opened by the universal productivity slowdown in the developed world since the start of the decade of 2000. It is first of all, within the well-outlined framework of the French economy, to make sure of the existence of such a slowdown and to research some explanatory elements. To do so, two types of data have been mobilised: macroeconomic data and firm-level data. If both are useful in characterising the potential changes in productivity, only the wealth of information at firm-level will allow us to confront some economic interpretations of this slowdown with empirical observations. Two productivity indicators will be considered over the two types of data: labour productivity (LP) and total factor productivity (TFP). We will see that the diagnostics of productivity slowdown are consistent for the indicators and the two datasets. Company-level data, furthermore, reveal that the dispersion of productivity between firms has intensified, suggesting an increase of the difficulties in reallocating the production factors, labour and capital (cf. Boxes 1 and 2).

Breaks in productivity trends

On the basis of macroeconomic data: Breaks in downward trends at the start of the 1990s and 2000s

Over the period 1976-2015, prior to the first oil crisis, the evolution of total factor productivity per hour (TFPH) saw two significant downward

1. For a literature review, see for example Crafts & O'Rourke (2013), or Bergeaud et al. (2016). For the US, see for example Byrne et al. (2013).
2. This visible decline in productivity gains has led certain observers to suggest that the measurement of GDP might be ignoring a growing section of business activity linked to the digital economy and the collaborative economy. Recent works on the matter (for example Byrne et al., 2016; or Syverson, 2016), however, show that, for the US, even with extreme hypotheses, the valuation of new activity associated with the digital economy would not call into question the drop in productivity observed at the start of the decade of 2000, and would even intensify this slowdown.

Box 1 – **Productivity indicators**

The aim of this study is to identify and estimate the potential dates of breaks in structural trends of two productivity indicators: labour productivity (LP) and total factor productivity (TFP). These two indicators are calculated over each of the two mobilised databases: macroeconomic data taken from national accounts (source being Insee [French National Institute of Statistics and Economic Studies]) and individual company data taken from databases built at Banque de France. These databases are presented in box 2.

The labour productivity (LP) indicator is output volume (Q) over amount of labour (L) $LP = Q/L$. The total factor productivity (TFP) indicator is output volume (Q) over a geometric average (in accordance with a Cobb-Douglas function) of the two factors considered, capital (K) and labour (L). $TFP = Q/(K^{\alpha}.L^{\beta})$. We expect constant returns from two factors of production, which correspond to the constraint: $\alpha + \beta = 1$. TFP is thus defined by the relation: $TFP = Q/(K^{\alpha}.L^{1-\alpha})$. Over the macroeconomic data, these two indicators are calculated at the overall level of the whole economy whereas they are calculated for each company on the basis of individual data.

Output volume (Q) corresponds to GDP volume over the macroeconomic data and to the volume of added value generated over the individual company data. Over these data, which do not have a price measurement of each company's added value, the volume of the added value is calculated, for each company, by deflating the added value of that company into a current value by a price index by branch (level 40 of the nomenclature of NAF rev 2 French economic activities) of the gross added value, with this index having been taken from national accounts.

Over the macroeconomic data, the evaluation of the volume of fixed revenue-earning capital (*K*) uses the one conducted by Bergeaud et al. (2016). It is based on the perpetual inventory method by using investment as an inflow and downgrading as an outflow, the latter being calculated with a constant depreciation rate over time. Two types of revenue-earning capital are distinguished: capital tied up in buildings and in materials, for which depreciation rates are different (respectively 2.5% with an average lifespan of 40 years, and 10% with an average lifespan of 10 years). Over the company data, the evaluation of the volume of fixed revenue-earning capital (*K*) is also conducted on the two construction products and the equipment. For each of these two products, the companies' accounts provide a value of the immobilised fixed revenue-earning capital at historical costs (that being at the purchase price of each investment making up this capital). To move on to a measurement in volume, these measurements at historical costs are deflated by a price index of the average age of the delayed investment of the capital component considered. The average age of each of these two components of capital is evaluated drawing on the proportion of depreciated capital, reconstituted from companies' accounts. Finally, over the two types of data, capital which is involved in the calculation of TFP of a year is that which is immobilised at the end of the preceding year.

Over the macroeconomic data, two alternative measurements of labour (*L*) are mobilised: the average number of employees (*N*) or the average number of hours worked (*H*) which is equal to the product of the number of employees (*N*) and of the average yearly number of hours worked per employee (Y). $H = N.Y$ We thus construct over these data two measurements of each of the two productivity indicators: labour productivity per hour (*LPH*) and per employee (*LPN*) and TFP per hour (*TFPH*) and per employee (*TFPN*). Over the company data, we do not have a measurement of the duration of employees' labour (*Y*). We therefore construct over these data one sole measurement of each of the two productivity indicators: LP per employee (*LPN*) and TFP per employee (*TFPN*). Over the four decades from 1974 to 2015, the average yearly number of hours worked per employee in France fell by 22% with sub-periods of declines faster than others (for example the first three decades compared to the last one). Because of this, per hour and per employee indicators can see contrasting evolutions. The empirical literature on macroeconomic data generally privileges hourly productivity indicators (cf. for example Bergeaud et al., 2016). But, in order to compare the evolutions characterised over macroeconomic data to those characterised over company data for which we do not have information on the duration of work, the two measurements are therefore considered over macroeconomic data.

The value of the weighting coefficient (α) which is involved in the calculation of TFP takes, over the macroeconomic data, a fixed value of 0.3 ($\alpha = 0.3$), as in Bergeaud et al. (2016) who show that the results (in terms of rhythms of TFP growth and of the dating of these breaks) are robust with the choice of foreseeable values ($\alpha = 0.25$ or $\alpha = 0.35$). Over the company data, the average value of the share of revenue from capital in the added value is 30%. We have retained for this parameter a specific value for each sector (as a nomenclature in 40 sectors) and equal to the average observed over the mobilised individual database. The values retained thus vary from 0.168 in the Medical and Social Accommodation sector (QB) to 0.622 in the Electricity, Gas, Vapour and Air Conditioning Production and Distribution sector (DZ); the average for all sectors is 0.303.

Finally, to characterise the breaks in productivity using an econometric approach, it is useful to neutralise the effects of short-term economic variations. To do this, we use over macroeconomic data an indicator of the capacity utilisation rate (CUR, source: Insee) and over individual company data variations of the turnover logarithm (TO, source: *Fiben*, *Fichier bancaire des entreprises*, which is managed by Banque de France).

breaks[3], the first at the start of the 1980s, with growth declining from 2.1% to 1.5%, then at the start of the 2000s, with the TFPH growth reaching zero (figure 1-A). The evolution of labour productivity per hour (LPH) saw three downward breaks at almost to the same time as that of TFPH, at the start of the 1980s, with yearly LPH growth going from 3.9% to 2.4%, then at the start of the 1990s, with LPH growth moving to 1.9% and finally at the start of the 2000s, with LPH growth then dropping to 0.5% (figure I-C)[4]. These dates of breaks differ slightly from those detected in previous studies, for example Bergeaud et al. (2016), for two reasons. First of all, the data are updated here with regards to that preceding study. Then, because the estimation that underpins the detection of breaks here takes into account the economic climate and its possible impact on the

3. Box 3 outlines the methodology for detecting breaks in trends.

4. Annex 1 presents the robustness tests in relation to these tests for breaks.

Box 2 – **Data**

Two databases are used: macroeconomic data and individual company data taken from databases built at Banque de France.

The macroeconomic data are taken directly from 2010 base national accounts, 2015 provisional accounts (source being Insee) with the exception of the series of fixed revenue-earning capital (*K*) which are essential to calculating TFP. The series of capital (*K*) are taken from Bergeaud et al. (2016) who built them using the perpetual inventory method drawing on macroeconomic investment data (source: Insee), see also Box 1. These series are available on www.longtermproductivity.com.

The individual company data are taken from Fiben [Company Banking File] data which is managed by Banque de France. Fiben is a very large database which gathers accounting data (corresponding to the tax returns) of all companies (Metropolitan France and Overseas Departments [*Départements d'outre mer - DOM*]) whose turnover exceeds €750,000 per year or which hold more than €380,000 in credit. This database is therefore not as exhaustive as Insee's Ficus-Fare databases but it focuses on the companies which make up most of the added value and the private sector workforce (market sectors with the exception of the financial sector) and whose accounting data are of a higher quality. The Fiben database has seen its coverage increase over the period considered, being affected by different factors, due mainly to the fixing of thresholds in nominal and non-real terms. The companies present in this database correspond to the legal unit, and to a legal definition of the company. The Fiben base covers 84% of employment of the companies present in BIC-BRN in 2004, with the companies having fewer than 20 employees being less well-covered than the others (54% of employment).

A clean-up of this database was conducted in order to avoid the presence of abnormal data. For the calculations of the indicators of total factor productivity and labour productivity, we apply a method based on the outliers principle developed by John Tukey (Kremp, 1995), which deletes values located beyond quartile 1 (and 3) which are less (and more) than three times the interquartile spread. We conduct the processing of abnormal observations first for the logarithm variable then for the growth rate variable.

Using the cleaned Fiben database, we have an unbalanced sample made up of between 59,767 and 130,750 companies per year over the study period in order to study the evolution of labour productivity (*LPN*) (11,428 companies over the balanced sample and the period 1992-2014) and between 42,241 and 109,579 companies to study the evolution of *TFPN* (7,857 companies over the balanced sample and the period 1993-2014, knowing that to obtain a sizeable sample over the balanced panel, the study period starts a year later for *TFPN*). The difference in the number of companies available is explained by the fact that the construction of the *TFP* indicator requires more accounting information than the *LP* indicator. The two indicators are calculated per company and per year (cf. box 1).

The problem of the convergence of smaller companies' productivity is not treated and the different indicators used are adapted to this limitation (for example the use of median indicators rather than average ones). The mobilised indicators in this study are always the median indicators over the field considered: sector, size, sector x size, the 5% most productive companies to characterise the technological frontier or the 95% remaining companies to characterise the others... This choice means that the indicators are not influenced by possibly extreme or even abnormal values which are often observed over individual data.

In order to characterise the possible heterogeneity of the dates of break, we have distinguished six business sectors (agriculture and silviculture, manufacturing industries, construction, retail, transport and other services, with the classifications having been conducted on the basis of NAF rev 2) and three size classes of companies, on average over the period of their presence in the database (size 1: less than 50 employees, size 2: 50 to 249 employees, size 3: 250 or more employees). Size 1 represents 87% of the companies in the two samples, with size 2 near 11% and size 3 a bit more than 2%.

The productivity frontier is defined as the median value of the 5% most productive companies. To characterise this frontier's catch-up effects, the median value of the 95% least productive companies is compared to the median value of the 5% most productive companies.

evolution of productivity, via the indicator of the capacity utilisation rate (CUR). But the overall diagnostic is very much the same and can be summarised by two main points: (i) a gradual slowdown in productivity was observed over the period and (ii) a slowdown occurred at the start of the 2000s, before the crisis of 2008.

The first drop (at the start of the 1980s) of the two productivity per hour indicators is also observed in many developed countries (cf. Bergeaud et al., 2016, for an overview) and can be explained by different factors, for example the second oil crisis but also the start of the implementation of policies aimed to strengthen the employment content of growth, e.g. a drop in the labour cost of the least qualified workers. The second drop, in the first half of the 1990s, is also observed (except for TFPH) in many countries, with the notable exception of the United States. It can also be associated in these countries with the toughening of policies of wage costs moderation, often by reductions in tax contributions targeted at low-paid work and therefore for the least qualified workers. In the US, a break in productivity growth is also observed at the start of the 1990s, but upwards, making this country a particular case. This acceleration, which has been the subject of many analyses (cf. for example Jorgenson, 2001), is generally associated with the rapid production and dissemination of information and communication technologies (ICT). As this has been shown in many subsequent analyses (for example Van Ark et al., 2008; or Timmer et al., 2011), the gap in ICT dissemination might be one of the main factors explaining the contrast between the United States and other countries with regards to productivity dynamics, this dissemination being much greater and faster in the US than anywhere else. Finally, the last fall in the two indicators, at the start of the 2000s, is observed in almost all developed countries, including the US. This slowdown has not yet had a consensual explanation.

The analysis of the evolutions of productivity in the following section rests on per employee – and not per hour indicators – due to the absence of information on the average duration of work in the individual data at firm level. For this reason, it is also useful at this stage to characterise the evolutions of productivity at the macroeconomic level over per employee indicators, and not only per hour since this has already been done. The differences in the evolutions of per hour and per employee indicators are obviously going to be linked to changes in the average yearly duration of work over the period, with this yearly duration having seen a sharp decline, even though not uniform between sub-periods. So, over the period studied here, employees' average yearly duration of work has declined to a rhythm of

Box 3 – **Detection of breaks in productivity**

The detection of breaks in productivity is conducted with the same methodology over macroeconomic data and over individual data. Over the latter, the detection of breaks is made over the medians per year of the indicators considered.

For each productivity indicator considered (*I*), the productivity trends are defined over the logarithm of the indicator (*i* = *Log(I)*):

$$i_t = \alpha + \sum_{k=0}^{m} \beta_k . (t - T_k) . \mathbb{I}(t \geq T_k) + \gamma . CUR_t + u_t .$$

With *i,* the productivity logarithm; *m* the number of breaks; $\{T_1, T_2, ..., T_m\}$ the dates of the breaks; $\mathbb{I}$ an indicative function such as $\mathbb{I} = 1$ if $t \geq T_k$ and $\mathbb{I} = 0$ otherwise; $\beta = \{\beta_1, ..., \beta_m\}$ the difference of the productivity growth trend between two consecutive periods; *CUR* capacity utilisation rate, and u_t the error term.

We first test the stationarity hypothesis, (i.e. *m* = 0), which would mean that productivity has a constant trend over the whole period. If the stationarity is rejected, we can exclude the presence of a unique trend. We can nevertheless not conclude with the presence of a stochastic trend since the unit root test is biased when there is structural change in the trend (Perron, 2006). The Bai and Perron test (1998) determines whether the series follows the model above, with linear trends per part, a linear regressor and errors I(0). The values of *m* and the dates of break $\{T_1, T_2, ..., T_m\}$ must be determined. Three tests (ADF, Phillips-Perron and KPSS) lead us to reject the stationarity of the series of labour productivity and TFP (in log) compared to a temporal trend.

Bai and Perron (1998) have developed a methodology to calculate simultaneously the number of breaks, their dates and trends (on the methodologies of breaks in trend, see Eksi, 2009, and Aue & Horvath, 2013). The main idea is to estimate $\{\beta_0, ..., \beta_m\}$ for each division $\tau = \{T_1, T_2, ..., T_m\}$ by minimising the sum of the residual squares. Then, a suitable value of τ is chosen with the help of the statistic *sup*F (τ +1|τ), with F the Fisher statistic.

around -1.6% from 1976 to 1982, -0.5% from 1982 to 1993, -1.0% from 1993 to 2003 and has remained stable thereafter[5]. It appears that taking the duration of work into account or not alters the positioning and intensity of some drops in productivity, without calling into question the diagnosis of a slowdown in particular at the beginning of the 2000s.

The two productivity per employee indicators have, like labour productivity per hour, seen three breaks over the period studied, and approximately at the same dates (Figures I-B and I-D). But, with regards to TFP, the TFPN indicator saw a first break in its rise at the start of the 1980s, with its average yearly growth moving from 0.8% to 1.3%. The break of the beginning of the 1990s was downward and brought the average yearly TFPN growth rate to 0.9%. Finally, the break of the start of the 2000s was also downward and almost led to a stability in TFPN over the following years, with this indicator's average yearly growth rate then reaching 0.1%, very close to that of TFPH, which is quite logical, with employees' average yearly duration of work remaining stable. With regards to labour productivity, the LPN indicator saw a slight acceleration, which was not significant, at the start of the 1980s, with its average yearly growth rate moving from 2.0% to 2.1%, then a large and significant drop at the start of the 1990s, with its growth rate moving to 1.2%, and finally a second one at the start of the 2000s, with its growth rate moving to 0.5%, like that of the per hour indicator (LPH) due to the stabilisation of employees' average yearly duration of work over this final sub-period.

For the comparison with the evolutions of productivity observed on individual data at firm level from the start of the 1990s, the two important results drawn from the macroeconomic data are as follows:

- Most of the productivity indicators (per hour and per employee, labour productivity and TFP) see a considerable downward double-drop, the first at the start of the 1990s and the second at the start of the 2000s, before the crisis of 2008. The first break is not as strong as the second and results at least partially from policies aimed at enriching employment growth (notably the reduction of employers' tax contributions) mitigated by the positive effect of the technological shock linked to ICT.

- Over the final sub-period, that is, since the start of the 2000s, the progression of productivity is historically weak. The average yearly growth of the two TFP indicators appears close to zero (0.1%) whereas that of the two labour productivity indicators seems only around 0.5% per year.

Using company level data: Downward breaks in the 2000s for most sectors and company sizes

The evolutions of productivity are characterised over individual firm-level data using the median of the TFP per employee (TFPN) and labour productivity per employee (LPN) indicators calculated within different scopes: the whole market economy, three company sizes (size 1: fewer than 50 employees; size 2: from 50 to fewer than 250 employees; size 3: 250 or more employees[6]), and six business sectors (agriculture, industry, construction, retail, transportation, other services) and the junction of the three sizes and these six sectors. As with the macroeconomic data, the breaks in productivity are characterised by the Bai and Perron method (1998) for each indicator and over each of the different company sector/sizes. The effects of cyclical economic variations are neutralised by introducing the variation of the turnover logarithm (TO) into the regression as an explanatory variable.

Company data relate only to the market sector whereas macroeconomic data also integrate the non-market sector. For this reason among others, the changes in productivity indicators may differ between these two types of data. Finally, it must be highlighted that as size 1 (fewer than 50 employees) represents around 90% of the companies in our database, the evolutions of the medians of our productivity indicators are, over the whole economy or over each sector, fairly close whether measured over the whole market economy or only over size 1.

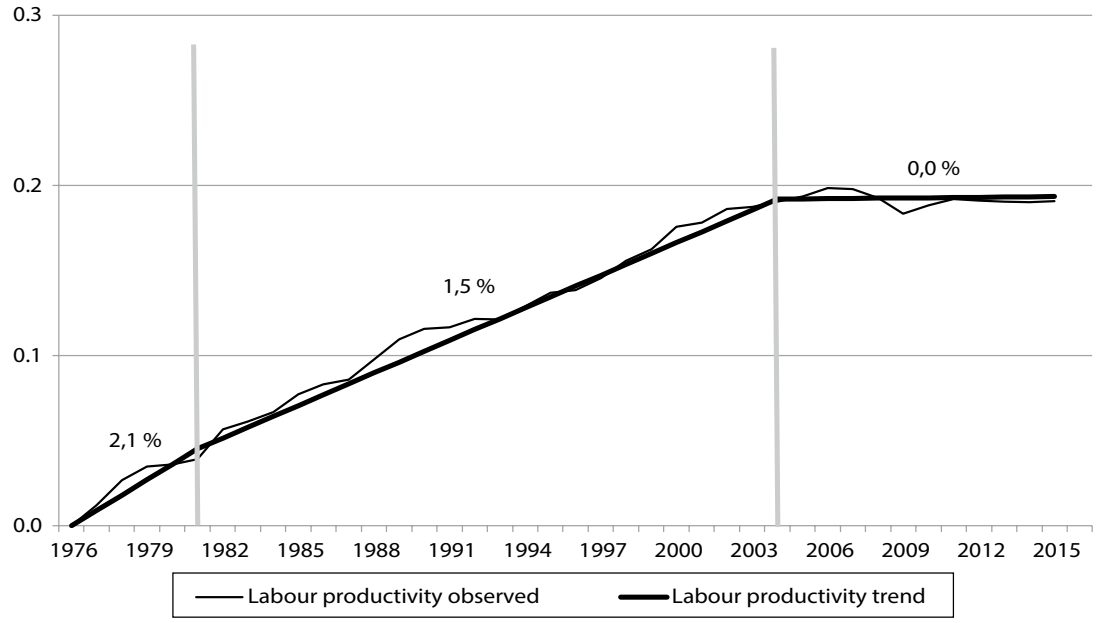
Over the whole data, the two indicators of TFP per employee (TFPN) and labour productivity per employee (LPN) see three significant breaks: at the start of the 1990s, at the start of the 2000s

5. Over the period studied, these evolutions of the duration of work have been influenced by the drop in the legal weekly work hours, from 40 hours to 39 hours in 1982 and from 39 to 35 hours in 1998-2000, as well as by the standardisation of the 5th week of paid holiday in 1982.

6. These thresholds have been chosen due to the existence of major legal thresholds for these workforces and/or due to the existence of this sizeable criterion in the definition of the categories of companies according to the definition of the Modernisation of the Economy Law (MEL).

Figure I
Trends of different productivity indicators on macroeconomic data

A – Total hourly factor productivity (TFPH)
in log, 0 base in 1976, trend average yearly growth rate in % (Bai and Perron method with CUR)



B – Total factor productivity per employee (TFPN)
in log, 0 base in 1976, trend average yearly growth rate in % (Bai and Perron method with CUR)

C – Labour productivity per hour (LPH)
in log, 0 base in 1976, trend average yearly growth rate in % (Bai and Perron method with CUR)

D – Labour productivity per employee (LPN)
in log, 0 base in 1976, trend average yearly growth rate in % (Bai and Perron method with CUR)

Reading note: the vertical bars indicate the breaks in productivity growth, determined on the basis of the Bai and Perron method (1998) with the capacity utilisation rate as the cycle control (cf. Box 3). The figures which appear next to the curve over each sub-period correspond to the indicator's estimated average yearly growth rates over the corresponding sub-period; they are greyed out if these trends are not significantly different from the preceding one (which is the case only for the break in 1982 in graph-D).
Coverage: whole economy.
Source: National accounts, 2015 provisional, 2010 base, Insee; authors' estimations.

and at the time of the crisis, in 2008 (Table 1). The first break in the mid-1990s reflects a strong acceleration in productivity, which corresponds to the economic recovery after the recession of 1993. This cyclical recovery is thus only partially captured by the indicator of the turnover variation. The second break of the beginning of the 2000s corresponds to a severe slowdown in productivity, as observed using the macroeconomic data. Finally, the third break, concurrent with the start of the crisis in 2008, also corresponds to a slowdown in productivity which average yearly growth becomes lower than over the other preceding sub-periods. This last break is often not statistically significant.

The changes in productivity are similar, for each of the two indicators considered, between only the size 1 companies and those which have just been commented on over all three sizes. For the TFP per employee (TFPN) indicator, they are also similar over the two larger sub-sets of size, sizes 2 and 3. For the labour productivity per employee (LPN) indicator, the number of breaks is smaller: two for size 2, at the end of the 1990s and in 2008, and just one in 2008 for size 3. But these breaks mean a drop in productivity which average yearly growth from 2008 also becomes inferior or equal to that observed over the preceding sub-periods.

Over four of the six sectors considered – agriculture, industry, construction and transport – the two productivity indicators also see downward breaks in all sectors, after sometimes an acceleration, but this is either at the start of the 2000s (or at the very end of the 1990s), or in 2008, or at these two dates. In the other services, a downward change is also observed for the TFP indicator (TFPN) in 2008. Changes of the same type are generally observed in these sectors for each of the three company sizes. Only two sectors among the six considered are an exception to this: retail and, only for the productivity per employee indicator (LPN), the other services. In these two activities, productivity accelerates at one of these two dates at least and the growth rate observed at the end of the period is equal to or greater than that observed on average over the preceding sub-periods. This more atypical behaviour is only seen in small retail companies and is observed over the three company sizes with regards to labour productivity in the other services.

The significant result drawn from company level data is that, except for a few rare exceptions like the retail sector and, for the labour productivity indicator only, in the other services, the two productivity indicators see a slowdown, both on all activity and in each sector, at the start of the 2000s or in 2008 or at these two dates. This slowdown brings productivity growth at the end of the period to levels equivalent or inferior to those observed on average over the preceding sub-periods. Such evolutions are generally observed on each of the three company sizes considered. The use of company-level data therefore confirms almost across the board the assessment made with aggregate data of a slowdown in productivity after the start of the decade of 2000. The notable difference is that the time of this slowdown doesn't appear to be necessarily only at the start the 2000s, but also, or sometimes only, from 2008 onwards.

Searching for causes of the slowdown in productivity in France using company data

A few interpretations of the slowdown in productivity

As documented above, productivity saw a downward trend before the financial crisis, which was widespread over the sectors and company sizes, and its growth remains particularly weak in the current period. Numerous explanations have been put forward for this slowdown, which is hitting the most advanced countries (Bergeaud et al., 2016), and company data will shed light on several of them.

- A decline in the contribution of technological progress to productivity growth (Gordon, 2012, 2013, 2014 et 2016): the current wave of technological progress might not be as booming as the one the world saw following the second industrial revolution which boosted growth, directly or through convergence to the United States, up to the 1970s (see Cette, 2014 and 2015, for an overview of this debate). In this hypothesis, productivity should then slow down for companies at the frontier.

- A decline in the dissemination of technologies between companies at the frontier and those not, due to the growing importance of "tacit knowledge", linked to the increase in complexity of technology with time (Andrews et al., 2015): the convergence of the productivity levels of the least and the most productive companies should then decelerate.

Tablea 1
Trends of various productivity indicators on unbalanced company data – average yearly growth rate in %

A – Total factor productivity per employee (TFPN)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Agriculture	size 1	**2.3**																		**- 0.2**					
	size 2	1.9					0.7									**5.6**				**- 2.7**					
	size 3	**2.4**													2.5										
	all sizes	**2.3**																		**- 0.1**					
Industry	size 1	**0.9**					**4.0**						**2.9**							**0.5**					
	size 2	**0.9**					**3.0**													**0.5**					
	size 3	**1.7**					**2.8**													**0.6**					
	all sizes	**1.3**					**3.4**													**0.4**					
Construction	size 1	0.1							**3.1**					**- 3.5**							- 2.8				
	size 2	- 0.8					**3.5**					**- 2.0**									- 3.7				
	size 3	**1.0**													**- 3.0**					- 2.4					
	all sizes	0.1							**3.1**					**- 3.4**							- 2.8				
Retail	size 1	0.6						**3.0**						**0.0**							**1.5**				
	size 2	0.6						1.5						**- 0.5**							- 0.5				
	size 3	**1.3**										**0.2**								**- 0.7**					
	all sizes	0.6						**2.8**						**0.0**						**1.1**					
Transport	size 1	**5.5**								**0.9**															
	size 2	**5.4**							**1.2**																
	size 3	**5.7**						**2.5**											**- 0.8**						
	all sizes	**5.6**								**1.0**															
Other Services	size 1	- 0.5							- 0.6						0.2					- 0.4					
	size 2	- 1.3					- 0.6					0.0								- 0.8					
	size 3	- 0.5														**- 2.5**					- 2.3				
	all sizes	**- 0.5**							- 0.5						0.2					- 0.5					
All sectors	size 1	- 0.1					**3.8**						**0.7**								- 0.1				
	size 2	0.2						**2.6**						**0.7**							- 0.4				
	size 3	0.6						**2.7**							**0.6**						- 0.5				
	all sizes	0.0					**3.7**						**0.8**								**- 0.2**				
Macroeconomic data		**0.4**						**0.9**								**0.1**					- 0.1				

B – Labour productivity per employee (LPN)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Agriculture	size 1	**4.3**																			**1.4**				
	size 2	**4.4**							1.2								**7.0**				**- 1.4**				
	size 3	1.1										**4.1**									**- 0.7**				
	all sizes	**4.2**																			**1.6**				
Industry	size 1	**2.2**									**3.8**										**1.6**				
	size 2	**2.8**											**3.8**								**1.9**				
	size 3	**3.4**													**3.9**						**1.3**				
	all sizes	**2.3**									**3.8**										**1.7**				
Construction	size 1	- 0.4							**3.0**					**- 2.4**							- 2.2				
	size 2	0.6								**1.7**					**- 1.8**						- 2.3				
	size 3	**1.4**										**- 1.2**						**- 2.9**							
	all sizes	- 0.3							**2.9**					**- 2.4**							- 2.3				
Retail	size 1	0.1								**2.8**					**0.9**						**1.8**				
	size 2	**1.1**										**0.9**				**0.9**					**0.6**				
	size 3	**1.3**						1.1							0.8						0.8				
	all sizes	0.2								**2.6**					**0.9**						**1.8**				
Transport	size 1	**2.2**													**0.7**										
	size 2	**3.1**								**0.5**							**0.6**				**1.3**				
	size 3	**3.9**									**- 0.6**							**1.5**							
	all sizes	**2.5**																**0.7**							
Other services	size 1	**- 1.1**									- 0.4				0.3						0.5				
	size 2	**- 0.9**											- 1.5								**- 0.4**				
	size 3	- 0.1																0.3							
	all sizes	**- 0.8**									- 0.5						**0.2**				0.4				
All sectors	size 1	**0.9**									**3.0**						**1.0**				0.9				
	size 2	**1.9**														**1.3**					**0.3**				
	size 3	**2.1**																			**0.0**				
	all sizes	**1.1**									**2.8**						**1.0**				0.9				
Macroeconomic data		**1.4**							1.1									**0.7**				**0.2**			

Reading note: for size 1, in agriculture, the trend of labour productivity per employee was at 4.3% per year from 1990 to 2008, then at 1.4% from 2009 to 2014. The breaks in productivity growth are determined on the basis of the Bai and Perron method (1998) with turnover as the cycle control (cf. box 3). The numbers correspond to the indicator's estimated average yearly growth rates over the corresponding sub-period; they are in grey if these trends are not significantly different from the preceding one (or a trend negligibly different to 0 for the trend immediately after 1990). The tests on macroeconomic data differ from those presented in figure I since the estimation period was made shorter for the sake of consistency with the company data.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM].
Source: authors' database from Fiben, Banque de France; unbalanced sample; authors' calculations.

- "Winner takes all" phenomena linked to the characteristics of ICT (large economies of scale, linked especially to network effects; non-rival goods whose marginal production costs are nil): in this case, the most productive companies' productivity should rapidly accelerate relative to the least productive companies. These evolutions have an ambiguous impact on aggregate productivity, to the extent that they explain a growing divergence rather than an overall slowdown. It can be noted that they nevertheless lead to monopolies which stifle competition and, in turn, have a detrimental effect on productivity growth.

- An insufficiently efficient reallocation when faced with crises that require significant sectoral and geographical reallocation of the production factors. It can be a matter of technological shocks, like that of ICT, shocks to industrial specialisation in the context of globalisation, or shocks linked to the financial crisis or the bursting of the real estate bubble, which had a significant impact on construction in France. Berthou (2016) showed that the efficiency of the allocation of the labour force in France would have been particularly weak after the crisis. Fontagné and Santoni (2015) explain the differences in the efficiency of allocation by agglomeration economies, with the efficiency of allocation being better in the densest zones. In this case, the dispersion of productivity increases and that of the surviving companies decelerates.

Others arguments, more specific to the French case, have been put forward. Askenazy and Erhel (2015) have highlighted the role of the labour market: the legal relaxation of the use of fixed-term contracts (FTCs) and self-employed have thus contributed to developing low-productivity jobs, while the reduction of labour costs has incited companies to keep their unskilled workforce, even in times of crisis.

In France, using company data also drawn from the *Fiben* base, Chevalier et al. (2008) have examined specifically the convergence of productivity up to the beginning of the 2000s. They highlight a deceleration of the convergence of company productivity from the mid-1990s to the start of the 2000s which might be linked to an acceleration of the most productive companies' productivity. This relative acceleration was explained by three factors:

- Information and communication technology (ICT) has particularly benefited the already most productive companies, which have a well-trained workforce capable of taking full advantage of this technology shock.

- Globalisation and the development of foreign trade have benefited the most productive companies since they are the only ones able to finance the fixed costs necessary to break into a foreign market (Bernard & Jensen, 1999).

- By lowering the level of profitability, the strengthening of competition linked to the deregulation of the 1990s led the most productive companies to try to escape neck and neck competition, whereas it discouraged the least productive companies from catching up to the sector average productivity level (Aghion et al., 2005).

The evolution of productivity at the frontier: increase of dispersion between the most productive firms and the others

A decline in technical progress would suppose a productivity slowdown at the production frontier, while a winner-takes-all mechanism would on the contrary lead to its acceleration. Nevertheless, in this latter case, companies at the frontier in a given year should increase their lead.

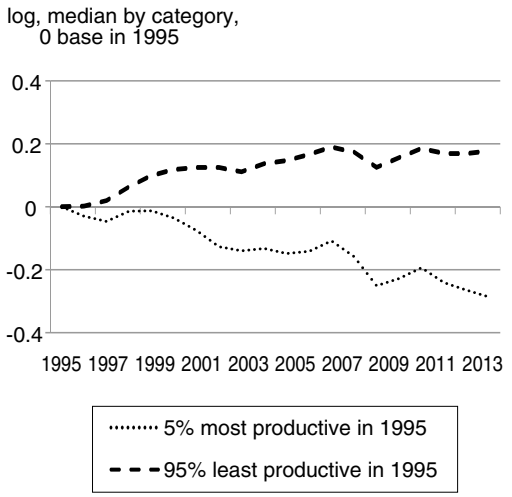
To decide between these two explanations, we will examine the evolution of the productivity of companies at the frontier from two angles. Firstly, we will monitor the productivity of the companies which were the most productive at a given date, and keep this sample after that date, even if it does not necessarily constitute the productivity frontier in the following years. Secondly, we will monitor the productivity of the most productive companies each year, with these companies possibly being different from one year to the next. In the two cases, we retain the companies in the 5% most productive but the results are not qualitatively different for the 2% or 10% most productive.

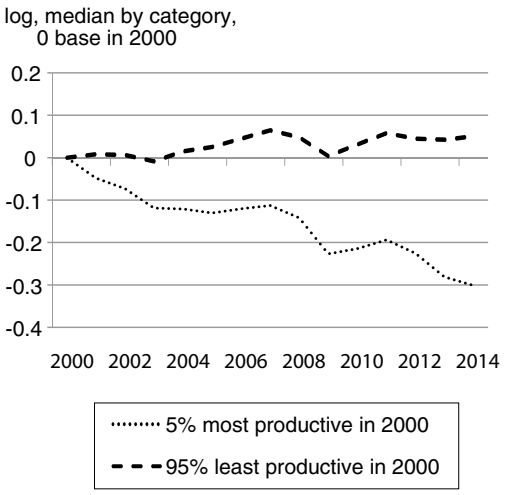
With Figure II, we notice, firstly, that the median productivity of the most productive companies at a given date – 1995, 2000 and 2005 (the thin line) – follows a downward trend, whereas it increases for the least productive companies at this same date (dashed thin line).

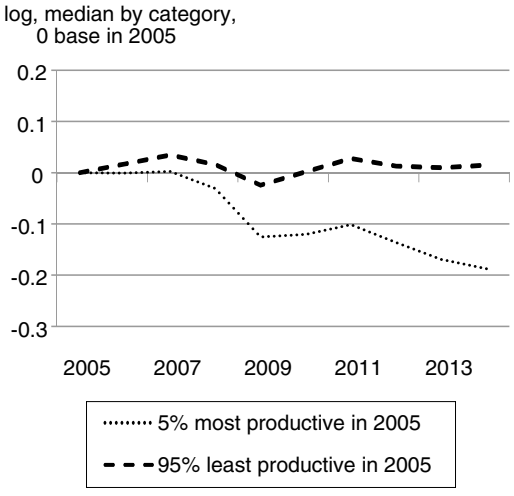
This indicates a convergence of the companies' productivity over the whole period: whatever the date of reference, the most productive companies' productivity at a given date decreases

Figure II
Development of the productivity of the most productive company at a given date compared with that of other companies – balanced panel

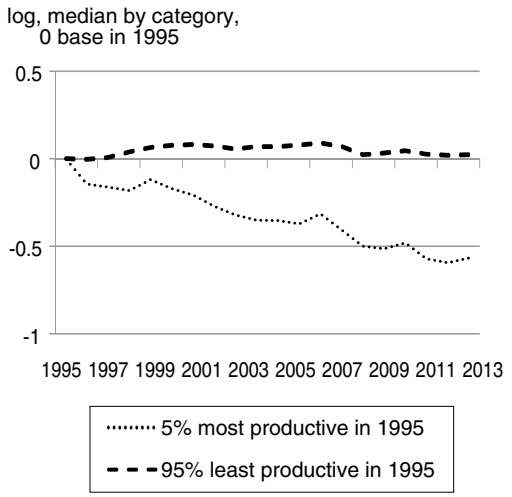
A – Productivity per employee

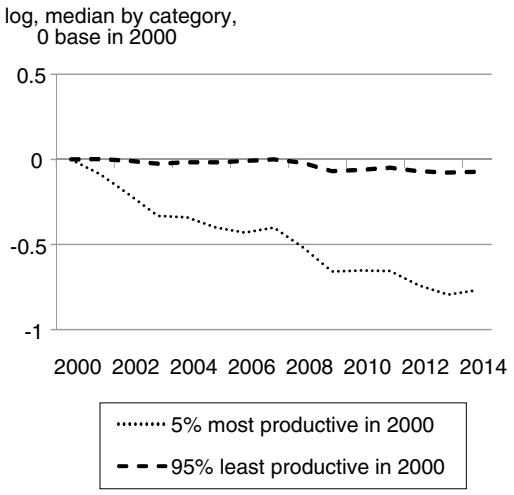


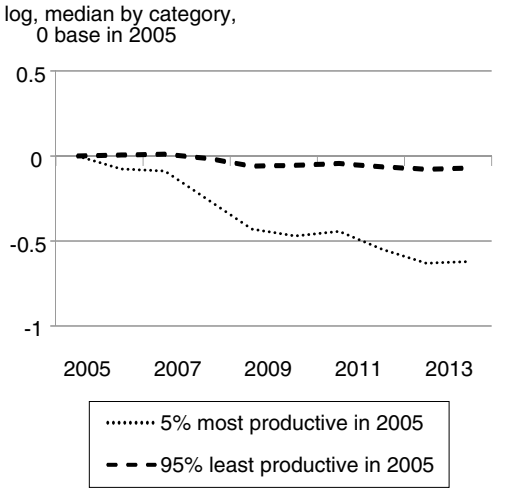




B – Total factor productivity







Reading note: on the first graph on the top left, the dotted line represents the median productivity of the companies which were the 5% most productive in their sector in 1995, and the dashed line represents the median productivity of the companies making up 95% of the least productive in their sector in 1995.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM].
Source: authors' database from Fiben, Banque de France; balanced sample; authors' calculations.

compared to that of the other companies. It should nevertheless be noted that the median productivity of the most productive companies stays very much above that of the least productive companies at the date of reference, or that of all the companies in the sample whatever the period of reference. Thus, in 2014, the most productive companies in 1995 remain 1.9 times more productive (against 3.4 times in 1995) than the companies that were less productive than them in 1995.

The productivity of companies at the frontier in a given year declines, except over some very rare and short sub-periods. This decline intensified slightly at the end of the period. These evolutions do not seem in line with a 'winner-takes-all' dynamic: the productivity of the most productive companies does not accelerate, contrary to what would be expected if these companies gained more and more market share at zero marginal cost. It does indeed seem difficult to envisage that a dynamic of this type could apply to all sectors of the economy, whether their characteristics correspond or not to the ICT sectors (economy of scale linked to network effects, non-rival goods).

We are looking now at the evolution of the productivity frontier, with a different sample each year. Contrary to Figure II, Figure III represents the median productivity of the 5% most productive companies of the year[7]. The black line therefore defines the productivity frontier, with a renewal each year of the companies that define it. The dotted line corresponds to the median productivity of the other companies. The spread between the two lines therefore constitutes an indicator of the dispersion of productivity between the companies at the frontier and the others. Since the mid-1990s, the productivity of the companies at the frontier has accelerated in relation to that of the other companies, with a pause at the turn of the 2000s. The financial crisis did not slow down these evolutions which intensified, on the contrary, in 2014.

The productivity frontier has gained considerable speed over the recent period, very closely in line with the results of Andrews et al. (2015) over international data. This does not run parallel with a decline in technological progress, a hypothesis defended by Gordon. Nevertheless, in the case of France, the dissemination of ICT has been less considerable than in other countries (Cette et al., 2015). The progression of productivity at the productivity frontier in France therefore does not necessarily correspond to technological progress on a global scale, since existing technologies might also still be in ongoing dissemination throughout the most productive companies. The efficiency frontier is of course international, but it is striking to notice the similitude of the results obtained over French data in this article and over international data in Andrew et al. (2015). It should be noted that, considering the under-representation of Germany and especially of the USA in the company data used by Andrew et al. (2015), relative to the main countries of the OECD[8], the frontier which has been empirically characterised there is not necessarily the global efficiency frontier.

The concept of the productivity frontier is nevertheless difficult to apprehend here: in fact, we notice that the companies in our database stay on average for 3 years among the most productive in a given year, for both TFP and labour productivity. Furthermore, this duration is close to that of the results of Andrews et al. (2015) over international data. Considering their very high initial relative level, the productivity of the companies at the frontier returns naturally to the average, as is illustrated in figure II[9]. Then the frontier represented in figure III therefore corresponds to a temporary performance, possibly unsustainable in the long term for a large proportion of firms.

The other companies' productivity has decelerated, even stagnated for TFP, since the financial crisis. This relative acceleration of the most productive companies therefore demonstrates an increase of the dispersion of productivity between very productive companies and other companies. This is confirmed in Figure IV, representing the interquartile or interdecile dispersion[10]: the dispersion has greatly increased since the crisis and reaches its highest levels at the end of the period. This may correspond to the hypothesis of reallocation difficulties following

7. These figures correspond to graphs 1 of Andrews, Criscuolo and Gal (2015). Nevertheless, the frontier is defined here at the national level and not global like in this study.

8. Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, the UK, Greece, Hungary, Italy, Japan, South Korea, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Slovenia, Slovakia, the US.

9. Without, however, reaching this average, since these companies remain more productive than the media, even after 19 years of decline of their relative level of productivity.

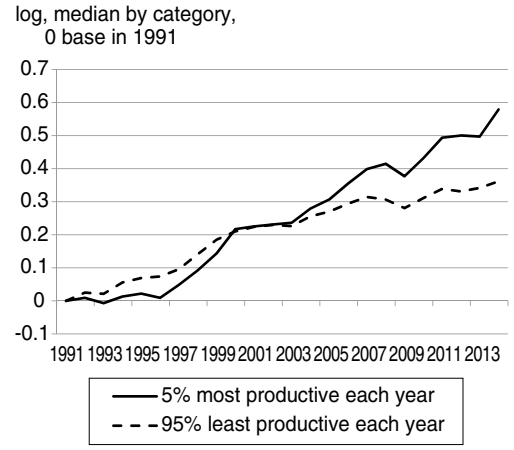
10. Taking into account the fact that the database is not comprehensive, these dispersion indicators were chosen because they are less sensitive to the sample's variations than the indicators based on the standard deviation or the Gini coefficient.

shocks. In fact, sectoral shocks can emphasise the need to reallocate, but if market rigidities or a lack of skilled labour stifle these reallocations, low-productive companies will continue to operate and their productivity will slow down, whereas that of successful companies with adequate factors of production accelerates. The impact of these shocks can be seen, for example, in the construction sector: following the financial crisis, the residential property sector adjusted through a reduction of construction work rather than a drop in property prices; this resulted in a drop in the median productivity of the sector's companies (cf. Table 1) and difficulties in reallocating this sector's labour force.

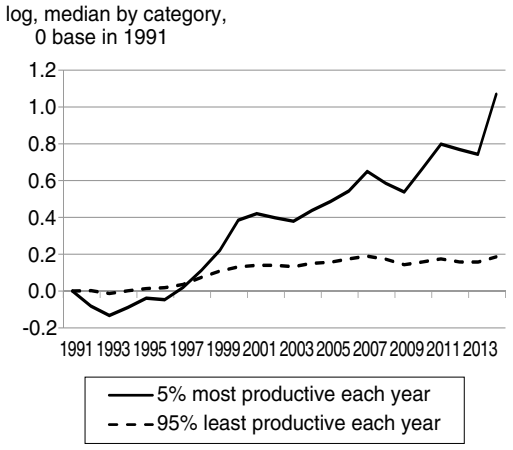
Such difficulties in reallocation have been confirmed by economic literature, for example Bartelsman et al. (2016) over several European countries. For the US and the UK, Foster et al. (2014) and Barnett et al. (2014) have shown that reallocations had a less positive impact

Figure III
Productivity of the most productive companies each year

A – Productivity per employee – unbalanced sample



B – Total factor productivity – unbalanced sample

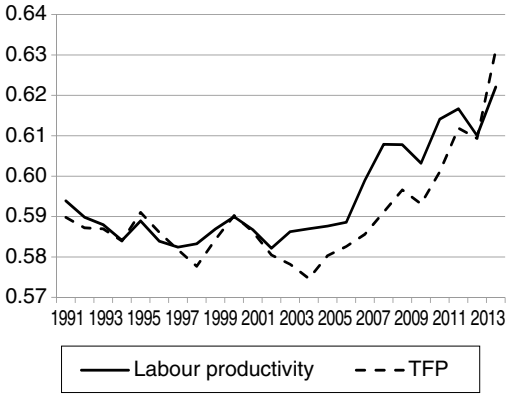


Reading note: contrary to figure II, median productivity is measured over the whole database each year, not over the most or least productive companies in the base year. The straight line measures the median productivity of the 5% most productive companies in the year and sector. The dashed line represents the median productivity of all the other companies.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM].
Source: authors' database from Fiben, Banque de France; unbalanced sample; authors' calculations.

Figure IV
Companies' productivity dispersion indicator – unbalanced sample

A – Interquartile dispersion (Q3-Q1)/(Q1+Q3)

B – Interdecile dispersion (D9-D1)/(D1+D9)



Reading note: these two graphs present dispersion indicators, on the basis of the interquartile or interdecile spread. The higher these indicators, the greater the dispersion.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM].
Source: authors' database from Fiben, Banque de France; unbalanced sample; authors' calculations.

on productivity after the Great Recession. Furthermore, Berthou (2016) shows that the efficiency of labour allocation in France would have been particularly weak since the crisis compared to other European countries. The studies on companies confirm these results, especially the *Wage Dynamics Network* study of the Eurosystem. 70% of companies (weighted by their workforce) declare in it that the lack of an available skilled labour force is an obstacle to recruitment in France, compared to just over 40% in Spain and just over 30% in Italy (Jadeau et al., 2015).

Among the explanations for these reallocation difficulties, the impact of the financial crisis on the functioning of the banking system has been highlighted for several countries. Nevertheless, for France, it does not appear that erroneous allocations of credit to insolvent companies ("zombie lending") have developed significantly with the crisis (Avouyi-Dovi et al., 2016). Hence, the explanations are rather to be found in rigidities on the labour market, in particular obstacles to labour or enterprise mobility (Fontagné & Santoni, 2015; Bergeaud & Ray, 2017), in terms of initial and continued training, or in market regulations which might reduce competition by entry barriers. Finally, the collapse of international trade, which was particularly notable during the Great Recession, hit highly productive companies – which are also more export-oriented companies – the most. Except in 2008-2009, this explanation does not appear to be confirmed with the French data that we have used.

No slowdown in the convergence of productivity in the 2000s

Among the hypotheses to explain the slowdown in productivity at the aggregate scale, Andrews et al. (2015) have highlighted a slower convergence of the least productive companies' productivity with that of the most productive ones. This slower convergence could be explained by low dissemination of technological progress from the most productive companies to the least productive.

This slower convergence can be tested using an equation of β-convergence, which makes productivity growth depend on the gap with the frontier.

$$\Delta prod_{it} = \beta \cdot (prod\left(95^{th}\ percentile\right)_{t-1} - prod_{it-1}) + X_{ist} + \varepsilon_{ist} \quad (1)$$

For company i, of sector s, productivity growth per employee or TFP, *prod* (logged), is expressed according to the gap between the median of the productivity log of the 5% most productive companies in their sector and year considered, $prod(95^{th}\ percentile)$, and its productivity, $prod_{it}$, and according to fixed effects (year, sector, size or company according to the specifications), $X_{ist,}$ with ε_{ist} error term[11].

If there is convergence, productivity growth will be much faster than the gap with the productivity frontier will be high: β will be positive and significant. Convergence is conducted towards a target that depends on fixed effects: the productivity of the company converges in the long-term with $prod(95^{th}\ percentile)_{t-1} + X_{ist}\beta$. As is shown in Chevalier et al. (2008), lagged productivity is endogenous, being correlated to the firm's unobserved heterogeneity. Estimated using the ordinary least squares method (OLS), it can be shown that β will be underestimated, whereas it will be overestimated with company fixed effects. One solution would be to use an estimator such as Arellano-Bover's (1995). Nevertheless, this type of estimator leads to a considerable loss of precision in the estimation of β, whereas the bias of the OLS estimation runs parallel with the absence of convergence. If β is significant and positive, then a convergence of companies' productivity can effectively be concluded.

The results over the whole period are presented in Table 2. With the OLS estimation, whatever the fixed effects are, a significant convergence is found, with nearly 11% of the gap with the frontier made up each year for TFP and 14% for labour productivity per employee (LPN). Using company fixed effects (columns 7 and 8), the convergence is a lot faster, which stays in line with the definition of the objective of long-term convergence at company level but also with the estimation bias mentioned above.

The convergence is faster for productivity per employee (LPN) than for TFP. In fact, it seems easier to increase the capital intensity of a company in order to increase its productivity than to increase the efficiency of its production process with a constant capital stock. We have tested whether the speed of convergence was lower for sectors intensive in ICT. By using the share

11. An alternative specification consists in regressing over the level of the company's lagged productivity only, without the productivity of the 95th percentile. In the case of convergence, then β is negative. The results, presented in Annex 2, are very close, as well as on convergence per year.

of income on ICT capital in the total income on capital as a proxy of the intensity of ICT (source being EU-KLEMS), we find a convergence speed which decreases with the intensity in ICT but in a limited way.

To study the evolution of the speed of convergence over the period, we use a slightly different specification:

$$\Delta prod_{it} = \alpha \cdot (prod(95\%)_{t-1} - prod_{it-1}) + \sum_{j=1991}^{2014} \beta_j D_j (prod(95\%)_{j-1} - prod_{ij-1}) + D_t + D_s + D_a + \varepsilon_{ist} \quad (2)$$

still with the indices *i* for the company, s for the sector and t for the year, *prod* is the log of the productivity indicator, *prod(95%)* the log of the median productivity of the 5% most productive companies in their sector, D_j year dummies; D_t, D_s et D_a, are fixed effects for year, sector and size, and ε_{ist} the error term.

The speed of convergence in year *j* is then $\alpha+\beta_j$. There is convergence if the sum of the two coefficients is significant and positive. The results of these estimations are presented in Annex 3 and displayed in Figure V[12].

The speed of convergence slowed down throughout the 1990s, with a low point in 1999. It then stagnated until the financial crisis. The shock of the financial crisis led to an acceleration of the convergence largely due to the economic climate and adjusted accordingly after. In 2014 the convergence slows down considerably. Other years must nevertheless be observed in order to confirm this new stalling of the speed of convergence, observed over one sole year at this stage.

12. The results over the balanced panel are presented in Annex 4. The balanced panel isolates the input-output effect, although the probability of survival decreases with time for the companies in this sample. The results are qualitatively similar, with the slowdown appearing even less evident over the recent period.

Table 2
Convergence of estimated productivity over the whole period

A – Total factor productivity

	(1) ols	(2) ols	(3) ols	(4) ols	(5) ols	(6) ols	(7) fe	(8) fe
Distance to the frontier$_{t-1}$	0.101***	0.104***	0.112***	0.115***	0.100***	0.118***	0.434***	0.512***
	(0.000351)	(0.000351)	(0.000365)	(0.000370)	(0.000351)	(0.000370)	(0.000704)	(0.000729)
N	1781198	1781198	1781198	1781198	1781198	1781198	1781198	1781198
R^2	0.0441	0.0560	0.0526	0.0549	0.0442	0.0662	0.197	0.248
Fixed effects								
Year		X			X	X		X
Sector			X		X	X		
Size				X		X		

Reading note: estimation of $\Delta prod_{it} = \beta \cdot (prod(95^{th}\ percentile)_{t-1} - prod_{it-1}) + X_{ist} + \varepsilon_{ist}$ with $(prod(95^{th}\ percentile)_{t-1} - prod_{it-1})$, company's distance to the TFP frontier *i* in year *t*-1, Xist fixed effects for year, sector, size or companies; "ols" for ordinary least squares and "fe" for company fixed effects; standard deviation in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

B – Productivity per employee

	(1) ols	(2) ols	(3) ols	(4) ols	(5) ols	(6) ols	(7) fe	(8) fe
Distance to the frontier$_{t-1}$	0.113***	0.115***	0.139***	0.113***	0.140***	0.140***	0.506***	0.530***
	(0.000268)	(0.000269)	(0.000294)	(0.000269)	(0.000293)	(0.000294)	(0.000532)	(0.000533)
N	3348931	3348931	3348931	3348931	3348931	3348931	3348931	3348931
R^2	0.0502	0.0566	0.0642	0.0502	0.0701	0.0701	0.236	0.257
Fixed effects								
Year		X			X	X		X
Sector			X		X	X		
Size				X		X		

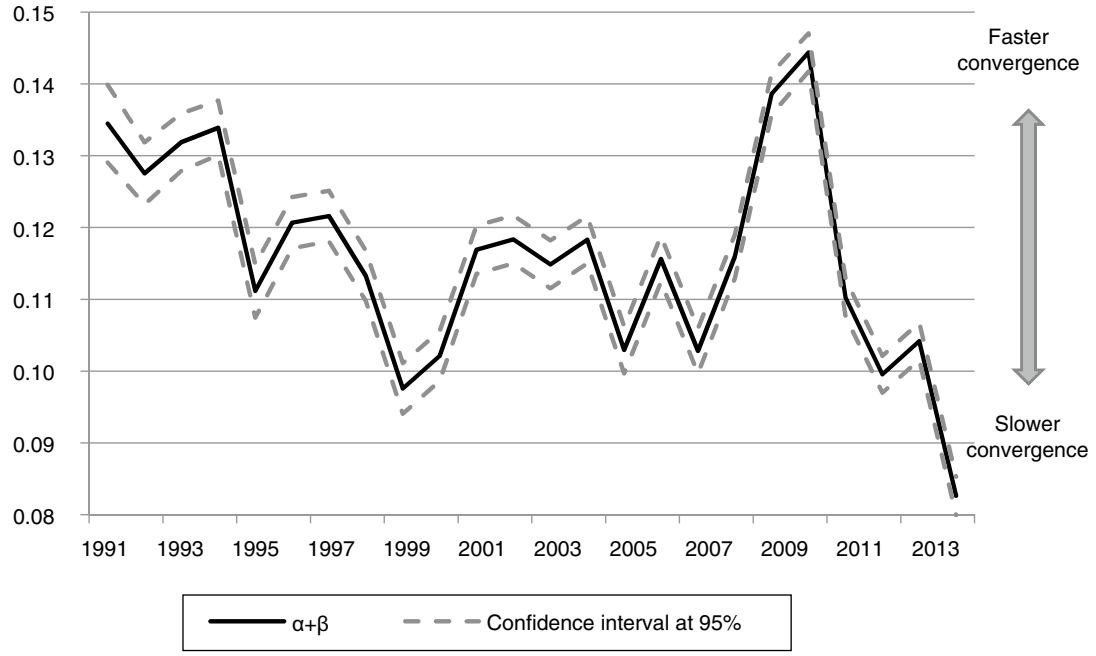
Reading note: estimation of $\Delta prod_{it} = \beta \cdot (prod(95^{th}\ percentile)_{t-1} - prod_{it-1}) + X_{ist} + \varepsilon_{ist}$ with $(prod(95^{th}\ percentile)_{t-1} - prod_{it-1})$, company's distance to the TFP frontier *i* in year *t*-1, Xist fixed effects for year, sector, size or companies; "ols" for ordinary least squares and "fe" for company fixed effects; standard deviation in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM].
Source: authors' database from Fiben, Banque de France; unbalanced sample; authors' calculations.

Figure V
Convergence of productivity per year

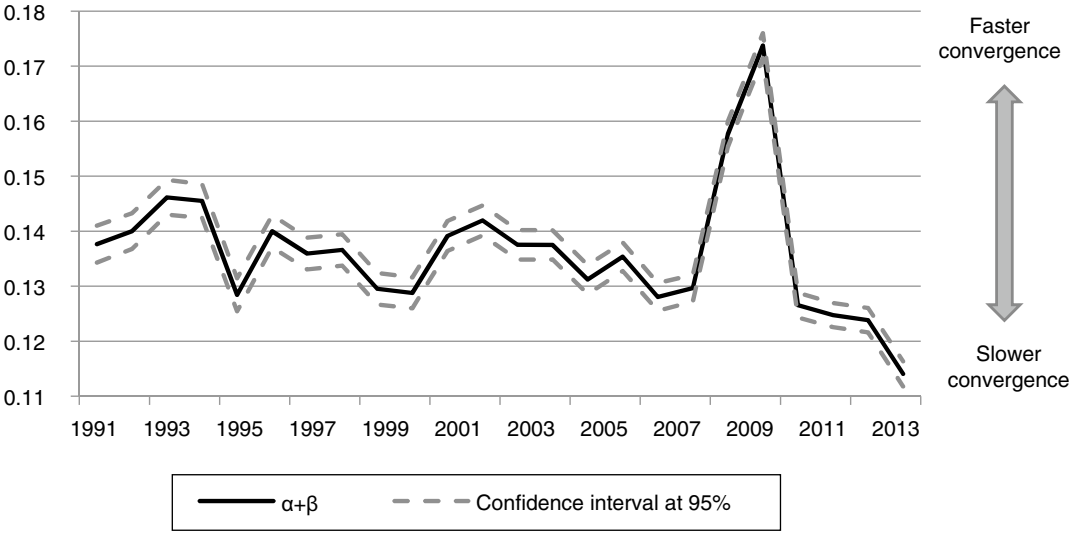
A – Total factor productivity
$\alpha+\beta_i$ - Convergence coefficients – TFP – unbalanced sample – OLS

$$\Delta tfp_{\alpha} = \alpha \cdot (tfp\,(95\%)_{\alpha-1} - tfp_{\alpha-1}) + \sum_{i=1991}^{2014} \beta_i D_i (tfp\,(95\%)_{i-1} - tfp_{i-1}) + D_s + D_t + D_{\alpha}$$



B – Productivity per employee
$\alpha+\beta_i$ - Convergence coefficients – Labour productivity – unbalanced sample – OLS

$$\Delta lp_{\alpha} = \alpha \cdot (lp\,(95\%)_{\alpha-1} - lp_{\alpha-1}) + \sum_{i=1991}^{2014} \beta_i D_i (lp\,(95\%)_{i-1} - lp_{i-1}) + D_s + D_t + D_{\alpha}$$



Reading note: these two graphs display the sum of the coefficients $\alpha+\beta_i$ of equation (2). The higher these indicators, the faster the convergence.
Field: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM].
Source: authors' database from Fiben, Banque de France; unbalanced sample; authors' calculations.

While there was a visible slowdown in the speed of convergence in the 1990s (confirming the results of Chevalier et al., 2008), the slowdown since the 2000s or 2010 has not been proven. While it has not been rejected, the hypothesis of a slowdown in the convergence of the least productive companies is therefore not confirmed at this stage either.

This result contrasts with that of an increase of dispersion measured by indicators of the interdecile or interquartile range (see figure IV). These two approaches are not independent of each other but differ on different points: i) the β-convergence is estimated by taking into account an error term ε_{ist}, whereas the dispersion indicators integrate the temporary shocks; ii) the β-convergence is estimated over companies present for two consecutive years, whereas the dispersion is characterised over all the companies present each year; iii) the estimation of the β-convergence includes fixed effects, which make the objective of convergence vary per sector, year and company size, these variations not being taken into account in the dispersion indicators; iv) finally, the dispersion indicators built up on the interdecile or interquartile range leave out by definition the productivity of companies on the periphery of our sample's distribution, which are part of the estimation of the β-convergence. In terms of interpretation, the contrast between the two approaches calls for cautiousness: while the dispersion of productivity levels has increased over the last few years, as the dispersion indicators show, the possible estimations, with their numerous limitations, do not allow for this increase to be attributed to a weakening convergence of the productivity levels.

* *
*

The most important results of our analysis concerning the evolutions of labour productivity and TFP in France over the last few decades are as follows:

- Both macroeconomic data and company data indicate that labour productivity and TFP slowed down in the 1990s then again in the 2000s. Over the macroeconomic data, this last slowdown is observed at the start of the 2000s, before the financial crisis began in 2007-2008. But over company data, it is sometimes observed rather at the time of the crisis, or at two dates in this same decade. Except for some very rare exceptions, the slowdown of the 2000s is observed over the company data over the three company sizes and the six business sectors considered. It appears that productivity growth is, since the slowdown of the decade of 2000, weaker than it has even been over the whole period considered.

- The company data clearly indicate that the slowdown of the French companies' productivity during the decade of 2000 would not result from a faltering of the technological frontier. The most productive companies' productivity growth does not undergo a visible drop. This observation seems to belie, at least for France, the idea of a decline of the effects of technical progress on productivity.

- The company data also indicate that the convergence of follower companies with the technological frontier would not have decreased over the decade of 2000, which seems to deny the idea of a weakening dissemination of the most productive companies' innovations to the other companies. At the same time, the dispersion of productivity levels seems to have intensified, which could attest to a less efficient allocation of the production factors to the most successful companies.

At the end of these empirical investigations over two distinct types of data (macro- and microeconomic), it therefore appears that the reasons for the drop in productivity in France before the financial crisis which hit in 2007-2008 remain in part uncertain. The idea of an inefficient allocation of the production factors to the most promising business activities and the most successful companies seems to still be of real importance. This idea is reinforced by the fact that the slowdown observed in France also occurs in all the main developed economies, even though these economies differ on multiple features: distance to the frontier, institutions, the education level of the labour force, etc. This universality suggests that the reasons for the drop might be similar in the different advanced economies. One factor which comes to mind straight away is of course the drop in real interest rates, which has become widespread since the 1990s. Such a drop in the cost of borrowed capital has ensured the survival of many companies which would have been condemned by more onerous credit conditions. It also made barely-effective investment projects profitable. It results overall in an allocation of productive resources that is worse, on average, for the dynamism of productivity.

The previous industrial revolutions were always accompanied by vast institutional changes which were beneficial to production, and the dissemination and improvement of new technologies (cf. for example Ferguson and Washer, 2004). In such an approach, it is therefore important for each country or economic zone to prepare itself for the implementation of ambitious structural reforms which will promote the rebirth of the ongoing technological revolution and whose premises appear across many domains (cf. Cette, 2014 and 2015, for a review of the literature in this domain). Not adapting well enough will condemn the country or the economic zone concerned to worse performance, in other words impoverishment, relative to the countries that will have adapted and will benefit more from the effects of the current technological revolution.

The history of the preceding technological revolutions have shown us that there was not necessarily any trade-offs to be made between the full benefits of technological revolutions, protecting workers, and beyond that, people's standard of living. The gains in productivity associated with the second industrial revolution, which transformed production methods and lifestyles in the 20th century, thus facilitated the financing of an enhancement of protections (social ones in particular), average living standards (purchasing power) and leisure (through the reduction of the average time spent working). It is the prospect of such gains that must guide the desired institutional transformations in order to promote a more effective allocation of productive resources and a galvanisation of productivity brought about by the not-yet-complete technological revolution of ICT and the digital economy. □

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ANNEX 1

TESTS FOR BREAKS OVER MACROECONOMIC DATA

Table A1-A
Break in the labour productivity per hour trend
(dates of break, crossed out if not significant)

Model/Period	1974 - 2014	1990-2014
Without cycle control	~~1985~~ -1990-~~1997~~-2001-2006	1999-2003-2008
CUR	1981 - 1995 - 2004	~~1997~~-2003
GDP	1984 - 2003	2004
GDP + GDP acceleration	1985 - 2003	~~1994~~-2003-2009

Table A1-B
Break in the TFP per hour trend
(dates of break, crossed out if not significant)

Model/Period	1974 - 2014	1990-2014
Without cycle control	~~1977-1985~~-1995-2006	1997-2008
CUR	1981 - 2004	2003
GDP	1981 - 1988 - 1999 - 2007	1996-2001-2008
GDP + GDP acceleration	1990 - 1999 - 2007	1995-2004-~~2009~~

Note: breaks in productivity growth, determined on the basis of the Bai and Perron method (1998) with the capacity utilisation rate, GDP growth or its acceleration as the cycle control or without cycle control (cf. box 3). Dates crossed out if the break is not significant. For labour productivity per hour over the period 1974 to 2014, without cycle control, the Bai and Perron method (1998) identifies 5 breaks, in 1985, 1990, 1997, 2001 and 2006, but only 1990 and 2001 are statistically significant breaks.
Coverage: whole economy.
Sources: National accounts, 2015 provisional, 2010 base, Insee; authors' estimations.

ANNEX 2

RESULTS OF THE CONVERGENCE TESTS WITH NO PRODUCTION FRONTIER

A – Total factor productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ols	ols	ols	ols	ols	ols	fe	fe
tfp_{t-1}	- 0.0984***	- 0.0993***	- 0.113***	- 0.0986***	- 0.114***	- 0.114***	- 0.466***	- 0.475***
	(0.000324)	(0.000328)	(0.000359)	(0.000326)	(0.000363)	(0.000364)	(0.000701)	(0.000706)
N	1781198	1781198	1781198	1781198	1781198	1781198	1781198	1781198
R^2	0.0493	0.0582	0.0555	0.0493	0.0645	0.0645	0.221	0.234
Fixed effect								
Year		X			X	X		X
Sector			X		X	X		
Size				X		X		

Reading note: estimation of $\Delta tfp_{it} = \beta tfp_{it-1} + X_{ist} + \varepsilon_{ist}$ with tfp_{it-1}, tfp in the company's log i in year t-1, X_{ist} fixed effects for year, sector, size or companies; "ols" for ordinary least squares and "fe" for company fixed effects; standard deviation in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Coverage: whole market economy except for the financial sector. Metropolitan France and DOMs [*Départements d'outre mer* - Overseas Departments]
Sources: authors' database from Fiben, Banque de France; unbalanced sample; authors' calculations.

B – Productivity per employee

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ols	ols	ols	ols	ols	ols	fe	fe
pt_{t-1}	- 0.115***	- 0.119***	- 0.133***	- 0.116***	- 0.135***	- 0.136***	- 0.489***	- 0.498***
	(0.000261)	(0.000266)	(0.000285)	(0.000261)	(0.000288)	(0.000289)	(0.000513)	(0.000520)
N	3348931	3348931	3348931	3348931	3348931	3348931	3348931	3348931
R^2	0.0554	0.0606	0.0632	0.0555	0.0682	0.0683	0.237	0.244
Fixed effect								
Year		X			X	X		X
Sector			X		X	X		
Size				X		X		

Reading note: estimation of $\Delta lp_{it} = \beta lp_{it-1} + X_{ist} + \varepsilon_{ist}$ with lp_{it-1}, productivity per employee in the company's log i in year t-1, X_{ist} fixed effects for year, sector, size or companies; "ols" for ordinary least squares and "fe" for company fixed effects; standard deviation in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM]
Sources: authors' database from Fiben, Banque de France; unbalanced sample; authors' calculations.

A – Total factor productivity per year

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
α+β	0,134	0,128	0,132	0,134	0,111	0,121	0,122	0,113	0,098	0,102	0,117	0,118
	(0,0027062)	(0,0021651)	(0,0019954)	(0,0019029)	(0,001851)	(0,0017831)	(0,0017558)	(0,001755)	(0,0017646)	(0,0017313)	(0,0016733)	(0,00167)
Confidence	0,139884	0,131876	0,1358906	0,1376896	0,1148541	0,1242331	0,1251061	0,1167816	0,1011093	0,1055762	0,1202483	0,1216808
interval at 95%	0,1290592	0,1232156	0,127909	0,130078	0,1074501	0,1171007	0,1180829	0,1097616	0,0940509	0,098651	0,1135551	0,1150008

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
α+β	0,115	0,118	0,103	0,116	0,103	0,116	0,139	0,144	0,110	0,100	0,104	0,083
	(0,0016664)	(0,0016517)	(0,0016406)	(0,0015961)	(0,0015625)	(0,0015175)	(0,0014372)	(0,0013355)	(0,0013125)	(0,0012804)	(0,0012942)	(0,0013339)
Confidence	0,1181963	0,1216044	0,1062357	0,1188139	0,1059255	0,1189874	0,1415068	0,1470523	0,1128604	0,102118	0,106756	0,0852946
interval at 95%	0,1115307	0,1149976	0,0996733	0,1124295	0,0996755	0,1129174	0,135758	0,1417103	0,1076104	0,0969964	0,1015792	0,079959

Reading note: estimation by ols of $\Delta prod_{it} = \alpha * \left(prod\,(95\%)_{t-1} - prod_{it-1} \right) + \sum_{j=1991}^{2014} \beta_j D_j \left(prod\,(95\%)_{t-1} - prod_{it-1} \right) + D_t + D_s + D_a + \varepsilon_{ist}$ with $prod_{it-1}$, TFP in the company's log *i* in year *t*-1, D_t, D_s and D_a fixed effects for year, sector, company size; standard deviation in brackets.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM]
Source: authors' database from Fiben, Banque de France; unbalanced sample; authors' calculations.

B – Productivity per employee per year

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
α+β	0,138	0,140	0,146	0,146	0,128	0,140	0,136	0,137	0,130	0,129	0,139	0,142
	(0,0017)	(0,0016)	(0,0016)	(0,0015)	(0,0015)	(0,0015)	(0,0014)	(0,0014)	(0,0014)	(0,0014)	(0,0014)	(0,0014)
Confidence	0,1410239	0,1432496	0,1493037	0,1485956	0,1314449	0,1429107	0,1388308	0,139472	0,1324079	0,131589	0,1418694	0,1446793
interval at 95%	0,1342795	0,1367484	0,1430101	0,1424256	0,1254393	0,1370743	0,1330484	0,13374	0,1266931	0,1259882	0,136399	0,1392417

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
α+β	0,138	0,138	0,131	0,135	0,128	0,130	0,158	0,174	0,127	0,125	0,124	0,114
	(0,0014)	(0,0013)	(0,0013)	(0,0013)	(0,0013)	(0,0012)	(0,0012)	(0,0011)	(0,0011)	(0,0011)	(0,0011)	(0,0011)
Confidence	0,1402297	0,1401619	0,1338355	0,1379293	0,1305815	0,1320791	0,1599767	0,1759997	0,1288072	0,1269227	0,1260372	0,1163485
interval at 95%	0,1348249	0,1348523	0,1285811	0,1327785	0,1255379	0,1272339	0,1553559	0,1714773	0,1243076	0,1225647	0,1216048	0,1117945

Reading note: estimation by ols of $\Delta prod_{it} = \alpha * \left(prod\,(95\%)_{t-1} - prod_{it-1} \right) + \sum_{j=1991}^{2014} \beta_j D_j \left(prod\,(95\%)_{t-1} - prod_{it-1} \right) + D_t + D_s + D_a + \varepsilon_{ist}$ with $prod_{it-1}$, productivity per employee in the company's log *i* in year *t*-1, D_t, D_s and D_a fixed effects for year, sector, company size; standard deviation in brackets.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM].
Source: authors' database from Fiben, Banque de France; unbalanced sample; authors' calculations.

ANNEX 4

CONVERGENCE OF PRODUCTIVITY - BALANCED SAMPLE

A – Total factor productivity

	(1) ols	(2) ols	(3) ols	(4) ols	(5) ols	(6) ols	(7) fe	(8) fe
Distance to the frontière$_{t-1}$	0.0670***	0.0717***	0.0711***	0.0670***	0.0762***	0.0763***	0.280***	0.312***
	(0.000975)	(0.000966)	(0.00101)	(0.000975)	(0.001000)	(0.00100)	(0.00183)	(0.00184)
N	172854	172854	172854	172854	172854	172854	172854	172854
r^2	0.0266	0.0585	0.0362	0.0266	0.0683	0.0684	0.124	0.174
Fixed effect								
Year		X			X	X		X
Sector 38			X		X	X		
Size				X		X		

Reading note: estimation of $prod_{it} = \left(\left(95^{th}\ percentile\right)_{t-1} - prod_{it-1}\right) + \mathrm{X}_{ist} + \varepsilon_{ist}$ with $\left(prod\left(95^{th}\ percentile\right)_{t-1} - prod_{it-1}\right)$, company's distance to the TFP frontier *i* in year *t*-1, X_{ist} fixed effects for year, sector, size or companies; ols for ordinary least squares and fe for company fixed effects; standard deviation in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM]
Source: authors' database from Fiben, Banque de France; balanced sample; authors' calculations.

B – Productivity per employee

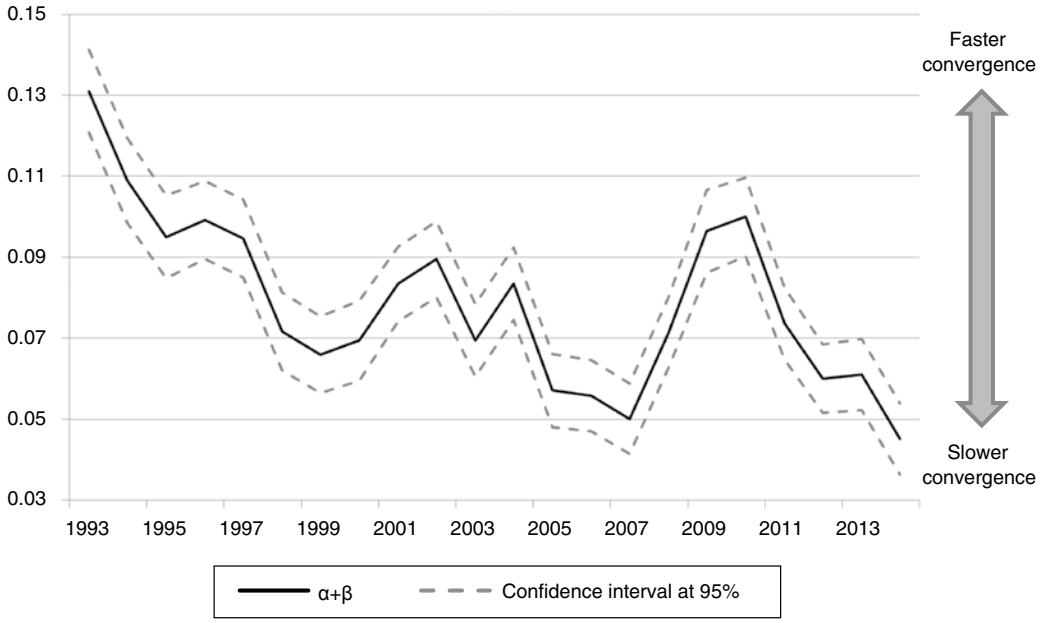
	(1) ols	(2) ols	(3) ols	(4) ols	(5) ols	(6) ols	(7) fe	(8) fe
Distance to the frontière$_{t-1}$	0.0761***	0.0784***	0.0856***	0.0763***	0.0882***	0.0884***	0.325***	0.340***
	(0.000806)	(0.000799)	(0.000847)	(0.000806)	(0.000840)	(0.000841)	(0.00155)	(0.00154)
N	262843	262843	262843	262843	262843	262843	262843	262843
r^2	0.0328	0.0553	0.0448	0.0330	0.0675	0.0676	0.149	0.181
Fixed effect								
Year		X			X	X		X
Sector 38			X		X	X		
Size				X		X		

Reading note: estimation of $prod_{it} = prod\left(95^{th}\ percentile\right)_{t-1} - prod_{it-1} + \mathrm{X}_{ist} + \varepsilon_{ist}$ with $\left(prod\left(95^{th}\ percentile\right)_{t-1} - prod_{it-1}\right)$, company's distance to the productivity per employee frontier *i* in year *t*-1, X_{ist} fixed effects for year, sector, size or companies; ols for ordinary least squares and fe for company fixed effects; standard deviation in brackets; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM].
Source: authors' database from Fiben, Banque de France; balanced sample; authors' calculations.

C – Convergence of productivity per year over balanced sample

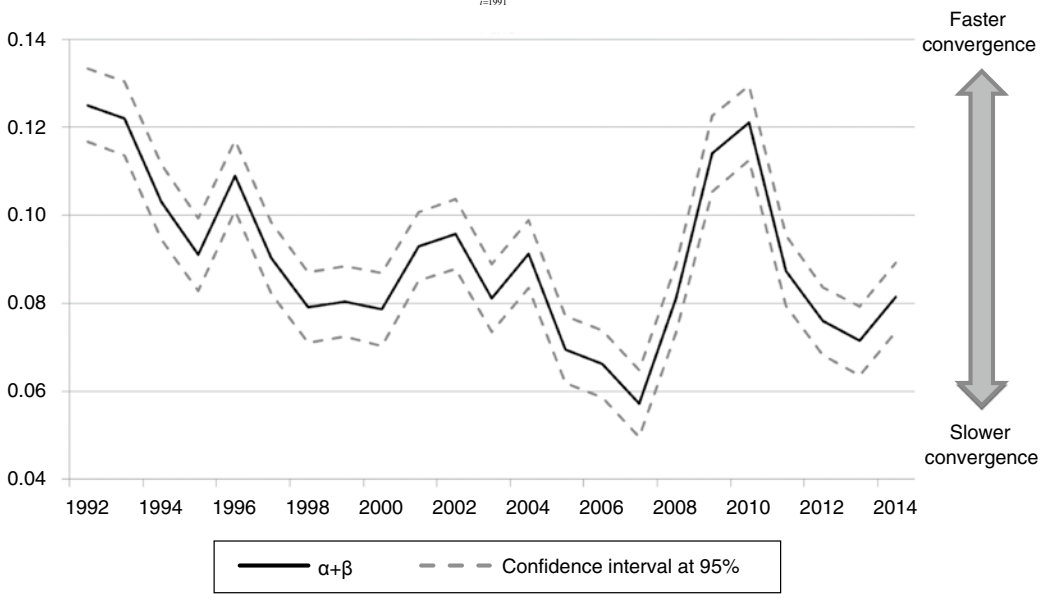
$\alpha+\beta_i$ – Convergence coefficients – TFP – balanced sample – OLS

$$\Delta tfp_{\alpha} = \alpha \cdot (tfp(95\%)_{\alpha-1} - tfp_{\alpha-1}) + \sum_{i=1991}^{2014} \beta_i D_i (tfp(95\%)_{i-1} - tfp_{i-1}) + D_s + D_t + D_{\alpha}$$



$\alpha+\beta_i$ – Convergence coefficients – Labour productivity balanced sample – OLS

$$\Delta lp_{\alpha} = \alpha \cdot (lp(95\%)_{\alpha-1} - lp_{\alpha-1}) + \sum_{i=1991}^{2014} \beta_i D_i (lp(95\%)_{i-1} - lp_{i-1}) + D_s + D_t + D_{\alpha}$$



Reading note: these two graphs present the sum of the coefficients $\alpha+\beta_i$ of equation (2). The higher these indicators, the greater the convergence; balanced sample from 1993 (TFP) and 1992 (labour productivity) to maintain a sufficient number of observations for the estimations.
Coverage: whole market economy except for the financial sector. Metropolitan France and Overseas Departments [*Départements d'outre mer* - DOM].
Source: authors' database from Fiben, Banque de France; balanced sample; authors' calculations.

Productivity slowdown and loss of allocative efficiency: A French disease?

Comment on the article "Stagnation of productivity in France: A legacy from the crisis or a structural slowdown?" by Gilbert Cette, Simon Corde and Rémy Lecat.

Flora Bellone*

Abstract – The article by Cette, Corde and Lecat presented in this special issue brings new stylised facts and a rich and fruitful discussion on the causes of the slowdown of productivity growth observed in France over the last decade. The facts established are solid. They back up the hypothesis that this slowdown is not a cyclical phenomenon, linked to the crisis of 2008, but is a structural phenomenon whose causes remain difficult to pin down. The authors put forward as a possible explanation the difficulties in reallocating resources between companies, linked notably to rigidities on labour markets and to regulations on goods markets. This comment aims to explain why the facts highlighted by Cette, Corte and Lecat are not sufficient to exclude other, alternative explanations which bring, in a more direct way, the shocks of globalisation and digitalisation into play. It draws conclusions from them in the perspective of future lines of research and recommendations of economic policy, in particular keeping aggregate productivity, not productivity at the frontier, as a target of policy action, and also considering, for each action, the risk of impoverishing reallocations.

JEL Classification: O47, F60, D61
Keywords: aggregate productivity, firms productivity, allocative efficiency, globalisation

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The article by Cette, Corde and Lecat addresses the difficult issue of the causes of the slowdown of productivity growth in France. To fully understand these causes, a correct and precise diagnostic still needs to be made. This is what the article aims to do by shedding a welcome light on two open questions: Firstly, to what extent is the slowdown of productivity growth in France linked to the crisis of 2008? Then, is this slowdown observed in every firm based in France or only in certain firms, or to a more aggregated level for all or some business sectors?

The article also presents a review of the alternative explanations of this downturn that can be found in the literature: the slowdown of technological progress, the phenomenon of divergence of productivity between companies linked to the unequal dissemination of digital technologies and/or to winner takes all phenomena associated with new technologies, the deterioration of the efficiency of resources allocation due to new rigidities on product markets and/or factor markets... The article attempts to distinguish between these different explanations and seems to take the side of one cause in particular: the worsening of the difficulties of resource allocation in France since the turn of the 2000s due to rigidities, notably on the labour market and the product markets. As a consequence of this diagnostic, the article pleads the case for ambitious structural reforms in order to facilitate the reallocations of resources towards the most productive sectors and firms in France.

The present comment begins with a summary of the main stylised facts established for France by Cette, Corde and Lecat. These facts are judged to be robust and don't really suffer criticism, the authors being experts and well aware of the inherent limits to the estimations of productivity on the macro or microeconomic data that they use. Where this comment departs from the conclusions drawn in the article is on the interpretation of the facts established and on the recommendations of economic policy made by the authors. Finally, as a conclusion, we discuss the possible complementary works that might be conducted in order to be able to more robustly identify any French specificities in the current dynamics of productivity and resource reallocation observable in the global economy.

The study by Cette, Corde and Lecat (2017)

The article by Cette, Corde and Lecat presents stylised facts on the dynamics of productivity in France over the long period, with particular attention to the breaks in trends that occurred over the recent period, from 2000 to 2014. These facts are established drawing on macroeconomic data, from Insee's national accounts, over the period 1976-2014, and microeconomic data, taken from the Banque de France's database Fiben (Fichier bancaire des entreprises – a file on banking companies) over the period 1989-2014.

The main stylised fact highlighted in this article is a significant slowdown of French firm's aggregate productivity growth and median productivity, not only from 2008 onwards but also since the start of the 2000s. This downturn therefore precedes the crisis of 2008 and appears as a structural phenomenon over the recent period. This stylised fact established for France goes in the same way as what is observed for other advanced economies over the same period.[1] Still in accordance with the facts established for other large economies, Cette, Corde and Lecat show that the slowdown affects all the categories of firm size and all the large business sectors of manufacturing and market services.

In relation to this literature, it is the way in which the microeconomic data are used, that we find particularly interesting because it introduces some simple but important methodological contributions, such as for example the systematic use of median values, rather than average values which are much more sensitive to outliers, for the measures of productivity based on company data. Likewise, the care given to data cleaning procedures is noteworthy. Finally, this study is the first, to our knowledge, to track, drawing on administrative microeconomic data, the distribution of the productivity of individual firms in France over such a long period, covering the crisis of 2008. This consistency in the series is one of the advantages of the *Fiben* base collated by Banque de France.

Beyond this general stylised fact, Cette, Corde and Lecat establish three other facts on which they base their critical analysis of the possible causes of the slowdown of productivity growth in France. These three additional stylised facts are as follows: first of all, the firms at the productivity frontier in France did not see a shift in

1. See Byrne, Fernald & Reinsdorf (2016); Gordon (2016); Syverson (2016) for the US, OECD (2015) and Cette et al. (2016) for other industrialised countries, mainly European.

productivity growth in the 2000s; then, the pattern of convergence of follower firms towards this frontier did not decline over the decade of 2000; finally, the dispersion of companies' productivity levels grew strongly in France over this same decade.

For Cette, Corde and Lecat, the first two facts argue against the technological explanations for the phenomenon. According to them, the stability of productivity growth at the frontier shows that the rhythm of technological progress did not change course in France. Moreover, the maintained dynamic of convergence of follower firms towards this frontier excludes the hypothesis of a phenomenon of polarisation. However, the increased dispersion of firms' productivity levels appears to them to be perfectly compatible with the hypothesis of a deterioration of the efficiency of resource allocation in France. Throughout this comment we will review, one by one, each of these results in order to evaluate their robustness, especially against possible alternative interpretations.

How should the dynamic of companies at the frontier be interpreted?

In their article, Cette, Corde and Lecat, the productivity frontier as the median value of the 5% most productive companies each year. It is this value that increases at a growing rate over the period, therefore not demonstrating the characteristic downturn of the median value of productivity for the full set of French firms. The question asked is whether this productivity frontier trend can indeed be interpreted as a proxy of the rhythm of technological progress in France. Our response to this question is much more circumspect than the affirmative one proposed in the study.

Firstly, it must be noted that this stylised fact is not robust to a change of the definition of the productivity frontier. An alternative way of defining the productivity frontier is in fact to consider a consistent group of firms having the highest level of productivity at a given date or over a given period, and then follow this consistent group of firms' trend. But, when Cette, Corde and Lecat carry out this exercise, they find that productivity growth notably slowed down for these companies over the same decade.

To explain this paradox, Cette, Corde and Lecat highlight the weak persistence of the firms that make up the frontier, with these firms remaining at the frontier for three years on average. This weak persistence is also a trait which appears in the previous study by Andrews et al (2015)[2] : based on the OECD ORBIS international company data over the period 2001-2009, that less than 15% of the firms identified as being at the frontier in a given year stay there for 4 years thereafter. How can this weak persistence of companies at the frontier be explained?[3] Does it reveal a change of technological regime implying more frequent changes of leadership? Or is it the sign of a weaker link between firms' productivity and their level of technology in the current era? One reason why the link between productivity and technology might have weakened over the recent period is that globalisation creates new opportunities for productivity gains but only for the companies able to join global business chains to their advantage.

So, the frontier firms could be firms which benefit not only (or not necessarily) from the best technologies but also (or rather) better industrial organisation opportunities, having a positive impact on their ability to find skilled workers or to source the most appropriate inputs or intermediary tasks. On a more sombre note, these high levels of productivity could also reveal better opportunities of access to less competitive markets, even opportunities to avoid corporation tax, labour legislation or environmental legislation in a situation where countries are in competition.[4] It is therefore important to further explore the hypothesis that the gains in productivity, which underpinned the dynamic of acceleration of the productivity frontier in France in the 2000s, were linked to company restructurings which engendered temporary gains rather than to technological progress which engendered more sustainable long-term gains.

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2. The study by Andrews et al. (2015) proposes the same type of empirical exercises as Cette, Corde and Lecat. It is conducted on international data taken from the ORBIS database of the Bureau Van Dijk, reprocessed by the OECD. Regarding the Fiben data, the OECD ORBIS data have the advantage of covering 23 OECD countries in a harmonised manner. They nevertheless have a certain number of disadvantages, such as the least reliable accounting information reported.

3. This fact contrasts with the stylised facts on the heterogeneity of companies initially established at the beginning of the 1990s In particular, Baily et al. (1992) revealed the strong persistence of companies' productivity on the longitudinal data from the Census Bureau covering the decades of 1970 and 1980. They showed in particular that about 50% of the American establishments in the first quintile of productivity still appeared in this quintile 5 years later.

4. It should be noted that the companies belonging to the frontier have a higher probability of being multinationals (Andrew et al., 2015). On the importance of industrial restructurings in the dynamics of productivity of the large groups and the complexity of the links between the productivity of these groups and the wealth of the countries, see Baldwin (2016) and OECD (2017).

How should the absence of divergence of follower firms be interpreted?

Cette, Corde and Lecat also explore the hypothesis of a divergence between low productivity firms and frontier firms in France but, this time, contrary to the study by Andrews et al (2015), they do not find, with the Fiben data, any support for this hypothesis over the recent period. Conversely, they find that the pattern of convergence of follower firms at the 5% frontier that did not slow down over the decade of 2000.

This result of convergence is difficult to interpret. Firstly, it seems counter-intuitive in that the overall downturn of productivity growth, on the one hand, and the acceleration of this same growth for firms at the frontier, on the other hand, should rather bring about divergence. Must we conclude that the slowdown of productivity growth was more pronounced for firms in the middle of the distribution than for those at the bottom of it? If this is the case, and if we also consider the high volatility of the firms at the frontier, is it then pertinent to interpret this result of convergence as a phenomenon of technological dissemination from leading firms towards followers? In all cases, the latest works conducted on the OECD ORBIS data rather back up the hypothesis of a polarisation of the distribution of productivity (and wages) between the most productive firms and the least productive firms in OECD countries (Berlingieri et al., 2017). Interestingly, this study also shows that sectoral indicators of the degree of international openness and of the degree of intensity in the use of digital technologies are positively correlated with this phenomenon of divergence.

How should the increased dispersion of productivity levels be interpreted?

An important stylised fact in Cette, Corde and Lecat's study is the observation of an increased dispersion of firms' productivity levels over the decade of 2000. This observation underpins the argument that the difficulties in allocating resources are an important cause of the slowdown of productivity growth in France. So, the study shows an increase of the interquartile and inter-decile dispersions of French companies' productivity distributions, which is very clear from 2000 to 2014 and increases over the last few years It is then argued that this observation is compatible with the hypothesis of a deterioration in the efficiency of resources allocation in France, over the same period.

Several questions nevertheless are worth being asked: firstly, to what extent can the dispersion of productivity be considered as a reliable indicator of allocative inefficiency? Then, to what extent can this trend be considered as a specifically French problem? Finally, what could be the causes of a recent deterioration of allocative efficiency in France?

The interpretation of the dispersion of firms' productivity levels as an indicator of economic efficiency may refer back to the framework of a general equilibrium model with heterogeneous companies and market distorsions (see in particular the Hsieh and Klenow's reference model, 2009).[5] If, however, we consider a richer theoretical framework, including technological shocks and/or shocks of international openness, the dispersion of productivity will be co-determined by these factors. In other words, in a world where globalisation and digitalisation are two serious candidates for the explanation of diverging trends of productivity levels between firms, it would be useful to explore the hypothesis of a deterioration of allocative efficiency due to market distorsions by controlling also the influence of these factors.

An alternative method to that of Hsieh and Klenow (2009) to quantify allocative inefficiency consists in mobilising decomposition techniques of productivity growth, following the work of Olley and Pakes (1996) or its dynamic extensions.[6] Applied on internationally comparable micro data, these methods allow the identification of gaps in allocative efficiency between industrialised countries. For example, Bartelsman et al. (2013) propose this type of analyses, on harmonised micro level data sets, in 5 countries including France and the US, over the period 1993 to 2001.[7] They show that Olley and Pakes's covariance term, which measures the link between firms' productivity and market share, is twice as high in the United

5. An illustrative model of this type is that of Hsieh and Klenow (2009) which serves as a reference in this literature. But, when it is applied to France, this model does not establish any substantial difference of allocative efficiency between this country and the US, with the two countries exhibiting very similar productivity dispersion values (Bellone & Mallen-Pisano, 2013).

6. See in particular Melitz and Povanec (2015).

7. For France, the data mobilised are Insee's data.

States than in France.[8] A study by Andrews and Cingano (2014) backs up this result on the OECD ORBIS data but nevertheless shows that France's degree of allocative efficiency remains much higher than the European average, and, notably, than that of the UK.

One of the most recent works, in line with this, is that of Decker et al. (2017) who shows that the loss of allocative efficiency also accounts for a large part of the decline of productivity growth in the US over the decade of 2000. For the authors, this decline reflects, above all, weak entrepreneurial dynamism. If we refer to this study, the deceleration of allocative efficiency might therefore not be a specifically French problem but a problem that might also be affecting economies with much more liberalised markets.

Finally, with regards to the causes of this allocative inefficiency, exploratory works are, for the moment, struggling to shed light on any pre-eminent factor. For example, the study by Andrews and Cingano (2014) based on the OECD ORBIS data show the levels of employment protection and product market regulation to be one of the causes of the differences in allocative efficiency between countries. But, as Cette, Corde and Lecat accurately point out, other studies further plead the case for the hypothesis of a deterioration of the allocation of capital. For example, Gamberoni et al. (2016), working on the CompNet microeconomic database of the European Central Bank, defend this hypothesis for European economies.[9]

The challenges in evaluating countries' "allocative efficiency" and issues of economic policy

In conclusion, the article by Cette, Corde and Lecat points out, with new stylised facts, the difficulties in resource allocation that could underpin the slowdown of productivity growth observed in France. This emphasis on structural change is welcome as it enlarges a debate that until now mainly confronted arguments relating to technology with arguments relating to measurement errors.[10]

Nevertheless, much work remains to be accomplished to both quantify the effects of allocative inefficiency and to understand its causes. Regarding quantification, international and inter-temporal comparisons must be expanded, but they raise many challenges concerning the comparability of microeconomic databases and the reliability of the methods.[11] Beyond these challenges, one may also wonder whether these works focus too much on issues of intra-sectoral allocations, and not enough on problems of inter-sectoral allocations. For example, MacMillan and Rodrik (2011) and Rodrik (2013) evoke a paradox in the dynamic of aggregate productivity of less advanced countries. While they all saw very high gains in productivity in each of their manufacturing sectors over the last 25 years, only a small number of these countries saw aggregate productivity grow substantially. They explain this paradox by the fact that the share of the manufacturing industry in these countries tended to decline despite the gains in productivity. Put otherwise in these countries, the sectors which see the greatest gains in productivity are, paradoxically, not those which attract the most employment. Such risks of "impoverishing" employment reallocations are to be considered in advanced economies too, to the extent that the jobs released from firms suffering a loss of competitiveness might not be automatically reallocated towards high value added companies in the same sector but instead towards lower value added firms in other sectors.

Then, with regards to research on the causes of the inefficiency, the reasons why the allocation of labor, or of capital, might have become more inefficient in France over the recent period should be discussed further. Why might these difficulties have gotten worse over the decade of 2000? And in particular, to what extent might they be truly specific to France, while we observe a similar trend in the United States?

8. According to Olley and Pakes's method (1996), a high covariance term conveys the fact that the most productive companies exhibit relatively large market shares, which demonstrates an efficient functioning of markets. These values are respectively 0.24 for France and 0.51 for the US. Interestingly, it should be noted that on the data mobilised by Bartelsman et al. (2013), the intra-industry dispersion of productivity is weaker in France than in the US (the standard deviation there is 0.22 against 0.38 for the US). This reveals, again, the limits of simple measures of dispersion in comparing countries' allocative efficiency.

9. See also the commentary on these results by Benoît Cœuré in his allocution entitled "Convergence matters for monetary policy" for the opening of the conference "Innovation, firm size, productivity and imbalances in the age of de-globalization" of the CompNet network which was held in Brussels on 30 June 2017 (available on the Europa site of the European Commission).

10. See Aghion et al. (2017) for a recent contribution to this debate.

11. To cite another example, Nishida et al. (2017) draw on a method developed by Petrin and Levinsohn (2012) in order to show that the reallocations of resources, and therefore the gains in terms of allocative efficiency, have greatly contributed to the aggregate productivity growth of a country like India while the traditional analyses, like those of Olley and Pakes, attribute the basis of aggregate productivity growth in this country to an effect of growth within companies.

Finally, one last line of research might aim to further explore the role of globalisation in the dynamics of productivity and of resource reallocation, observable in France and the other industrialised countries (Bellone & Chiappini, 2016). While the slowdown of productivity growth in these nations, or the dynamics of divergence between the most productive and the least productive firms are, at least in part, linked to the globalisation shock, it is to be feared that structural reforms alone only have a tiny impact on France's ability to escape this slowdown dynamic or to limit these phenomena of divergence.

In terms of economic policy, our analysis, like that of Cette, Corde and Lecat, leads to the recommendation of policy actions that aim to promote structural change in France. Two points of difference may nevertheless exist between our approach and what the authors might support. The first point of difference relates to the idea that productivity gains made by firms at the frontier could easily be disseminated to the whole economy, on the condition only that certain market rigidities be lifted. While, like the hypothesis we have made in our comment regarding them, these gains do not reflect (or not only) technological progress but rather (or also) industrial restructurings of companies which have taken advantage of globalisation, it is much less obvious that these gains are able to be disseminated to the whole economy. We believe, in all cases, that it is important that the government keeps aggregate productivity as the target in order to evaluate the benefits of its actions, without being tempted to substitute it for productivity at the frontier, since the dynamic of this frontier is not necessarily representative of growth potential for the country as a whole.

A second point of difference might concern the timing of actions. For our part, we recommend that the government first sets its priorities in terms of industrial strategies, including its choices under constraints in matters of ecological transition and international competitiveness, and then proceeds with its structural reforms with the aim of orientating the resources, capital and labour, towards the sectors and firms that meet these priorities. This vision of structural reforms is a pragmatic vision, far from a liberal vision whereby flexibility and free enterprise would alone be capable of leading France to revive a dynamic of strong and inclusive growth. In the current state of our open economies, such a *laissez-faire* policy might risk leading to more divergent trends rather than to the convergence hoped for. □

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Foreword – The crisis, ten years after: Lessons learnt for monetary and financial research

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Abstract – Ten years after the global and European financial crises, significant progress has been made both in financial and economic research to address the shortcomings of mainstream modelling frameworks used to inform monetary and financial policymaking. This article first reviews the progress made in the field of econometric modelling, namely more elaborated financial sectors, partial non-linearity, addressing the effective lower bound for interest rates, and dealing with heterogeneity across countries and economic agents. We then describe how such progress has helped assessing the impact of unconventional monetary policy and the interaction between monetary and prudential policies, also building on the extensive use of micro-data. We conclude that more research remains needed on the transmission of negative rates and their financial stability repercussions, and to understand better central bank communication (including forward guidance on monetary policy) by introducing elements of bounded rationality. Research remains also needed on building models with more heterogeneous agents, given the relevance of heterogeneity for the transmission of monetary policy and the rising importance of inequality in the broader policy discussion.

JEL Classification: E4, E5, G1, G2
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Introduction

Ten years after the beginning of the Great Financial Crisis, the repercussions of the economic and financial fallout are still being felt. Bold and unprecedented action by public authorities, accompanied by progress in the institutional and regulatory financial architecture, have, however, helped to reduce economic slack, to bring down record unemployment and to put the world economy and the euro area, at last, back on a path of solid economic expansion.

These successes would not have been possible without a considerable rethink of the interactions between the financial and real economy, the workings of unconventional monetary policy measures at, or close to, the effective lower bound, and the importance of sound regulatory and supervisory policies. The global and euro area crises exposed significant shortcomings in the mainstream modelling frameworks used at central banks to analyse and forecast economic and inflationary trends, in particular the absence of a financial sector as a possible source or amplifier of economic shocks (see Cœuré, 2012, for an earlier discussion of the post-crisis modelling agenda). Many models today feature a fully fledged banking sector that accounts for the presence of financial frictions and that also allows the effects of macroprudential policies to be analysed (that is, policies aimed at safeguarding the stability of the overall financial system). Similarly, the short-term interest rate that used to summarise the monetary policy stance in macroeconometric models needed to be replaced with a more elaborate exposition of the monetary transmission mechanism, including the role of public and private balance sheets. This allows the transmission channels of central bank asset purchase programmes and the effects of such measures on financial asset prices and the broader economy to be fully understood.

This foreword takes a central bank perspective on progress made in monetary and financial research, drawing in particular (but not only) on research undertaken at the European Central Bank (ECB). It does not touch upon all areas relevant to central bank policies. For example, debate is still raging among economists on the appropriate balance between fiscal stabilisation and fiscal sustainability in recessions (including on the size of fiscal multipliers), on the shortcomings of real and nominal adjustment mechanisms in Europe's economic and monetary union and on the design of more efficient risk-sharing arrangements. Another topic that has received considerable attention since the crisis is the causes of low inflation. Over the past few years, inflation has been persistently low across many developed countries despite a sizeable reduction in economic and labour market slack. This has brought back into the spotlight a discussion on the shape, specification and location of the Phillips-curve as well as on the role of broad financial conditions in stimulating economic growth and, ultimately, inflation: see Kuttner and Robinson (2010), Ball and Mazumder (2011), and the collection of articles edited by Ciccarelli and Osbat (2017). Notwithstanding their importance, these questions will not be addressed in this article.

The section 2 of this foreword reviews the advances in econometric modelling stimulated by the recent crisis, while section 3 discusses the analysis of the impact of non-standard monetary policy measures. Section 4 takes stock of the recent contributions made to the literature on the interactions between macroprudential and monetary policies, focusing on the euro area. Finally, the conclusions include suggestions for future research.

Challenges for Pre-crisis Macroeconometric Models

Before the outbreak of the Great Financial Crisis, the vast majority of models developed within national administrations, international organisations and central banks had increasingly been derived from first principles, with rational and forward-looking households and firms, building on the seminal contributions of Christiano et al. (2005) and Smets and Wouters (2007). The theoretical foundations of such dynamic stochastic general equilibrium (DSGE) models and their quantitative assessment offered policymakers an internally consistent framework for a structural interpretation of alternative monetary and fiscal policy scenarios. State-of-the-art macroeconometric models took into account nominal price and wage rigidities and real rigidities in consumption and investment, and incorporated a Taylor-type interest rate rule for the conduct of monetary policy. Most models featured a detailed fiscal sector and, in some cases, they took into account financially constrained households whose consumption was driven by their current income rather than by lifetime optimisation. Despite differences in the degree of micro-foundation, the estimation period and the country of reference, there was a significant convergence in international organisations and the global central banking community in the qualitative and quantitative assessment of the transmission of macroeconomic policies.[1]

The Great Financial Crisis and the ensuing Great Recession exposed several shortcomings of this modelling strategy (see, for instance, Lindé et al., 2016, and the MaRs Report, 2014). The most apparent limitation was the absence of a meaningful financial sector, which left models at a loss to explain the origins of the crisis and its consequences for the economy. Second, the prevailing models were built on a standard linear Gaussian set-up and were fine-tuned to analyse the impact of moderate shocks. The Great Financial Crisis was the most severe shock experienced by developed economies since the Great Depression and, as such, it represented a significant departure from the assumptions underlying these models. Third, models did not take into account the lower bound constraint on nominal interest rates, a constraint which started to bind just a few months after the beginning of the crisis. And, finally, the crisis brought to the forefront of the policy debate the importance of heterogeneity in the transmission of macroeconomic policies, both within and across economies.

Absence of a Financial Sector

Before the crisis, only a limited number of macroeconometric models used for policy purposes assigned a role to financial markets: among these, see in particular Christensen and Dib (2008), Christiano et al. (2004), and Dib et al. (2013). The crisis has revealed the relevance of the effects of financial shocks on the real economy and also the role of the financial system in propagating non-financial shocks. Del Negro et al. (2016), for example, show that DSGE models with financial frictions produce superior forecasts in periods of financial distress, although they do not perform as well in tranquil periods. In this respect, a prominent contribution is Christiano et al. (2014) who augment the standard monetary DSGE model to include a Bernanke-Gertler-Gilchrist financial accelerator mechanism

1. See, among others, the FRB-US and SIGMA models of the Federal Reserve Board, the NMCM, the NAWM and the EAGLE models of the European Central Bank, the GIMP of the IMF, the TOTEM model of the Bank of Canada, the QUEST model of the European Commission and the OECD fiscal of the Organisation for Economic Co-operation and Development.

and idiosyncratic uncertainty faced by entrepreneurs about the outcome of their capital investments. The authors document that, contrary to more standard financial shocks, such as equity shocks, allowing the volatility of such cross-sectional idiosyncratic uncertainty to fluctuate over time captures the procyclical nature of credit. Other relevant extensions to incorporate financial frictions in macro models of the euro area include Queijo von Heideken (2009) and Lombardo and McAdam (2012).

The crisis however made it clear that incorporating financial frictions without explicitly modelling financial intermediaries meant that the models were unable to generate the adverse feedback loops between the financial system and the real economy that had been a prominent characteristic of the crisis. Gerali et al. (2010) represent one of the first attempts to introduce a banking sector into a quantitative DSGE model of the euro area with financial frictions. They find that the banking sector not only exacerbates the propagation of supply shocks, but also that shocks originating there can explain the bulk of the decline in euro area GDP in 2008. In addition, the destruction of bank capital has severe implications for investment and economic activity. Building on Gerali et al. (2010), Darracq Pariès et al. (2011) develop and estimate a model for the euro area where some firms are financially constrained and can only borrow by using revenue and capital as collateral. Households, in turn, borrow using housing and part of their wage income as collateral. In addition, the model features a bank capital channel and regulatory constraints. The estimated model allows for a structural interpretation of the real-financial feedback loops that were set in motion by the euro area crisis and highlights the role of bank risk aversion in amplifying a rise in corporate risk. Dedola et al. (2013), building on the seminal paper by Gertler and Karadi (2013), consider financial frictions in the form of balance sheet constraints on financial intermediaries to study the international dimension of unconventional policies in open economies. They find that with financial integration, unconventional policies in one country also benefit other countries and help stabilise financial and credit conditions globally. Fahr et al. (2013) quantify the effects of ECB interventions in mitigating the fall in economic activity and in dampening downside risks to price stability.[2]

Non-linearity

While standard linear models had proved useful for both forecasting and scenario analysis in "normal times", they quickly became unreliable for assessing the impact of economic and financial events of extreme magnitude, such as the increase in systemic risk and in the risk of secular stagnation and of sovereign default, as also noted by Hamilton (2016). In particular, both the Great Financial Crisis and the euro area crisis showed that the propagation of financial shocks can take place in a highly non-linear fashion when financial markets freeze and asset prices spiral downwards due to fire sales (Brunnermeier & Pedersen, 2009; Caballero & Simsek, 2013). The work by Boissay et al. (2016) takes an important step towards modelling the endogenous build-up and unravelling of credit imbalances. In their model, a credit boom may arise in response to a sequence of favourable conditions that push efficient banks, which finance productive

2. Recent development of the ECB New Area Wide Model (NAWM) also aims to facilitate the analysis of the ECB's non-standard measures and especially asset purchases, in a coherent, structural, macroeconomic modelling framework.

projects to expand their corporate lending and amplify an economic boom.[3] Similarly, macroprudential research agendas initiated after the crisis, such as the ECB's MaRs project[4], also stressed the importance of including non-linearities and endogenous credit imbalances in macroeconomic models (see also Section 4). As documented by Hubrich and Tetlow (2015), among others, a non-linear framework is needed to properly assess the interaction of financial distress events with real economic activity, inflation and monetary policy.

The Effective Lower Bound

A large body of research has investigated the effects of economic policy when nominal policy rates are at their lower bound. Researchers generally find that the response of the economy to policy stimulus can be very different from in periods when nominal interest rates are expected to stay in positive territory (Christiano et al., 2011; Eggertsson, 2011; Woodford, 2011). Hence, the inclusion of an explicit effective lower bound on nominal interest rates, which effectively limits the ability of monetary policy to provide adequate stimulus to the economy using standard policy instruments, represents a key direction of development for models designed for forecasting and policy analysis. For example, Coenen and Warne (2014) use the ECB's New Area-Wide Model (NAWM; Christoffel et al., 2008) to analyse the evolution of the risks to price stability during the financial crisis. They show that the risk of deflation was amplified by the existence of the lower bound on nominal interest rates, which thus induced a noticeable downward bias in the risk balance, strengthening the case for unconventional policy measures to fill the resulting "policy gap" (Lindé et al., 2016; section 3 of this article; and Kilian & Manganelli, 2008, for a formal measure of the balance of risks). Constraints arising from the effective lower bound have been compounded by a parallel gradual fall in the natural rate of interest in most developed economies, pushing central banks' policy rates down further.[5]

Heterogeneity Across Countries and Economic Agents

A very active line of research has focused on the relevance of heterogeneity among economic agents for the analysis of economic dynamics (Krusell & Smith, 2006). Households may differ in their wealth but also in their patience (Carroll et al., 2015), employment status (Krusell et al., 2010) and productivity (Nakajima, 2012). Krueger et al. (2016), motivated by the US experience during the Great Recession of 2008-2009, show how wealth inequality can strongly amplify the effects of macroeconomic shocks. Using a DSGE model with household heterogeneity, Gornemann et al. (2016) conclude that "a monetary policy focused on unemployment stabilization helps "Main Street" by providing consumption insurance. It hurts "Wall Street" by reducing precautionary saving and, thus, asset prices."

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3. Specifically, a moral hazard problem between among banks in the interbank funding market lies at the root of financial recessions. As the economy slows, households start to save more and the interest rate declines, allowing also inefficient banks to borrow from the interbank market too. A crisis is triggered when the interest rate falls below a certain threshold and the share of inefficient banks borrowing in the interbank market becomes "too large". Since asymmetric information makes it difficult prevents to distinguish between good and bad banks, counterparty risk increases in the interbank market. As a result, the interbank market freezes, corporate credit collapses and the economy experiences a severe downturn.

4. The MaRs network was launched in spring 2010 by the European System of Central Banks, which consists of the 28 European Union (EU) national central banks and the ECB.

5. The natural rate of interest is the rate that is consistent with stable inflation and output (Wicksell, 1936), While it can be estimated in various different ways, there is broad agreement in the academic literature that it has declined over recent decades. Some estimates even suggest that the natural rate is currently negative in the euro area (Holston et al., 2016; Lemke & Vladou, 2016),

At a more aggregate level, the recent financial crisis also increased the need to understand how cross-country financial factors can affect macroeconomic performance. This is particularly important in a monetary union, such as the euro area, where heterogeneous cross-country conditions in financial markets and banking sectors have been a challenge for the single monetary policy. To address some of these issues, the ECB is currently developing a new multi-country macroeconometric model for the official projections of the five largest countries of the euro area (ECB-MC). The new model aims to provide a higher degree of granularity and a more explicit role for the financial sector, both of which are needed to achieve a more realistic modelling of the monetary policy transmission mechanism, beyond the standard channels.[6] It does not however take into account household heterogeneity. Indeed, the vast majority of models – for reasons of tractability – continue to rely on a representative agent approach, thus leaving out key interactions among heterogeneous markets and agents. Policy models face a significant trade-off between enlarging the coverage, in terms of heterogeneity of agents/sectors/countries, and tractability. As a result, the distributional implications of changes in policy often remain neglected or highly stylised in policy models, a significant shortcoming at a time when inequality features prominently on the policy agenda in advanced economies.

The ECB, together with Eurosystem national central banks, has addressed this shortcoming by collecting household-level data on wealth and the structure of household portfolios in the euro area in the context of the Household Finance and Consumption Survey (HFCS). Besides documenting stylised facts about household portfolios, the HFCS has also been a valuable source of information about how household heterogeneity can affect the monetary transmission mechanism and for the calibration of economic models. For example, a key variable determining the strength of monetary transmission across countries is the marginal propensity to consume out of income (MPC), which can vary substantially depending on household characteristics, such as wealth (Carroll et al., 2014). In addition, the HFCS data have been used to estimate which wealthy households may behave as if they were credit constrained because they have substantial, but illiquid assets, the "wealthy hand-to-mouth" (Kaplan et al., 2014). Heterogeneous Agent New Keynesian (HANK) models can include a fraction of "wealthy hand-to-mouth" (Kaplan et al., 2016). When accounting for household heterogeneity in terms of wealth and liquidity, the intertemporal channel of monetary transmission (through the substitution effect) becomes less important than the income channel (through a general equilibrium increase in labour demand). Other examples where household heterogeneity can be relevant for monetary policy include the prevalence and distribution of fixed and adjustable-rate mortgages, credit-constrained households and leveraged households.

Moreover, recently the HFCS has also been used to assess the distributional impact of monetary policy (Draghi, 2016). For example, the two waves of the survey conducted so far, in 2010 and 2013, allow an assessment to be made of how net financial income has shifted between different households as interest rates have fallen, at least partly as a result of the loosening in the monetary policy stance.[7] The results suggest that, for the euro area as a whole, although net

6. The development of a multi-country extension of the NAWM, named the Euro Area and Global Economy (EAGLE) model (Gomes et al., 2012), was also undertaken to tackle these issues. Bokan et al. (2016) document how the new financial and banking features of the EAGLE-FLI version of the model interact across countries and modify the transmission mechanism in the model.

7. In this period yields on two-year euro area benchmark bonds fell by 130 basis points and on ten-year bonds by 110 basis points.

financial income as a fraction of total household income fell slightly, the position of those households with the lowest net wealth remained unchanged (since their debt payments were higher than their financial income), while the wealthiest households lost the most.

Impact of Non-Standard Policy Measures

Faced with the effective lower bound on policy rates, major central banks such as the US Federal Reserve System, the Bank of Japan, the Bank of England and the ECB took unprecedented action to mitigate downward pressures on economic activity and inflation. Some of the unconventional measures, such as large-scale asset purchase programmes, were widely used to address the lower bound constraint, while others, such as negative rates, long-term refinancing operations and targeted lending programmes, or a broadening of the collateral eligible for pledging against central bank refinancing, were more country-specific. The use of these unconventional policy measures has prompted considerable research efforts to study the effects of these new policies on asset prices, economic activity, and ultimately inflation.[8]

Liquidity Provision

Early in the crisis the ECB granted full and unlimited access to central bank liquidity, at a fixed rate and against adequate collateral, and offered a variety of long-term refinancing operations to counterparties. Garcia-de-Andoain et al. (2016) identify two main effects of central bank liquidity provision on interbank markets. First, central bank liquidity replaced the supply of liquidity in the (then frozen) interbank market during the Great Financial Crisis (2008–2010). Second, it increased the supply of liquidity in the interbank market in stressed countries (Greece, Italy and Spain) during the sovereign debt crisis (2011–2013). Research also found that weakly capitalized banks borrowed more from the central bank using riskier collateral than strongly capitalized banks. Weakly capitalized banks, in turn, bought the bonds of their, often stressed, sovereign (Drechsler et al., 2016). While fully consistent with a central bank's role as a lender of last resort (LOLR) that insures against systemic liquidity risk, these finding points to potential adverse side-effects for financial stability and, consequently, the need for strict banking supervision to accompany the LOLR function.

The use of micro-data was central to understanding the transmission mechanism of the ECB's liquidity policies. For example, Gambacorta and Marques (2011) illustrate that bank-specific characteristics, such as the amount of short-term funding, securitisation activities, the proportion of fee-based revenues and the capital position, can affect shifts in loan supply. Similarly, Altunbas et al. (2017) relate the systemic dimension of banks' risk to certain characteristics observed prior to the 2007-2009 crisis, such as strong credit growth and increasing reliance on wholesale funding. Stronger reliance on wholesale funding made banks more vulnerable to interbank market freezes and, hence, more likely to tap central bank facilities. Using information on banks' lending rates and their bidding behaviour in the two series

8. Krishnamurty and Vissing-Jorgensen (2011), Gagnon et al. (2011) and D'Amico and King (2012), for the US, and Joyce, Lasaosa et al. (2011), for the UK, investigated the impact of unconventional policies on asset prices while Gertler and Karadi (2013) and Del Negro et al. (2015) study the impact of the policies on the US economy.

of targeted longer-term refinancing operations (TLTROs), ECB research (European Central Bank, 2016, box 3) shows that banks located in vulnerable countries that have participated in TLTROs have lowered their lending rates by more than non-participating banks. This has channeled the monetary stimulus to private-sector borrowers in the euro area who have been most in need of accommodation.

An alternative strategy to measuring the effects of liquidity policies, pioneered by Lenza, Pill and Reichlin (2010), makes use of standard vector autoregression (VAR) models. The analyses rely on different assumptions regarding how non-standard policy measures affect the real economy. They characterise the impact of the initial ECB liquidity policies through variations in money market spreads and the slope of the yield curve. Darracq Pariès and De Santis (2015), by contrast, study the ECB's three-year LTRO using the Bank Lending Survey (BLS). Ciccarelli et al. (2013), also using a VAR approach, document that the ECB's liquidity operations mitigated existing restrictions on private liquidity funding. All these studies point to positive macroeconomic effects of the non-standard measures adopted by the ECB in the first phase of the crisis. However, the results are affected by significant model and estimation uncertainty.

Asset Purchases

With the first Covered Bond Purchase Programme (CBPP), the ECB initiated a series of asset purchase programmes in 2009. Beirne et al. (2011) show that the CBPP was effective in pushing money market rates down and, more generally, easing the borrowing conditions of banks, firms and households, while, at the same time, improving liquidity in a segment of the financial market that saw spreads widening and liquidity deteriorating as the crisis progressed. During the most severe phase of the European sovereign debt crisis, the ECB supplemented the CBPP with the Securities Markets Programme (SMP) with a view to ensuring depth and liquidity in dysfunctional segments of the sovereign debt market. Several studies support the view that SMP purchases helped lower both yields and volatility, albeit sometimes only temporarily (Eser & Schwaab, 2016; Ghysels et al., 2017). Carpenter et al. (2014) find evidence that both the ECB's liquidity policies and the SMP eased money market conditions in the euro area, resulting in an overall increase in bank lending. In August 2012, the ECB announced the Outright Monetary Transactions Programme (OMT), aimed at addressing the risk of self-fulfilling spikes in sovereign bond yields due to a perceived risk of euro area break-up, unrelated to economic and fiscal fundamentals. The OMT announcement had an immediate and strong effect on government bond yields although the programme was never activated. The sharp fall in yields in peripheral Member States, and the parallel rise in safe-haven bond yields like those on German Bunds, in the aftermath of the OMT announcement, is mostly associated with a repricing of the risk of currency redenomination (De Santis, 2015). The overall reduction in interest rates was particularly significant for Italy and Spain. Results from a multi-country VAR show that lower interest rates had overall positive effects on activity and prices in those countries (Altavilla et al., 2016).

While asset purchase programmes of the ECB up to mid-2014 were by and large motivated by the emergence and prevalence of considerable frictions in financial markets, the decision to launch the Public Sector Purchase Programme (PSPP) in January 2015 was taken against the background of a protracted period of low

inflation and risks of a destabilisation of medium-term inflation expectations. Building on the seminal work by Vayanos and Vila (2009), whose framework of preferred-habitat investors creates scope for central bank asset purchases to affect asset prices, a growing body of the literature, using both event studies and time-series analysis, finds that the PSPP was effective in easing broad financial conditions and in stimulating the macroeconomy (Altavilla et al., 2015; Altavilla et al., 2016; Andrade et al., 2016; Blattner & Joyce, 2016).

Collateral Frameworks

One important channel of transmission of central bank policies operates via the use of collateral in financial markets. Collateral gives lenders the opportunity to receive some payment in case of borrower default. Collateral can also improve borrower incentives to repay a loan (see for example Boot et al., 1991) or signal borrower ability to repay as in Bester (1985). It may, however, also reduce lender incentives to monitor and screen borrowers (Rajan & Whinton, 1995) and create a false sense of security, while default risk remains, depending on the value of the assets used as collateral. Collateralised debt thus both lowers the information cost of borrowing and can become information-sensitive and create market instability in adverse states of the world, as pointed out by Gorton and Metrick (2012) and Holmström (2012; 2014).

Central banks change the mix of assets available for use by private market participants in two ways. First, through the collateral framework of their liquidity-providing operations, and second, through large-scale asset purchases, see e.g. Corradin et al. (2017). Changes in eligibility criteria and haircuts for collateral pledged in ECB refinancing operations impact the price of affected assets. Eligible assets, or asset with lower haircuts, are more valuable. For example, in conjunction with the move to the fixed-rate full-allotment regime, the ECB announced that it was possible to borrow against USD-denominated bonds subject to the requirement that the bonds are deposited in the European Economic Area. This change in the collateral framework increased the price of eligible USD bonds relative to ineligible but otherwise similar USD bonds (Corradin & Rodriguez-Moreno, 2016). A similar effect is found when comparing bonds issued by sovereign agencies to those issued by the sovereign itself. Because the former are subject to a higher haircut at the ECB than the latter, even though they have identical risk, their price in the market is lower. Also, an important effect of the ECB's asset purchases under the SMP was to stabilise the value of the targeted government bonds, increasing their liquidity power when used as collateral.

At the same time, research also suggests that central bank bond purchases can also have unintended side effects for the collateral use of targeted bonds. Bond purchases decrease bond supply and can therefore increase bond specialness – the scarcity premium for procuring a bond in the repo market. For instance, Corradin and Maddaloni (2017) examine the Italian government bond market during SMP purchases. On the other hand, Aggarwal et al. (2017) show that central bank purchases of lower-quality bonds can mitigate disruptions in short-term funding markets because they reduce the lending fees for which low-quality collateral can be upgraded to high-quality collateral, which is in high demand in the private market when there is stress in the financial system (as measured by

the Composite Indicator of Systemic Stress, CISS, see Holló et al., 2012). Good collateral assets are necessarily scarce and, hence, requiring collateral for financial transactions may lead to considerable distortions in the pricing of financial assets. For example, it may lead to volatility in secured markets and a decoupling of secured and unsecured bond prices when credit risk leads agents to hold more secured bonds (Heider & Hoerova, 2009). The main lesson from this strand of research is that collateralised lending can address moral hazard and asymmetric-information problems in financial markets, but can create its own financial stability issues, consistent with the findings of Holmström and Gorton and Metrick. This also echoes concerns expressed by regulators on risks in securities lending and repos (see e.g. Bank for International Settlements, 2015; Financial Stability Board, 2013).

Negative Interest Rates

Several central banks around the world (e.g. in Denmark, Switzerland, Sweden and Japan) have set negative interest rates as a measure to further stimulate economic activity, to empower other policy measures, such as asset purchases, or, in the case of small open economies, to stabilise their currencies. The ECB took that step for the first time in June 2014 and has since then set the rate it pays banks for their deposits at –0.4%. The breach of the zero-lower bound naturally raised the question of whether negative rates would be transmitted differently through financial markets and whether cash substitution effects would kick in.

This has led to a further refinement of the lower bound terminology. As Cœuré (2016) illustrated, the "physical lower bound" for nominal interest rates is determined by the materialisation of disintermediation risks, *i.e.* when the opportunity cost of holding money falls below the cost of holding assets with negative yields. The "economic lower bound", by contrast, is determined by a situation in which further rate cuts would either have no effect or would actually have adverse effects on aggregate economic activity. This might happen when bank profitability falls, *e.g.* through the impact on net interest margins or the reluctance of banks to charge negative rates on retail deposits (see Heider et al., 2017), so that capital generation *via* retained earnings is reduced and eventually lending is restricted due insufficient capital accumulation (see *e.g.* Bernanke & Reinhart, 2004), or the recent concept of a "reversal rate" by Brunnermeier and Koby (2017).

In addition, challenges for financial stability may arise if negative rates prompt banks to increase their exposure to lower quality credit portfolios and thus lead to excessive risk-taking by banks. This happens if banks are financing risky loans with negative net present value (Dell'Ariccia et al., 2014). Indeed, Heider et al. (2017) show that under negative policy rates banks with higher deposit ratios concentrate their lending on riskier firms in the market. However, possible adverse effects on financial stability are related to banks' business models and can be mitigated by more stringent prudential supervisory activity. Furthermore, the risk taking of high-deposit banks is concentrated in banks that have comparatively low equity holdings.

The exact magnitude of the effect of negative interest rates on aggregate bank profitability is uncertain, as the relevant policy counterfactual of a non-accommodative monetary policy is missing. Recent empirical evidence (International

Monetary Fund, 2017; Rostagno et al., 2016) shows, however, that the overall impact on bank profitability of negative interest rates is positive, in particular in the short term, as low and negative interest rates, as long as they are still above the economic lower bound, tend to induce an increase in asset prices and therefore higher collateral values (Carpenter et al., 2013; Demiralp et al., 2017). Moreover, through its general equilibrium effects, accommodative monetary policy has an overall positive impact on the financial position of borrowers. Recent research by Beck et al. (2013) shows, for instance, a negative relationship between economic growth and non-performing loans.

Constraints arising from the effective lower bound have also been alleviated by the introduction of *forward guidance*, *i.e.* communication by the central bank about its reaction function and its expectations about the future course of the economy (see Cœuré, 2017, for a discussion). Standard DSGE models tend to overestimate the impact of forward guidance on the economy, a phenomenon known as the "forward guidance puzzle" (Del Negro et al., 2015). Some explanations of the puzzle have been provided which depart from the rational expectation paradigm and assume bounded rationality making economic agents partially myopic (Gabaix, 2015; García-Schmidt & Woodford, 2015).

New Prudential Frameworks

The euro area crisis was characterised by the dynamics of the sovereign-bank nexus and mutually reinforcing contagion effects: rising sovereign default risks had negative effects on bank capital through, for example, higher funding costs and increasing liquidity and solvency risks, while bank solvency risks in turn amplified sovereign default risks through bail-out pressure (see *e.g.* Cooper and Nikolov, 2015, for a theoretical model and Alter & Beyer, 2014, for an empirical analysis). During the sovereign debt turmoil the market for high-quality collateral, mainly in the form of government bonds, became increasingly segmented along national borders. Domestic banks in fiscally stressed countries increased their holdings of domestic sovereign bonds considerably (Ongena et al., 2016; Colangelo et al. 2017). These findings have confirmed the need to break the doom loop between banks and sovereigns and to put in place homogeneous financial and regulatory rules (Colliard, 2015), and have thus vindicated the decision in 2012 to create a Single Supervisory Mechanism (SSM) for 19 euro area countries.

Policy Interaction, Transmission and Potential Conflicts between Monetary and Prudential Policies

With the setting up of the SSM in November 2014, the ECB has been tasked with two more policy functions, beyond the central bank's traditional monetary policy role, namely micro- and (together with national competent authorities) macroprudential policy. Microprudential policy ensures the soundness of individual financial institutions while macroprudential policy aimes at safeguarding the stability of the financial system as a whole (Hanson et al., 2011). The SSM was established on the basis of the principle of separation of monetary and prudential policy, and central bankers generally consider that sound banking and price stability are mutually reinforcing objectives (Cœuré, 2013). It is nevertheless useful for research to explore further the interaction of microprudential,

macroprudential and monetary policies. Beyer et al. (2017), for example, illustrate that in an economic environment characterised by low interest rates, low inflation and low economic growth, microprudential policy has a preference for tightening capital requirements in order to increase banks' resilience to adverse shocks. A preference for tighter capital requirements is reinforced by the literature on the "risk taking channel" of banks that shows that low profitability and lower interest rates provide incentives for banks to take on more risk by increasing maturity transformation and investing in riskier assets (see e.g. Dell'Ariccia et al., 2016; Maddaloni & Peydro, 2013).[9] In the short run, tighter micro-prudential policies may weight on bank lending and, to this extent, play a procyclical role. Macroprudential policy, in contrast, is clearly counter-cyclical, for example by releasing countercyclical capital buffers in order to mitigate contagion and spill-over effects. However, an accommodative monetary policy can mitigate the short-run costs of an increase in capital requirements, especially at the lower bound of interest rates (Mendicino et al., 2017; Beyer et al., 2017).

Impact Analyses of Prudential Policies

Significant research efforts have been devoted to developing general equilibrium models that help to shed light on the links between financial intermediation and the economy and, eventually, the channels of transmission of macroprudential policies. In the European System of Central Banks (ESCB), macroeconomic modelling efforts initiated under the macroprudential research network (MaRs) have led to the development of a (new) macroprudential framework for policy analysis. The 3D model of Clerc et al. (2015) is the result of a collective ESCB effort to design a decision-support tool for valuable feedback to policymakers on capital regulatory policy (MaRS Report, 2014; Clerc et al., 2015; Mendicino et al., 2016).Contrary to previous models, it includes default risk not only for non-financial firms and households but also for banks (hence "3D").[10] A distinctive feature of the model is that it provides a rationale for capital regulation as a welfare improving response to two types of distortions: limited liability of banks and bank funding cost externalities. Both distortions lead to excessive risk taking by banks. Capital requirements align private and social risk-taking incentives and can be beneficial for welfare.

A transmission channel that is of particular importance when analysing the impact of regulatory policy on bank behaviour is the bank capital channel (see Boivin *et al.*, 2010, and the discussion in Heider et al., 2017). There exists broad evidence that banks that are operating closer to capital constraints react more strongly, in terms of their lending supply, when they are exposed to changes in their capital (either a required increase in capital or expected loss of market value). The more banks are leveraged, the more sensitive is their loan supply reaction to tighter capital requirements. Empirical studies based on Italian and US data find that the impact of changes in monetary policy rates on poorly capitalised banks is significantly larger (Gambacorta & Mistrulli, 2004; Kishan & Opiela, 2006; Van den Heuvel, 2007; 2012). Maddaloni and Peydro (2013) provide further evidence

9. This might be even further exacerbated if banks face restrictions imposed by institutional or regulatory constraints that require the achievement of nominal targets for banks' returns.

10. The 3D model was recently operationalized to all SSM countries and it is now part of the macro-prudential toolkit of the ECB and the euro area macro-prudential policy authorities. The operationalization of the 3D model occurred under the Task Force on Operationalization of Macroprudential Research (OMRTF). The aim was to provide a common tool to all SSM countries for macro-prudential policy analysis. For further details, see OMRTF Report (2017) and Mendicino et al. (2016).

that euro area banks with a stronger capital position were able to ease lending conditions more during the crisis than banks with higher capital constraints.

Another different set of regulatory instruments are requirements for liquidity or liquidity buffers (see e.g. Bank for International Settlements, 2010, 2015) for detailed discussions and analyses). Micro- and macroprudential liquidity instruments, such as the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR), have a direct impact on banks' funding needs and composition. As a result, increasing funding costs might be passed on and transmitted to credit supply conditions. Empirical evidence for the euro area is, however, still scarce as these instruments are either only currently being phased in (LCR not fully until 2019) or will only be in place from 2018 onwards (NSFR) (see, however, the recent cost-benefit analysis of liquidity regulation by Hoerova et al., 2017). Evidence for the US suggests that more liquid and longer-term funded banks might respond less strongly to monetary policy actions (see, for example, Kashyap and Stein (2000) who report that monetary policy has a greater impact on banks with lower liquidity buffers).

To conclude, evidence suggests that coordination between microprudential and macroprudential policies is critical to assess the appropriate adjustment of capital and liquidity buffers according to the cycle (see e.g. Angelini et al., 2012). While there are valuable benefits to be gained from information-sharing between microprudential supervision and monetary policy making, the "separation principle" applied to these two functions ensures that the decision-making responsibilities of these two areas remain distinct.

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The Great Financial Crisis and the euro area crisis have profoundly challenged economic thinking and modelling and have led to a redirection of economic research both in academia and at central banks. This change in the direction of travel was needed to support policymakers in their effort to remain faithful to their mandate amid daunting and unprecedented challenges. New ways of thinking and innovative modelling approaches were required to design, calibrate and monitor the effects and effectiveness of non-standard measures, such as asset purchases, forward guidance, liquidity operations and negative interest rates. In particular, new macroeconomic models have been and are being developed that give more importance to financial markets and heterogeneity across countries, firms and households. The analysis of interlinked bank-level, firm-level and household-level data have supported this effort. Moreover, remarkable progress has been made in analysing prudential and regulatory policies and their interaction with monetary policies (in particular when employing non-standard measures).

This foreword suggests that research in both academia and in central banks is now arguably in a better position to support policymakers in their quest to fulfil their mandates than a few years ago. However, knowledge gaps remain. On the modelling side, with the likelihood of hitting the effective lower bound having increased noticeably on the back of the fall in real natural interest rates, more

efforts need to be undertaken to incorporate unconventional policy measures and non-linearity in the transmission of shocks into mainstream macroeconomic models. What might be unconventional today might well become conventional in the future. This requires, among other things, to complement the current dominant use of *ad-hoc* event studies, which fail to capture the persistence of central bank actions, to quantify the impact of such measures on both asset prices and the broader macroeconomy. Considerable knowledge gaps also remain with respect to the transmission of negative rates, and their financial stability repercussions, calling for a more explicit treatment of the role of bank profits in determining bank lending decisions and, ultimately, macroeconomic outcomes. Advances in this direction should also help improve further our understanding of how regulatory actions affect financial markets and banks in their intermediation capacity. Introducing elements of bounded rationality can help understand better the impact of central bank communication and in particular of forward guidance. Further progress is also warranted when it comes to incorporating nonlinearity in the transmission of shocks. Finally, given the relevance of heterogeneity for the transmission of monetary policy and the rising importance of inequality in the broader policy discussion, central banks need to understand better the distributional consequences of their measures. For this, we need models with more heterogeneous agents. A continuation of the current research efforts is therefore required.

With that in mind, theoretical and empirical models will continue to fulfil their role of clarifying the assumptions on which policy recommendations rest, allowing for general equilibrium analysis, and disciplining the policy making process (Cœuré, 2012). As General Eisenhower once said: *"In preparing for battle I have always found that plans are useless, but planning is indispensable"*. So, when preparing for the next crisis, we should be conscious that models will prove useless again at times, but that modelling will nevertheless remain indispensable. □

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Fiscal policy coordination in a monetary union at the zero lower bound

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Abstract – Following the 2008 Financial Crisis, Euro Area governments faced adverse economic environments: high ratios of public debt to GDP, depressed outputs and the prospect of monetary policy hitting the zero lower bound (ZLB). This article assesses to what extent the conduct of fiscal policy differs within a monetary union at the ZLB. Using a fiscal DSGE model with two regions (North and South) calibrated to replicate the conditions where, absent any additional shock, the Euro Area economy would have been stuck at the ZLB for three years starting in 2013, we show that cross-border spillovers from fiscal policy are substantially higher without monetary offset and increase with the extent of fiscal consolidation measures. Spillovers can amount up to half (resp. one sixth) of the domestic impact in the case of VAT-based (resp. spending-based) consolidations. Outside the ZLB, fiscal expansion in one region triggers monetary tightening which has negative effect in the whole union, and gives rise to gains from fiscal cooperation. At the ZLB however, national objectives tend to be closer and the coordinated policy is less consolidating. Moreover, cooperation encourages symmetric rather than asymmetric policies.

JEL Classification: E10, E61, E62, F45
Keywords: DSGE model, monetary union, ZLB, fiscal policy, coordination

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Following the large increases in public debts across the Euro Area after the 2008 financial crisis, the will to return to lower levels arose, either to reduce actual or perceived default risks that would drive the cost of public debts up, or to enhance future resilience and prepare for potential future shocks. However, fiscal consolidation tends to reduce economic activity in the short term, therefore creating a trade-off for governments between their willingness to reduce public debt levels and to foster the economy in the short term. Moreover, fiscal policy in one country of the Euro Area may affect the other countries, either positively or negatively, notably because of monetary policy reaction. The goal of this paper is to analyze how these spillovers are affected by the prospect of monetary policy becoming unresponsive to fiscal shocks (*i.e.* possibility of a Zero Lower Bound – ZLB hereafter – on interest rates). We use the Mélèze model developed at Insee (Campagne & Poissonnier, 2016a), a state-of-the-art Dynamic Stochastic General Equilibrium (DSGE) model with imperfect financial markets where only one asset is tradable, in a monetary union calibrated to distinguish two regions: a North region including Belgium, France, Germany and the Netherlands, and a South region including Greece, Ireland, Italy, Portugal and Spain. These two regions were characterized by different inflation, productivity and hence competitiveness paths in the decade preceding the crisis, and reached different levels of debt and output, which may lead to different incentives for fiscal policy. We consider two illustrative fiscal policy instruments, public spending and value-added tax, and only temporary shocks.

Our first contribution is methodological. In order to take into account the existence of two monetary policy regimes (constrained and unconstrained), we endogenize the possibility to reach or exit the ZLB and solve the model in a piecewise linear fashion following Guerrieri and Iacoviello (2015). In contrast with most previous analysis, we replicate the initial conditions faced by Euro Area governments when the monetary policy reached the ZLB at the end of 2012. We back out structural shocks that replicate observed dynamics in the two regions from 2004 to 2015, simulate the baseline dynamics of the economy with these shocks and define fiscal policy as a deviation from this baseline scenario, taking the form of a temporary spending or VAT shock expected to last three years from 2013Q1 to 2015Q4. Then we simulate paths along a grid of different shock sizes, with *ex ante* deficit reduction ranging from – 5% to + 5% of steady state GDP. We then define a policy objective function for each region assuming the goal of governance is to increase the output and reduce the deficit, with decreasing marginal gains. We calibrate this policy objective such that inaction is the optimal policy at the steady state. We take a close look at the coordinated fiscal optimum at the ZLB and compare it to the uncoordinated Nash equilibrium. We also define the sustainability of the coordinated fiscal optimum as follows: a coordinated optimum is deemed sustainable when both regions are better off than at the Nash equilibrium. Because its implementation crucially depends on the willingness of governments to cooperate, we explore under which conditions the coordinated optimum is sustainable.

Our second contribution is positive and shows that in a monetary union, spillover effects from fiscal policy are substantially higher at the margin when monetary policy is constrained by the ZLB than when it is not: while the literature usually finds effects on foreign output that amount to 5% to 10% of the domestic effect outside the ZLB, we find that those can reach 15% for spending-based consolidations, and 50% for VAT-based consolidations, when the monetary policy is constrained. Spillovers effects on economic activity of consolidation packages are also larger than those of stimulus packages, since a stimulus package will decrease the duration at the ZLB. The larger spillovers arising from VAT-based consolidations in case of ZLB reflect the fact that VAT hikes are less deflationary than public spending cuts, and have a stronger effect on the consolidating region's import demand.

Our third contribution is normative. We show, under the assumption that policy objectives are to increase activity and primary balance with decreasing returns, that the optimal coordinated policy is more expansionary at the zero-lower-bound, because fiscal multipliers are higher. We also show that larger spillovers mean that regional and union-wide objectives are closer and thus, coordination by external fiscal rules (such as the Stability and Growth Pact) is less necessary. Finally, in case of ZLB, we show that absent any default risk or financial constraint, that is if the central bank effectively acts as a lender of last resort, the optimal policy is somewhat similar in both regions. Indeed, because of large spillovers, stimulus in one region benefits it more than the other one, and thus, when both regions are depressed, decreasing gains from activity and primary balance imply that both regions should act in a similar way.

As a result, for our calibrated policy objectives, the optimal coordinated spending policy when monetary policy hit the zero lower bound in 2012 would have been to increase public spending by 0.3% of GDP in the North and to decrease it by ex-ante 0.3% of GDP in the South, which is close to the uncoordinated policy of increasing spending by ex-ante 1.3% of GDP in the North and by 0.3% in the South. Outside the ZLB, if monetary policy was not constrained, the optimal coordinated spending policy would result in strong consolidations with decreased spending of 2% of GDP both regions, which is very different from the uncoordinated policy of increasing spending by 0.8% of GDP in the North and no additional action in the South. Similar results are found for VAT-based policies. We find that in all cases, while not technically stable, the cooperative equilibrium is sustainable.

Literature

Our research question is part of a large body of literature on fiscal reforms, inter-regional spillovers and policy coordination. The effects of fiscal policies have been studied along three main lines: *(i)* sizes of fiscal multipliers, *(ii)* trade-offs between short-term and long-term benefits of fiscal policy, and *(iii)* externalities in a monetary union.

Regarding the first two axes, the effects of fiscal policies have been shown to be strongly dependent on the context (position in the business cycle, monetary policy stance, etc.), and on their content (productive/unproductive expenditures, tax composition, etc.). In a standard New Keynesian framework with independent monetary policy, the fiscal multiplier is typically lower than 1 (Coenen et al., 2012). Coenen et al. (2008), in a two-region DSGE model of the Euro Area and the United States, show that the effect on production of fiscal consolidation (defined as a decrease in the target value of public debt) is negative in the short run, regardless of its composition, while it can be positive or negative in the long run, depending on its composition and the variable of interest. Similarly, using a world economy model with six regions and two types of households –liquidity-constrained and overlapping generations households– Clinton et al. (2011) show that short-term pain can be mitigated if the consolidation is permanent and leads to a long-term reduction in distortionary taxes with respect to the baseline case. In a monetary union, Roeger and in't Veld (2010) also show that permanent consolidations lead to lower short-term costs, because the decrease in debt service costs in the long run has a strong positive effect on current expectations.

However, for strongly integrated economies, and beyond the domestic scope of fiscal policy, there may be sizable spillover effects on trading partners. Indeed, in a monetary union, fiscal policy not only affects the demand that is addressed to other union members and the real effective exchange rate, but also the union-wide interest rate (Farhi & Werning, 2016). Similarly, Erceg and Lindé (2013) study how currency union membership modifies the optimal composition of a fiscal consolidation package. They show that, at the domestic level, a tax-based fiscal consolidation may be preferable in the short run to a spending-based fiscal consolidation (defined as in Coenen et al., 2008), in contrast with the standard case of an open economy with independent monetary policy. This stems from the fact that cuts in public spending are more deflationary, and while independent monetary policy will mitigate their effects, a more distant central bank will react less, which increases their effect on output. They also find that the size of spillovers on foreign activity varies from 1/5th to 1/10th of the domestic impact on activity. This scale of spillovers is in line with in't Veld (2013) or Cwik and Wieland (2011), who also find external spillovers of 1/10th to 1/20th of the domestic impact for transitory consolidation programs in one Euro Area member on its trading partners, and corroborates our results outside the ZLB.

In addition, in't Veld (2013) shows that during a crisis, if the share of liquidity-constrained households is high and monetary policy is at the ZLB, spillover effects can be even larger: a Euro Area-wide fiscal consolidation nearly doubles the negative effect on any given region, compared to the case where that region is the only one consolidating. Conversely, Cwik and Wieland (2011) argue that the positive effect of the German stimulus plan on other Euro Area economies was offset by the negative effect of a real effective exchange rate appreciation vis-a-vis the rest of the world. Note that, as mentioned above, the stance of monetary policy, in particular if it is constrained by the zero-lower-bound, affects the fiscal multiplier (Christiano et al., 2011). More generally, and beyond the scope of the present paper, the conduct of fiscal policy (coordinated or uncoordinated) should take the whole economic environment into account.

Indeed, Annicchiarico et al. (2013) show for instance, in the specific case of Italy, that fiscal consolidation substantially reduced the benefits of business-friendly reforms after the financial crisis, in part because of the lack of independent monetary policy response to offset the effects of fiscal consolidation. Likewise, Furceri and Mourougane (2010) show that when taking into account the feedback effect of risk premium on government bonds in a monetary union without lender of last resort, short-term effects of stimulus packages are still positive, even more so for spending-based or wage tax-based policies.

All in all, these papers clearly posit the existence of spillovers in a monetary union. As such, those spillovers need to be taken into account when designing consolidation or stimulus programs. Our paper directly follows this literature and takes a broader normative approach to assess whether fiscal policies could have been better coordinated post crisis within the euro area.

Model

We use the Mélèze DSGE model, developed by Campagne and Poissonnier (2016a) on the basis of two standard models of the Euro Area (Smets & Wouters, 2003; Christiano et al., 2005). Designed to be as parsimonious as possible,[1] this model consists of two aggregate regions in a monetary union trading partially substitutable goods. In each region, firms and households interact on the goods, labor and capital markets. Both firms and households, as well as production factors are considered immobile across regions, but cross-border financial flows are allowed in the union and with a Rest-of-the-World.

Firms produce partially substitutable goods with a standard constant return to scale production function. Given our short-term –cyclical rather than structural– focus, total factor productivity (TFP) is exogenous and growing at the same pace in both regions. Price and wage stickiness "à-la-Calvo" (Calvo, 1983) allows for monetary policy to play a role in our model. To keep the labor market framework simple, there is no unemployment and labor only adjusts at the intensive margin.

In addition, following Gali et al. (2007), households are distinguished between "Ricardian" and "non-Ricardian". This distinction enables to replicate credible private consumption behaviors following fiscal policy shocks. Therefore, a fraction of households, Ricardian households, are financially unconstrained, hold financial assets (or debt) and own capital which they lend to firms in their region, whereas non-Ricardian households consume their full current income, and consequently do not hold any asset.

In each region, the government behaves according to a standard budget rule where public consumption ensures the convergence of the public debt to GDP ratio towards its steady state level. Moreover, it collects taxes on wages, consumption and investment, provides lump-sum transfers and borrows on financial markets. Public debt is traded across borders, and we assume that because of incomplete financial markets public debt is the only tradable asset.

The central bank sets the nominal interest rate common to both regions through a Taylor rule (Taylor, 1993), where it reacts to current consumer price inflation.[2] In simulations where we allow for the existence of a ZLB, the effective nominal rate on households' wealth cannot fall below a particular level, slightly above zero, to account for liquidity spreads. Financial frictions, in particular debt default and associated feedbacks on the yield curve, are voluntarily left out of the model, where we focus on the case where the central banks effectively act as a lender of last resort. However, to ensure the convergence of our open economy model, financial spreads proportional to the set of managed financial assets are introduced as in Schmitt-Grohe and Uribe (2003). Those spreads are calibrated to have a negligible impact on the model dynamic. The Rest-of-the-World, with which the currency union trades only in the form of assets, also obeys a budget rule to ensure convergence in the long-run.

Lastly, structural and policy shocks are introduced. Specific to each region, structural shocks hit preferences, productivity, labor supply and investment costs. Also, specific to each region, policy shocks hit public spending, public transfers, cost of public debt and net foreign assets. The union-wide policy shock is a monetary policy shock. In the estimating step of the model,

1. A specific focus on fiscal authorities is made below and a detailed outline of the complete model is provided in the Online Complement C1. Further robustness tests of both the calibration and the behavior of the model are presented in Campagne & Poissonnier (2016a) and Campagne & Poissonnier (2016b).

2. Including the output gap into the Taylor rule should reinforce our results as it will result in a stronger convergence of regional objectives at the ZLB (see below). In addition, absent official estimations of the Taylor rule, we choose to implement a rule consistent with the official mandate of inflation targeting.

measurement errors on public assets and inflation are introduced.

Fiscal Authorities

Tax rates on consumption and labor are deterministic and arbitrarily chosen by the government. This choice is consistent with a low variability of apparent tax rates in the data over the calibration period. In the absence of public production or employment in the present model, all dimensions of public expenditures are encompassed through public consumption, which endogenously reacts to economic developments. A noteworthy assumption is that public consumption is fully domestic. In addition, public investment (defined as public expenditures increasing public capital stock) is not considered as an instrument of fiscal policy in the model. We discuss the impact of this simplification in further details in section V.

Lastly, government behavior is modeled through a budget rule inspired on Corsetti et al. (2010). This rule is such that each regional government follows a convergence criterion derived from the Stability and Growth Pact. It adjusts its public expenditures in order to achieve convergence of its debt to GDP ratio to its target –here the pre-crisis (steady state) debt level to GDP– at an average yearly rate of convergence ρ_g of 1/20th of the previous period's deviation from the target ratio.

$$G_t^i - \overline{G}^i = \rho_g \left(pa_{t-1}^i - \overline{pa}^i \right)$$

where G_t^i denotes the level of public expenditures in region i and $pa_t^i = PA_t^i / P_t^i \overline{Y}^i$ the public debt to GDP ratio. $\overline{G}$ and $\overline{pa}$ denotes the steady state level of each variable.

All in all, the government is budget constrained by:

$$PA_t^i = \left(R_{t-1} - \psi^g \left(\frac{PA_{t-1}^i}{P_{t-1}^i \overline{Y}^i} \right) \right) PA_{t-1}^i + \upsilon_t^{c,i} CPI_t^i \left(C_t^i + I_t^i \right) + \upsilon_t^{w,i} W_t^i L_t^i - P_t^i G_t^i - \Phi_t^i$$

where PA_t^i denotes the nominal public assets of region i at the end of period t. The budget balance includes proceeds from value-added tax (υ^c) levied on private consumption and investment valued at consumer prices $CPI_t^i \left(C_t^i + I_t^i \right)$, and from labor tax ($\upsilon^w$) levied on the wage bill $W_t^i L_t^i$. Public consumption is denoted G_t, and Φ_t^i nominal transfers to households. In addition, R_t denotes the gross nominal interest paid on financial assets reduced/augmented by negligible transaction spreads $\psi^g \left(\frac{PA_{t-1}^i}{P_{t-1}^i \overline{Y}^i} \right)$.

Calibration

Structural and non-structural parameters

The model is calibrated to distinguish two regions within the Euro Area and match their pre-crisis situation: a *North* region including Belgium, Germany, France and the Netherlands, facing a *South* region comprising Ireland, Greece, Spain, Italy and Portugal. Northern countries are those with lower inflation and thus higher competitiveness gains before the crisis, while the cut-off point was decided as to make the two regions of similar size (in terms of population). This criterion follows a core-periphery approach and reflects the idea that observed differences in pre-crisis competitiveness might partially explain the differences in post-crisis responses with larger increase in public debts in countries such as Italy and Spain compared to Germany and the Netherlands.

The calibration is constructed to stay close to the traditional DSGE literature and to Eurostat's National Accounting data following a methodology similar to Campagne and Poissonnier (2016a).[3] It follows a two-step approach. First, "deep" structural parameters are calibrated based on an extensive literature review, and median values are selected within the range identified in the literature. As far as possible, region-specific data are used to construct adequate aggregate parameter values for each region. Unfortunately, the lack of cross-region analyses crucially limits our ability to tailor region-specific calibrations, and a large number of parameters were calibrated according to values identified in the EU empirical literature. Moreover, even region-specific parameters tend to have identical values, after aggregation of country-specific figures within each region (for instance, the degree of substitutability between goods). In a second step, remaining parameters are estimated by first order moment matching of observed data for a large number of endogenous variables (reverse inference) and subjected

3. *The methodology is presented in more details in the Appendix 1.*

to the steady state constraints.[4] Tables 1 and 2 present the values for the structural parameters and the main endogenous steady state variables. Parameters for inflation, TFP growth and technology are imposed to be equal across regions even if data suggests otherwise. As explained in Campagne and Poissonnier (2016a), these restrictions are necessary for the mathematical existence of a steady state solution.[5]

As for the fiscal policy block, the government follows a budget rule and hence targets a public debt to GDP ratio calibrated on National Accounting data.[6] We follow a calibration process similar to Coenen et al. (2008) for the calibration of NAWM (New Area-Wide Model of the Euro Area). Tax rates are calibrated using the implicit tax rates by economic function computed by Eurostat. Transfers (Φ^i) are used to clear the government budget constraints in the reverse inference process allowing to target the share of public consumption in GDP.

We also assume that public bonds are considered safe by all agents. This assumption seems reasonable to us since as we simulate the effect of fiscal policy starting in 2013, and we argue that from December 2012[7] the European Central Bank was perceived to act as a lender of last resort, and the importance of default risks' mechanisms for the conduct of fiscal policy was mitigated.

Note that in the long run our model represents a closed monetary union and the choice of a public debt to GDP target implies that the sum of public debts of governments are equal to that of the private assets of households. Whereas the net foreign asset position of the North region vis-a-vis the Rest-of-the-World (including the rest of the Euro Area) is only 1% of GDP in 2007, and can therefore be neglected, the South net foreign debt of 53% of GDP. In the model, this large net external debt is arbitrarily attributed within our regions, and the private assets to GDP ratios will not reflect actual data. In practice, the first order moment matching process suggests a solution where most of this external debt is assumed to be owed by South households.

Baseline shocks

The Euro Area reached the ZLB at the end of 2012, when the Euribor rate fell below 25 basis points. We argue that fiscal shocks starting in 2013 may have had different effects on regional outputs, that in turn affected the optimal behavior of regional governments.

Using Eurostat quarterly data on consumption, investment, output, public debt, inflation and interest rate, we estimate standard deviations and persistence of the following shocks from 2004 to 2012: monetary policy, productivity, preference, labor supply, investment cost, public spending and transfers, external assets and financial spreads, conditionally on the linearized model.[8] We back out the corresponding structural shocks, extending the period to the end of 2015. Finally, we use a piecewise-linear model with two monetary policy regimes following Guerrieri and Iacoviello (2015), which we calibrate using parameters estimated on the linearized model and simulate trajectories with the estimated structural shocks. This approximation allows us to use a linear filter from 2012 to 2015, much simpler for a model of this size. Trajectories in the baseline scenario obtained using the linearized or the piecewise-linear model are very similar.

Following this procedure, Table A2-1 in Appendix 2 shows a measure of fit for each variable, as well as the dependency of the estimation to the calibration of crucial deep parameters like the share of non-Ricardian households, the elasticities of substitution across goods and across labor inputs. The best fit is obtained with the calibration presented in Table 2.

Underlying structural shocks, their estimated persistences and standard deviations are detailed in Table A2-2 and Figure A2-I in Appendix 2. The financial crisis impact is best characterized by a persistent and large (four standard deviations) exogenous shock on investment costs, by successive and persistent and moderate shocks on productivity (half a standard deviation),

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4. Campagne and Poissonnier (2016a, 2016b) compare the simulations derived using this calibration procedure with standard DSGE models for standard transitory and/or permanent shocks. Results are in line with simulations presented in the extensive DSGE review in Coenen et al. (2012), as well as with the Insee-based macroeconometric model Mésange (Klein & Simon, 2010).

5. If TFP growth was systematically higher in one region, it would have an infinite relative size at steady-state.

6. This debt to GDP ratio corresponds to public asset net of liabilities as a share of GDP and consequently differs from the debt in the sense of Maastricht relevant in the Stability and Growth Pact framework. However, the difference has no impact on the analysis later developed in the paper.

7. Thanks to the now famous "Whatever it takes" ECB President's speech in July 2012.

8. Although, the number of estimated parameters could be deemed as small, we show in Appendix 2 that the estimated values are robust to a number of different calibrations of other parameters. In addition, the purpose of the paper is to compute the value of shocks that brought the euro area to the ZLB at the end of 2012, and other parameters are calibrated to remain close to standard euro area DSGE models.

successive and very persistent shocks on labor supply, and a very persistent and large shock on public spending. Monetary policy is considered somewhat neutral compared to the Taylor rule, over the period, despite the very low euro-wide nominal rate.

Figure I shows the trajectory under the shocks previously estimated, as well as the point at which the model enters the ZLB, denoted by the vertical line. Under that baseline scenario, output is depressed, relative to its pre-crisis trend, in both regions, as well as investment, consumption and hours worked. Public deficits are higher than their long-run average, especially in the South. Capital returns and interest rates are expected to stay low for long time.

This "baseline scenario" constitutes the central path of our simulations, around which the impact of additional fiscal shocks will be assessed, the question here being: in hindsight, knowing that the euro area economy would be stuck at the ZLB for at least three years starting from 2013, what would have been the impact of more stimulus or more fiscal consolidation?

Fiscal multipliers

The channels through which fiscal policy in one region (region A) affect output in the other region (region B) are external domestic demand, monetary policy and competitiveness (see Diagram). A stimulus package directly boosts domestic demand, with a positive effect on the output of the domestic economy (region A). It also tends to have inflationary effects in the domestic economy, which may be offset

Table 1
Observed and simulated data at steady state

in % if not specified elsewise	Data		Meleze	
	North	South	North	South
Output (GDP in billion euros)	1,354	778	1,354	778
Output per capita average growth rate(1)	2.3	1.3	1.9	1.9
Workin population (millions)	76.3	55.1	76.3	55.1
Total hours worked per week (thousands)	2,765	2,132	2,765	2,132
Gross Op. Surplus (in VA)	44.8	51.8	42.9	42.9
Gross wages (in VA)	54.2	46.7	42.5	42.5
Profit rate	-	-	14.6	14.6
Nominal 3 month Euribor(1)	3.2	3.2	3.2	3.2
Expected CPI-Inflation(1)	1.5	2.5	1.5	1.5
Private consumption (in GDP)	53.6	58.4	50.0	54.1
Public consumption (in GDP)	20.1	18.6	19.9	18.7
Investment (in GDP)	21.6	25.5	29.7	27.8
Trade balance (in GDP)	3.9	- 2.9	- 0.1	0.1
Imports from euro area partner(2)	4.6	7.7	5.8	9.5
PPP (GDP, normalized to 1 in the North)	1.00	1.06	1.00	1.06
Gross consolidated general government debt (in GDP) (1)	- 62.0	- 80.0	- 62.0	- 80.1
Private assets including firms (S1 excl. S13,) (1)	40.0	5.0	107	5.6
Net financial position (S2) (1)	1.0	- 53.0	32	- 52.0
Implicit tax rate on consumption	20.6	17.5	20.6	17.5
Implicit tax rate on gross labor revenues	38.5	37.0	38.5	37.0
Implicit tax rate on capital revenues	26.9	34.5	25.2	36.3
Transfers (in GDP)	15.7	14.1	28.5	31.2

Note: North is Belgium, Germany, France and the Netherlands, South is Greece, Ireland, Italy, Spain and Portugal. S1 correspond to the whole domestic economy, S2 to the rest of the world and S13 to the public sector.
(1) indicates annualized data; (2) is measured as the share of imports from EU partners in private consumption.
Sources: Eurostat, 2007 (ANA, inflation, Purchasing Power Parity (PPP), employment, Labor Force Survey), ECB average 2000-2007 (Euribor) and Eurostat, average 2000-2010 (CPI-inflation). Authors' computations and simulations with the Meleze model for the Meleze column.

by the central bank which sets a higher interest rate. This hike will decrease aggregate demand in both the domestic and foreign economies (resp. region A and region B) and lead to negative spillovers. On the other hand, the resulting inflation differential, coupled with fixed nominal exchange rates, increases foreign competitiveness and in turn foreign exports.

Table 2
Key structural parameters calibration

		North	South	
Union-wide				
Technology parameter	α	0.498		ANA
Depreciation rate	δ	0.016		D'Auria et al. (2009)
Capital rigidity	S	5.63		Smets & Wouters (2002)
Population size	$\mathbb{N}$	131 417 000		ANA
TFP growth rate*	g	1.9 %		ANA
Financial intermediation spread	ψ^g, ψ	0.005 %		Authors' computations
Monetary policy				
Smoothing parameter	ρ	0.9		Ratto et al. (2009)
Weight on inflation	r_π	1.68		Smets & Wouters (2003)
Regional specific				
Population share	n^i	0.58	0.42	ANA
Trade openness	α^i	5.8%	9.5%	ANA, authors' computations
Substitutability between goods	θ^i	6.85	6.84	D'Auria et al. (2009)
Substitutability between workers	θ_w^i	4.44 EZC	4.44 EZC	Bayoumi et al. (2004)
Households adjusted discount factor	$\widetilde{\beta}^i$	0.996	0.996	Authors' computations
Inverse risk aversion	σ_c^i	1.49 EZC	1.49 EZC	Smets & Wouters (2002, 2003)
Inverse Frisch elasticity	σ_l^i	1.69 EZC	1.69 EZC	Roeger et al. (2010)
Consumption habits	h_c^i	0.66 EZC	0.66 EZC	Roeger et al. (2010)
Share of non-Ricardian agents	μ^i	0.31 EZC	0.31 EZC	Roeger et al. (2010)
Price rigidity	ξ^i	0.88 EZC	0.88 EZC	Coenen et al. (2008)
Wage rigidity	ξ_w^i	0.66 EZC	0.66 EZC	Eggertsson et al. (2014)
Price indexation	γ_p^i	0.7 EZC	0.7 EZC	Authors' computations
Wage indexation	γ_w^i	0.8 EZC	0.8 EZC	Authors' computations
Fiscal policy				
Budget rule sensitivity	ρ_g	0.012	0.012	Authors' computations
Tax rate on consumption	$\overline{\nu}^{c,i}$	20.6%	17.5%	Eurostat (implicit tax rate)
Tax rate on net wages	$\overline{\nu}^{w,i}$	62.5%	58.7%	Eurostat (implicit tax rate)
Tax rate on capital revenues	$\overline{\nu}^{k,i}$	18.5%	25.7%	Eurostat (implicit tax rate)
Transfers to GDP ratio	$\overline{\Phi}^i$	27.8%	31.3%	Authors' computations
Government's objective (see section 6)				
Preference for spending-based consolidation	λ_g^i	0.34	0.37	Authors' computations
Preference for VAT-based consolidation	λ_c^i	0.47	0.48	Authors' computations
Output smoothing	σ_y	1	1	Authors' assumption
Deficit smoothing	σ_{pb}	5	5	Authors' assumption

Note: ANA stands for Annual National Accounting data from Eurostat in 2007. Author's computations correspond to values determined by inverse inference as explained in the text. Papers cited for calibration are given as an example of a paper close to the median of our literature review. EZC stands for euro area Calibration and corresponds to parameters calibrated on euro area data in the absence of adequate region-specific information. North represents Belgium, Germany, France and the Netherlands, whereas South includes Greece, Ireland, Italy, Spain and Portugal. Parameters name are those in Campagne and Poissonnier (2016).

The positive effect on domestic demand (region A) also increases foreign exports, leading to positive spillovers. The net effect on foreign output is negative when the inflationary effect of fiscal policy and of the subsequent monetary contraction dominates its effect on domestic import demand.

Figures II and III display the impact and cumulative marginal multipliers of spending-based and VAT-based temporary[9] fiscal consolidations of different sizes on domestic and foreign output, under the two cases, as deviations around the baseline scenario outlined above. As detailed in Campagne and Poissonnier (2016b) for the purely linear case, those multipliers compare with those obtained in most institutional DSGE models as well as with macroeconometric models.[10]

First, as expected, in the case of stimulus packages big enough to immediately lift the Euro Area out of the ZLB, the marginal effect of the last unit spent or raised is constant. In the case of spending shocks, the impact multiplier is around 1.1 while the 3-years average multiplier is comprised between 0.4 and 0.5. The effect on foreign output, yet relatively small, goes opposite to domestic consolidation or expansion in the short and medium run reflecting that, with our calibrations and our assumption that public consumption is entirely domestic, the monetary offset effect is higher than the external demand effect: if the North implements a spending-based deficit reduction outside the ZLB, the subsequent decrease in the interest rate by the central bank dominates and favors activity in the South.

In the case of VAT shocks outside the ZLB, impact and cumulative multipliers are similar and around 0.5 at impact. Spillovers on foreign output (region B) go in the same direction as Northern output (region A) and are negligible on impact. This results from the fact that VAT increases are less deflationary than spending cuts, and also that their effect on consumption has a bigger impact on external demand, both tending to correlate the domestic and the foreign effect. However, over three years, spillovers are weaker than for public spending cuts and even slightly negative.

Second, at the ZLB, the marginal effect of fiscal policy on domestic as well as foreign output changes. Spending cuts tend to have an increasing negative effect on the domestic output and a negative and increasing effect on the foreign output. In the case of VAT shocks, the effect is even stronger.

Figures A3-I and A3-II in Appendix 3 show that the spillovers, *i.e.* the marginal multiplier on foreign output (region B) relative to the marginal multiplier on domestic output (region A), increase significantly with the size of the consolidation package, a conclusion that is robust to several calibrations. In particular, the marginal effect of big VAT-based consolidation in the North on the South's output is between 20% and 50% of the domestic effect, compared to only – 20% in the linear case. Cooperative governments will take this externality into account.

As mentioned earlier, those public spending multipliers rely on the simplifying assumption that public consumption gathers the whole public spending while in the current context of low TFP growth in the euro area, international institutions advise changes in the composition of public spending in order to favor public investment and support potential growth. In the long run, public investment shocks are indeed expected to have higher multipliers than public consumption.

However, in the short run, fiscal multipliers tend to be close (Coenen et al., 2012) and the productivity boost of public investment with respect to public consumption materializes slowly (around five years in Abiad et al. (2015) or using the European Commission Quest III model). The present paper focusing on short-lived and transitory fiscal behaviors, we can expect to obtain similar results with public investment over the short and medium term, as transmissions channels would not differ significantly. In particular, our model remains focused on business cycles and does not include endogenous growth mechanisms that would allow higher long-term fiscal multipliers of public investment.

Policy coordination

Policy objective

Regional governments are expected to obey a simple budget rule linking current public consumption to past level of public debt, with the sole objective to stabilize the debt-to-GDP ratio around its steady-state level. However, the realism of such a rule might be questioned when large shocks occur. Following the 2008 crisis,

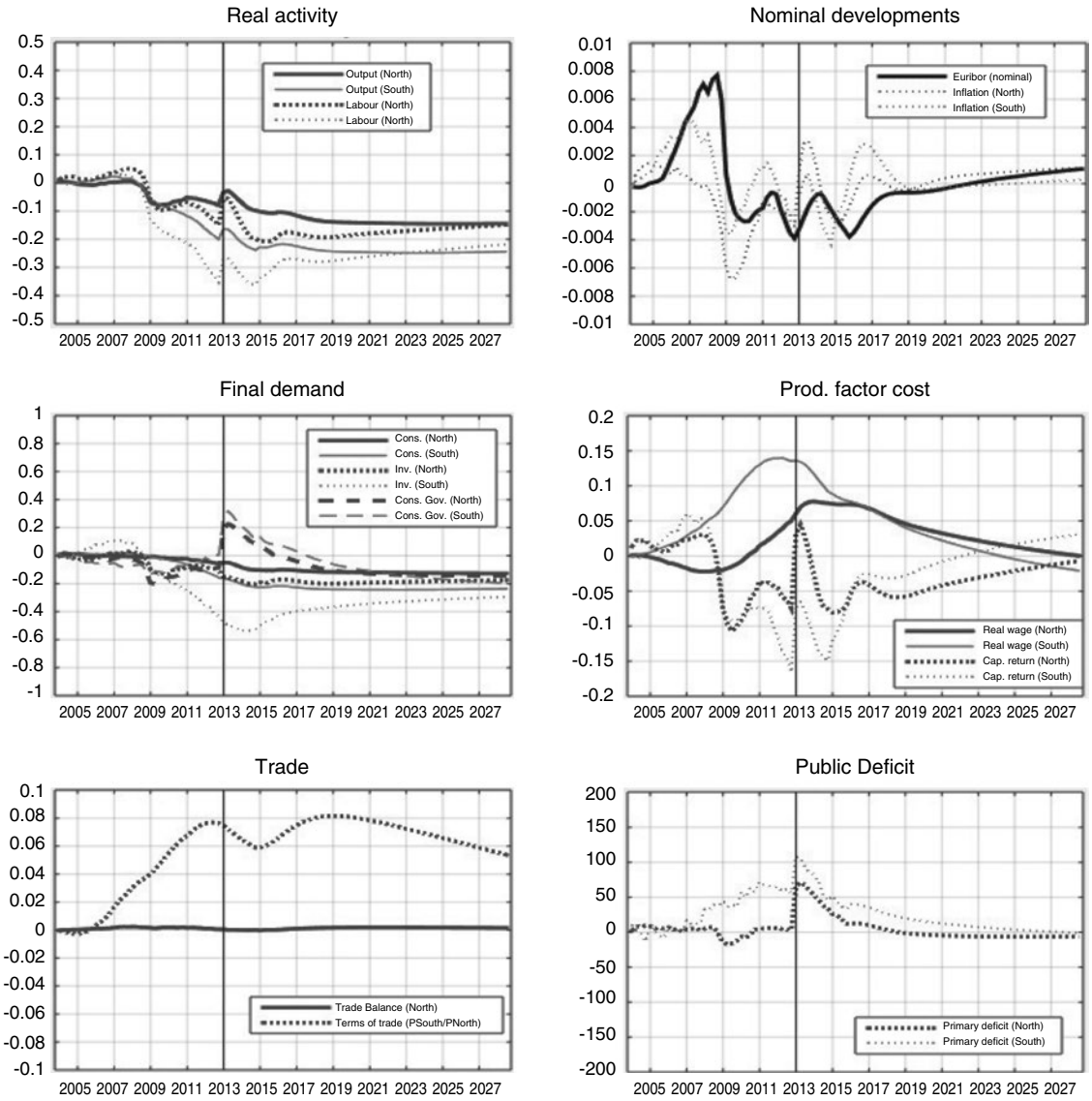
9. with an average duration of twelve quarters.
10. See Coenen et al. (2012) for a thorough comparison of fiscal multipliers across IMF, OCDE, and central banks' DSGE models, and Klein and Simon (2010) for the French macroeconometric model Mésange.

governments in the euro area implemented successive additional fiscal plans. This suggests that, given their national preferences and the global environment, governments may choose to foster activity at the cost of debt convergence or, on the contrary, to achieve a faster debt convergence at the expense of activity.

Our goal is to analyze how governments in each region could have decided to accelerate or reduce the pace of debt convergence by implementing additional fiscal policies when the ZLB was reached. For illustrative and simplification purposes, we consider that fiscal policies take the form of a temporary public consumption or VAT shock, starting in 2013. Shocks follow an auto-regressive process with a persistence calibrated as to amount to an average duration of twelve quarters.

In order to model governments' behaviors, we focus on a policy approach based on the

Figure I
Baseline scenario



Note: North represents Belgium, Germany, France and the Netherlands, whereas South includes Greece, Ireland, Italy, Spain and Portugal. The trajectories correspond to the simulation around the steady state using estimated structural shocks. Y-axes are in % deviations from the steady state.
Reading note: at the beginning of 2013, activity declined by 0.2% in the South region with respect to its steady state value, whereas public consumption increased by 0.2%.
Source: Authors' computations. Simulations with the Meleze model.

definition of an objective function for the government weighting its preference for deficit reduction against activity. We assume governments maximize an objective function (or minimize a loss function). We consider a static game, meaning that the government decides in 2013Q1 which fiscal unexpected shock will be implemented, while agents in the model do not expect the government to act strategically.

We assume that there exists a trade-off between fostering activity and reducing the deficit. However, the definition of such preferences is a difficult task and relates to the construction of an adequate objective function for the fiscal authorities, analogous to the central bank loss function used to derive optimal Taylor rules (Gali, 2008). We argue that a reasonable objective function needs to comply with a few constraints or expected properties: (*i*) it increases with activity, (*ii*) it decreases with the public deficit, (*iii*) it should not "unreasonably" favor one objective over the other, (*iv*) the government tries to smooth both its deficit and activity over the medium-term.

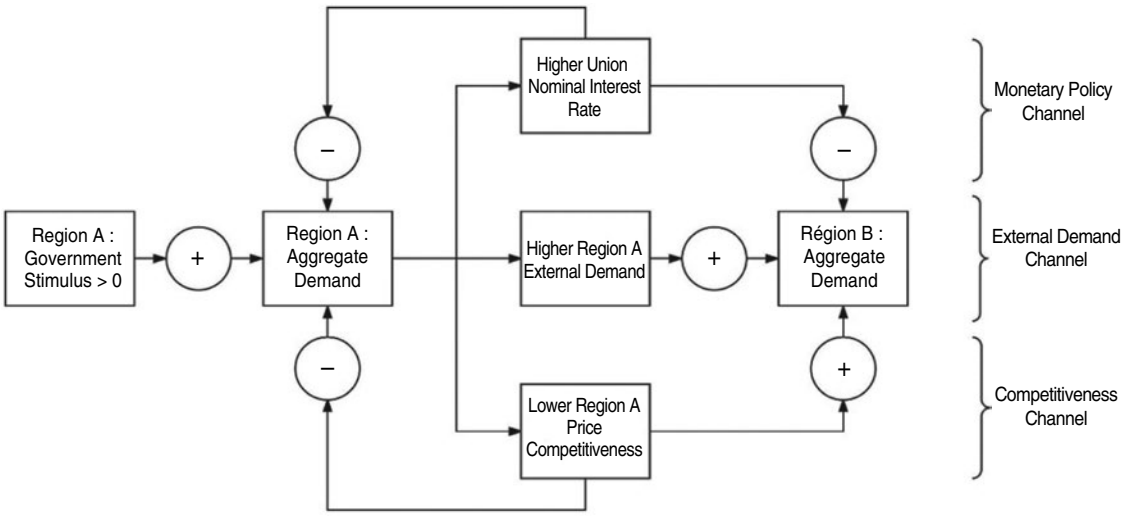
The two first properties represent the trade-off between fostering activity and improving debt sustainability. The third property relates to the fact that governments will not seek to boost activity by such an amount that the debt will explode, and vice versa. The fourth property ensures that the further a deviation from the steady state, the costlier it is. We also assume that spending-based and VAT-based consolidation have separable effects on governments' payoffs.

Having in mind all of these suitable properties, we assume government i will seek to maximize the static payoff V^i, choosing public consumption and VAT surprise shocks leading to a *ex ante* deficit reduction of respectively υ^g % and υ^c % of GDP:

$$V^i\left(\upsilon^g+\upsilon^c\right)=\sum_{t=0}^{H}\frac{\left[1+\widehat{y}_t^i\left(\upsilon^g,\upsilon^c\right)\right]^{1-\sigma_y}+1}{1-\sigma_y}+\lambda_i^g\cdot\frac{\left[1+\overline{pb}\,\widehat{pb}_t^i\left(\upsilon^g\right)\right]^{1-\sigma_{pb}}+1}{1-\sigma_{pb}}+\lambda_c^i\cdot\frac{\left[1+\overline{pb}\,\widehat{pb}_t^i\left(\upsilon^c\right)\right]^{1-\sigma_{pb}}+1}{1-\sigma_{pb}}$$

where $\widehat{y}\left(\upsilon^g,\upsilon^c\right)$ is the deviation of output from its steady state level, $\overline{pb}\,\widehat{pb}\left(\upsilon^g\right)$ (resp. $\overline{pb}\,\widehat{pb}\left(\upsilon^c\right)$) is the spending-based (resp. VAT-based) deviation of primary balance from steady state, expressed in unit of GDP. The parameter λ_g^i (resp. λ_c^i) defines the preference for spending-based (resp. VAT-based) fiscal consolidation and H is both the expected length of the fiscal policy and the government's objective horizon, here twelve quarters. Finally, σ_y and σ_{pb} define each government's smoothing preference.

Diagram
Three propagation channels for spillovers of fiscal policy

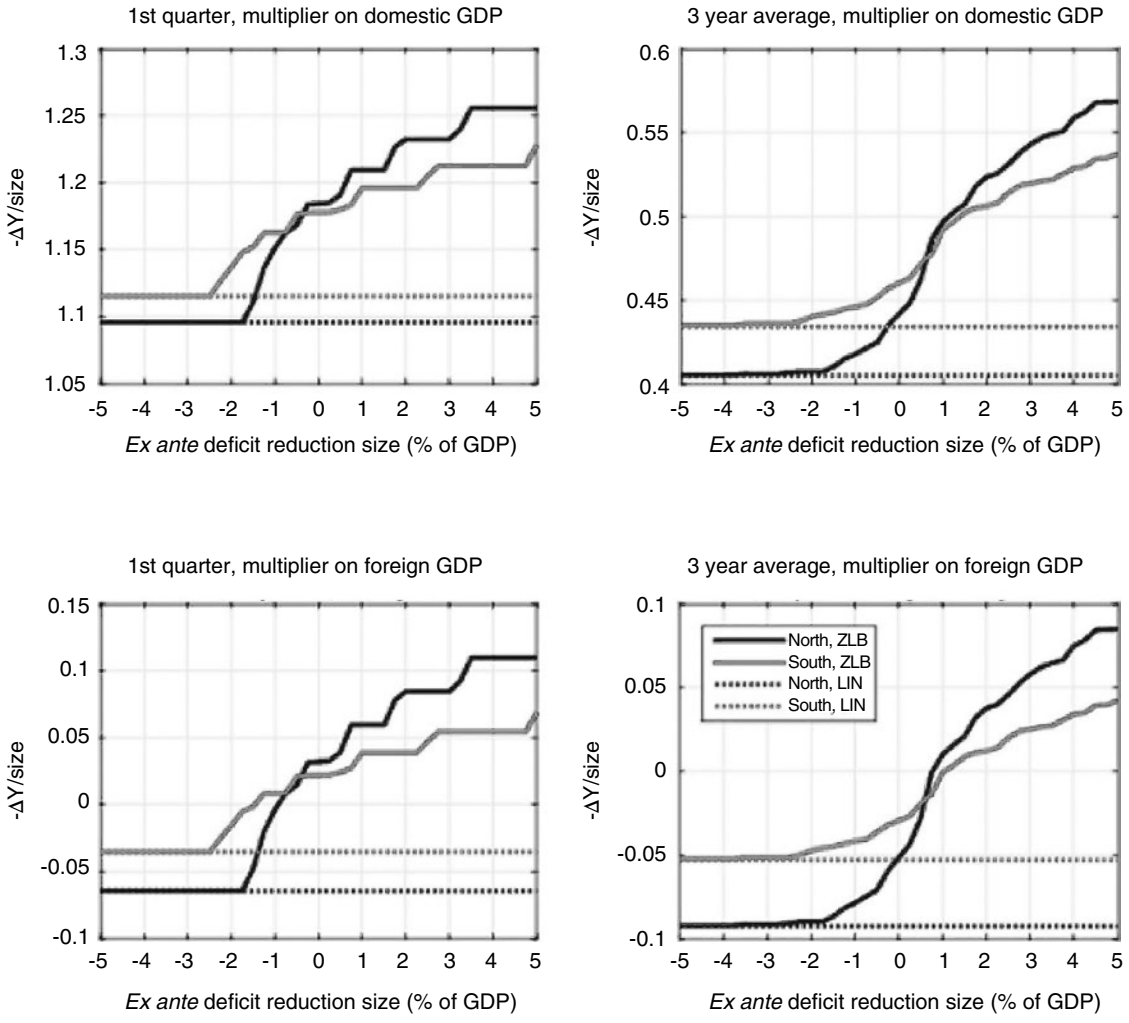


Lacking appropriate data to calibrate the parameters λ_g^i and λ_c^i, we assume that governments have no incentive to deviate from the budget rule when the economy is at the steady state. Namely, in the absence of shocks, we assume that governments will hold to the budget rule and choose to maintain a debt to GDP ratio at its target. This assumption implies that, in the vicinity of the steady state, $\partial V / \partial v^j \left(v^j = 0, v^{-j} = 0\right) = 0$. In other words, the marginal effects on the government payoff of a public consumption shock v^g (resp. of a VAT shock v^c) cancel each other for λ_j^i given by:

$$\lambda_j^i = \left(\sum_{t=0}^{H} \frac{\partial \hat{y}_t^i}{\partial v} \left(v^j = 0, v^{-j} = 0\right) \right) \left(\sum_{t=0}^{H} \frac{\partial \hat{pb}_t^i}{\partial v^j} \left(v^j = 0\right) \right)^{-1}$$

Figure II
Marginal fiscal multipliers of spending-based consolidation

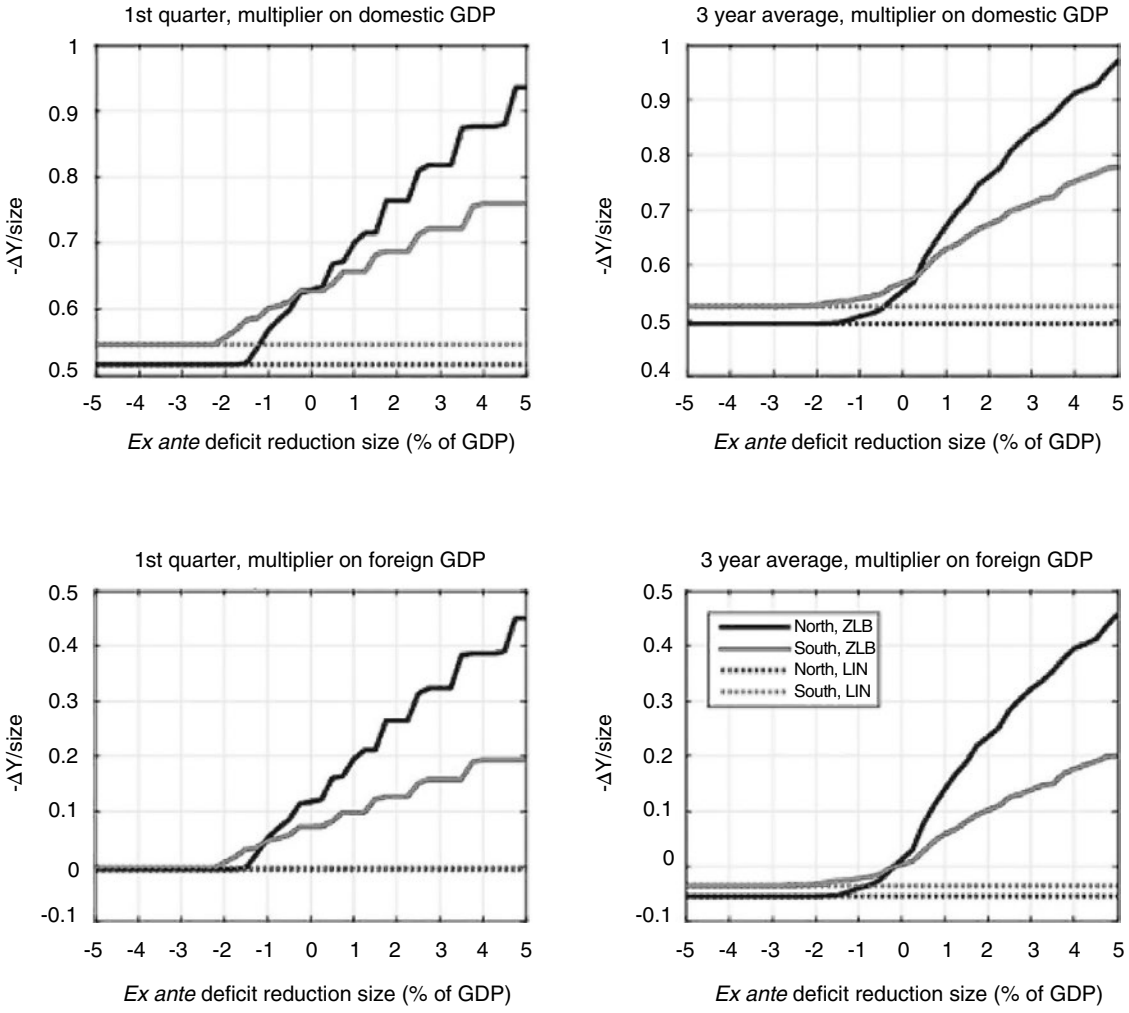
in deviation from the baseline scenario, in %



Note: Effects are normalized as the ratio of the marginal effect on output of the additional fiscal shock to its ex-ante size as a percentage of domestic GDP. Responses to a fiscal shock in the North are in black, to a fiscal shock in the South are in grey. Dotted lines (LIN) corresponds to multipliers in the linear case, whereas solid lines (ZLB) corresponds to the existence of a zero lower bound. Lastly, "1st quarter" corresponds to the impact multiplier, whereas "3-year average" corresponds to a multiplier computed over three years. Lower spillovers from Southern fiscal shocks partly relates to the smaller size of the South region. These figures read like regular multiplier: when positive, the effect of a consolidation on domestic (resp. foreign) output is negative.
Reading note: When the ZLB binds (solid lines), an ex ante 4% GDP of spending-based fiscal consolidation (ie. deficit reduction) in the North region (black lines) implies that an additional euro of deficit reduction leads to a a 1.25 euros decrease of North activity during the first quarter (top left panel), and a 0.55 euros decrease on average over three years (top right panel). In the South, spillovers induce an activity slowdown of slightly more than 0.1 euros of North GDP during the first quarter (bottom left panel), and of 0.075 euros on average over three years (bottom left panel). In other words, this means that spillovers amount to 7.5% to 10% of the input shock.
Source: Authors' computations. Simulations with the Meleze model.

The resulting calibrated values of λ^i for each government are shown in Table 2. A calibrated value of around 1/3 means that at the steady state, the payoff of a 3-percentage points improvement in the primary deficit or a 1-percentage point improvement in output is the same. Since the λ^i are calibrated as to maximize the governments payoff at the steady state, they depend on the government spending marginal multiplier at the steady-state and the elasticity of the primary deficit to output. We assume a log-utility for output ($\sigma_y = 1$) and calibrate $\sigma_{pb} = 5$ as the minimum value leading to interior solutions in the allowed

Figure III
Marginal fiscal multipliers of VAT-based consolidation
in deviation from the baseline scenario, in %



Note: Effects are normalized as the ratio of the marginal effect on output of the additional fiscal shock to its ex-ante size as a percentage of domestic GDP. Responses to a fiscal shock in the North are in black, to a fiscal shock in the South are in grey. Dotted lines (LIN) corresponds to multipliers in the linear case, whereas solid lines (ZLB) corresponds to the existence of a zero lower bound. Lastly, "1st quarter" corresponds to the impact multiplier, whereas "3-year average" corresponds to a multiplier computed over three years. Lower spillovers from southern fiscal shocks partly relates to the smaller size of the South region. These figures read like regular multiplier: when positive, the effect of a consolidation on domestic (resp. foreign) output is negative.
Reading note: When the ZLB binds (solid lines), an ex ante 4% GDP of VAT-based fiscal consolidation (ie. deficit reduction) in the North region (black lines) implies that an additional euro of deficit reduction leads to a slightly less than 0.9 euros decrease of North activity during the first quarter (top left panel), and a slightly more than 0.9 euros decrease on average over three years (top right panel). In the South, spillovers induce an activity slowdown of 0.4 euros during the first quarter (bottom left panel), and of 0.4 euros on average over three years (bottom left panel). In other words, this means that spillovers amount to 40% of the input shock.
Source: Authors' computations. Simulations with the Meleze model.

range of possible fiscal shocks (ie. *ex ante* deficit reduction of – 5% to + 5% of GDP).

Optimal Policy

As shown above, there are union-wide spillovers from regional fiscal policies. Therefore, there is room for strategic interactions within the monetary union. Outside the ZLB, and following consolidation package in the North, expansionary monetary policy will have positive effects in the South, and governments' objectives will diverge. However negative spillovers will prevail at the ZLB and regional objectives will converge. The optimal amount of coordination will thus differ whether monetary policy can or cannot react.

As in Mendoza et al. (2014), we study the solutions to one-shot cooperative and non-cooperative games defined as follows.[11] The strategy space is defined in terms of pairs of instrument values (υ^N, υ^S) chosen by regional governments.[12] As explained in the previous section, the game is static with payoffs taking into account the dynamic of the economy over a horizon of twelve quarters. We also assume than the strategy space does not include the possibility of transfers from one region's government to the other. Each regional government chooses its instrument value so as to maximize the objective functions V^i as defined earlier. Given the decision υ^j of the region j's government, the best response of region i is given by:

$$\upsilon^{i,*}\left(\nu^j\right) = \arg\max_{\upsilon^i} V^i\left(\upsilon^i \middle| \upsilon^j\right)$$

The Nash non-cooperative equilibrium is therefore given by the intersection of both best response curves at $\left(\upsilon^{N,*}\left(\upsilon^{S,*}\right), \upsilon^{S,*}\left(\upsilon^{N,*}\right)\right)$. We define the cooperative equilibrium as the solution from the optimization program of a union-wide social planner with the following payoff:

$$\omega V^N\left(\tau^N \middle| \tau^S\right) + (1-\omega) V^S\left(\tau^S \middle| \tau^N\right)$$

where ω defines the weight attributed to the North region. Our central assumption is that regions are weighted according to their population share (that is 58% for the North and 42% for the South), but this may not always be the case and therefore, multiple cooperative equilibrium can be sustained for different values of ω.

Each of these cooperative equilibria is said to be sustainable if and only if both regions are at least as well off as under the Nash equilibrium. Although each decision maker will have an idiosyncratic incentive to deviate from the coordinated policy, we assume that they expect that themselves deviating will result in the other decision maker also deviating. Both decision makers agree to stay at the cooperative equilibrium if they are both better-off by doing so.

In practice, since our solution is non-linear, we only solve for solutions on a discrete grid. At each node (υ^N, υ^S) within a given set of potential fiscal shocks ranging from *ex ante* deficit reductions of – 5% to + 5% of GDP), we simulate the trajectory of the economy and compute the values of Northern and Southern objective functions.

Note that for all the following figures, shocks are expressed (and grid is indexed) by this *ex ante* effect on the deficit expressed in % of GDP.

Strategic vs *cooperative game*

Figure IV displays each regional governments' payoff (that is, the value of the objective function) for the two fiscal shocks of interest, and their best responses to each possible action of the other government.[13]

Those first figures can be analyzed along three dimensions:

1. For a given action of a foreign government, what is the optimal domestic strategy?

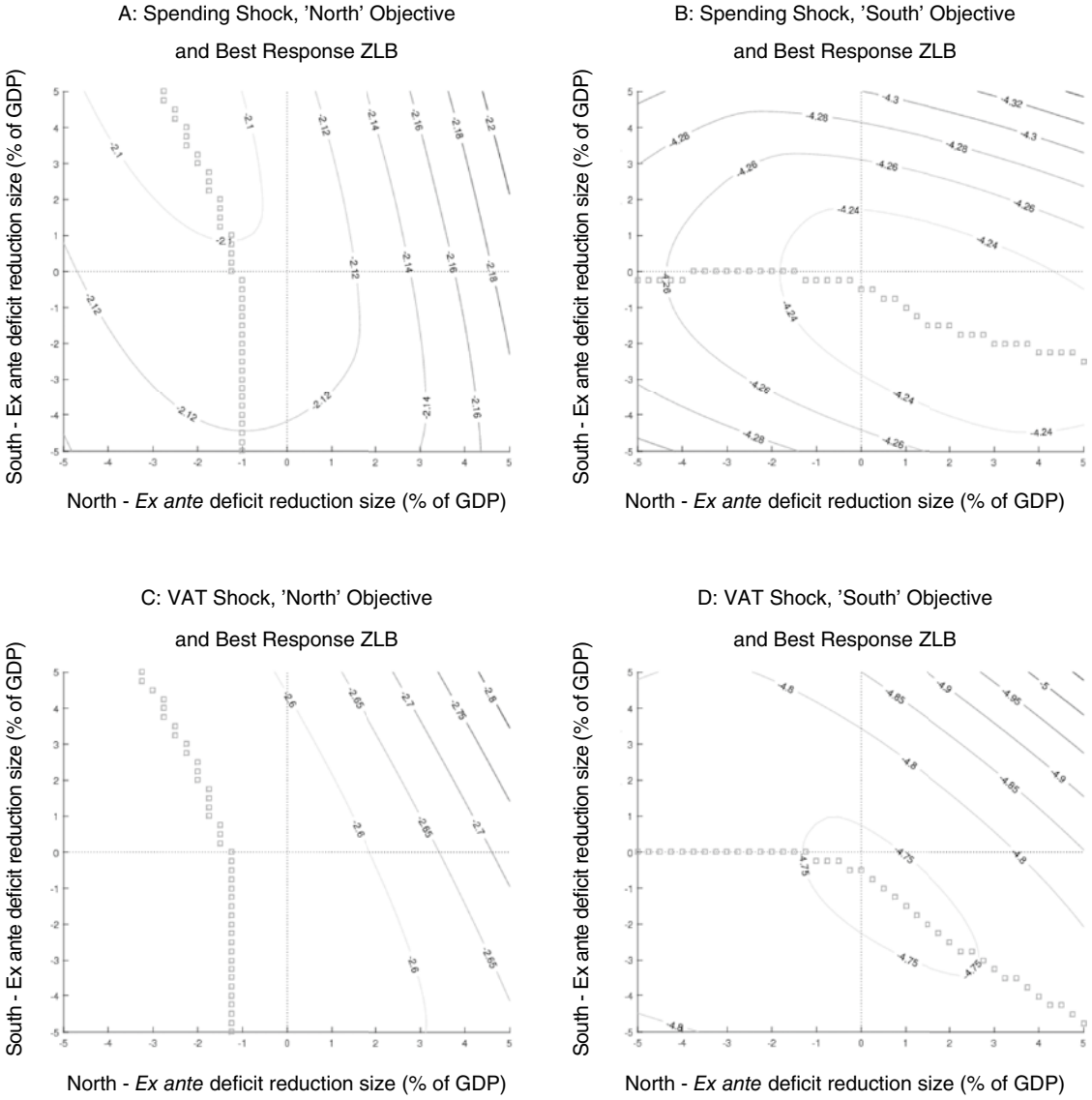
2. How does that optimal domestic strategy vary with the foreign government's action?

3. What is the combination of shocks that maximizes the domestic government's payoff?

Consider spending shocks from the point of view of the North region (top left panel). If the South chooses inaction, the optimal action of the North is to implement a small stimulus package, of around 1.5% of GDP. This choice (*i.e.* the value of the curve's x-intercept) depends on the North's preference for

11. We keep the notations of Mendoza et al. (2014).
12. For simplification purposes, we suppose that governments use only one instrument at a time, that is (υ^N, υ^S) = ($\upsilon^{N,g}$, $\upsilon^{S,g}$) or (υ^N, υ^S) = ($\upsilon^{N,c}$, $\upsilon^{S,c}$), making the policy space two-dimensional.
13. The action (υ^N, υ^S) = (0,0) corresponds to the baseline scenario detailed in Figure I.

Figure IV
Governments' objectives and best responses



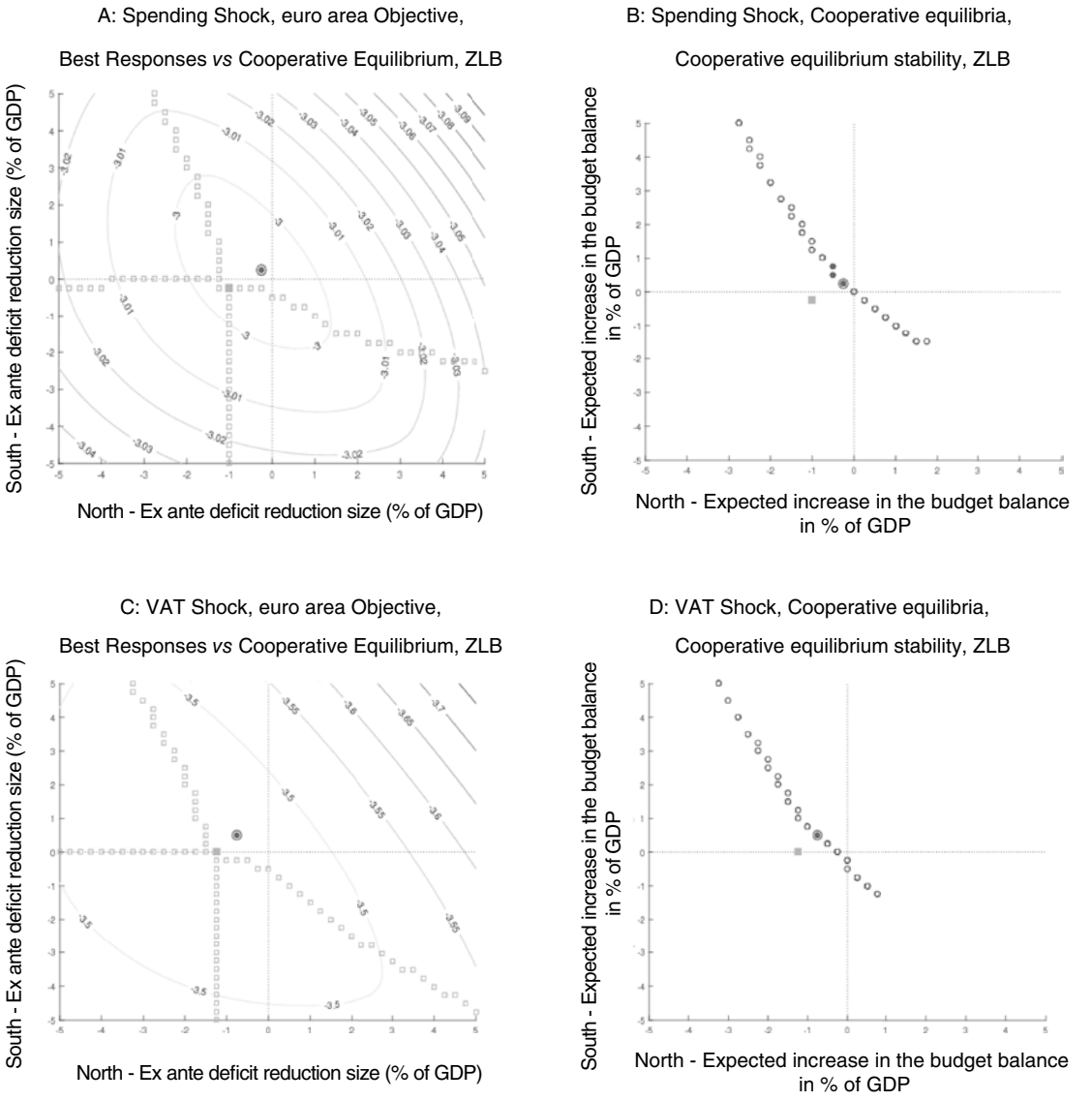
Note: Governments' objectives being surfaces, they are displayed through multiple iso-payoff curves. Squares are best responses.
Reading note: Considering VAT as the sole fiscal policy instrument for both regions (bottom panels), if the South region is expected to reduce its deficit by 2% of its GDP, the optimal behavior of the North region (left panel) is to increase its deficit by 2% of its GDP by lowering VAT taxes. This corresponds to the maximum of the objective function on the horizontal 2% line corresponding to the expected behavior of the South region.
Source: Authors' computations. Simulations with the Meleze model.

consolidation: both output and public balance were below their long-term value, the North has to choose which it favors. Moreover, the more the South chooses to consolidate (moving upward on the figure), the more deflationary pressures to the economies and the longer the duration of the ZLB. Therefore, a domestic consolidation package would become costlier to the North. Hence, North's optimal choice shifts to the left on the figure, towards a bigger stimulus package, and the overall best response slope for the North region is negative. Finally, as spending-based consolidations tend to have positive (but decreasing) spillovers inside the ZLB, the global maximum of the North's payoff function is obtained when the South consolidates a lot and the North compensates by stimulating. This global maximum is out of the range of allowed fiscal shocks. A symmetric behavior is observed for the South region. Consequently, the uncoordinated equilibrium is to increase spending by 1.25% of GDP in the North and increase spending by 0.25% of GDP in the South. Considering VAT shocks, the form of the best responses of North and South region are similar: due to the positive spillovers of VAT shocks, the North

chooses stimulus packages when the South consolidates a lot, and the situation is symmetric for the South.

Now, superposing both best responses, Figure V compares the resulting Nash equilibrium to the optimal coordination equilibrium, and assesses the sustainability of the coordination equilibrium under different weights attributed to each region. Panels on the left display the average objective of the entire monetary union when each region are weighed according to their population share, and compares it to the strategic interaction. In both case (public spending or VAT shock), the optimal and strategic equilibria are close, translating the fact that when foreign

Figure V
Uncoordinated vs cooperative equilibria at the ZLB

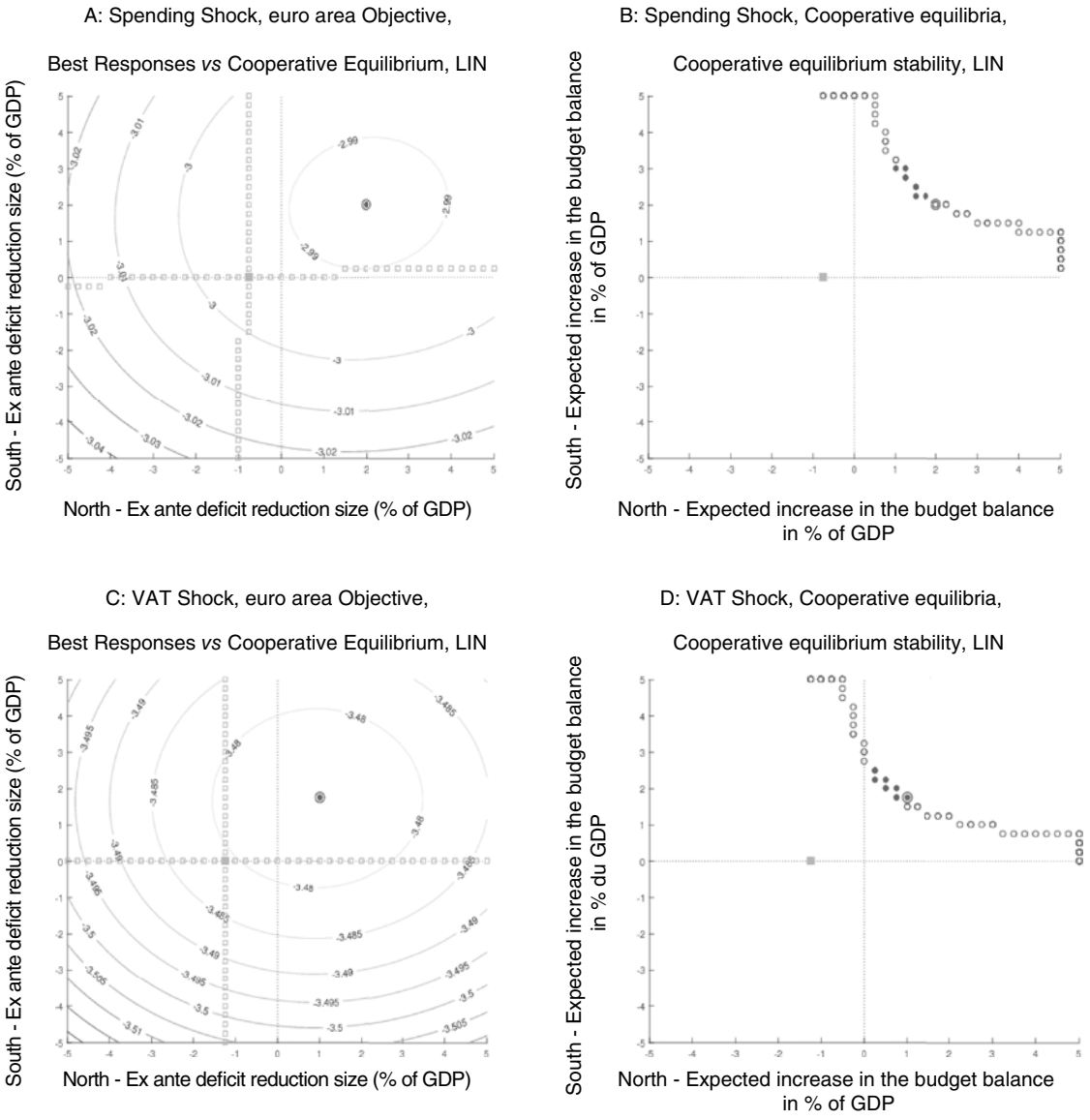


Note: On the left figures, the euro area aggregate (cooperative) objective being a surface, it is displayed through multiple iso-payoff curves. Uncoordinated strategic interactions are represented by empty squares for best responses. The Nash equilibrium corresponds to the filled square. The cooperative equilibrium using population weights is indicated by the circle. On the right figures, the weight associated to the North region in the aggregate cooperative objective varies from 0 to 1, and the corresponding cooperative equilibrium are still represented by circles. Full circles are sustainable equilibria; empty circles are unsustainable equilibria.
Reading note: When the ZLB exists, considering public spending as the sole fiscal policy instrument for both regions (top panels), the optimal behavior of a euro area wide government is to increase spending by 0.3% of GDP in the North and to decrease spending by 0.3% of GDP in the South (left panel, filled circle as the global maximum of the objective function whose iso-payoff curves are displayed). The uncoordinated policy is to increase spending by 1.3% of GDP in the North and increasing spending by 0.3% in the South (left panel, filled square corresponding to the intersection of best response curves displayed on Figure V).
Source: Authors' computations. Simulations with the Meleze model.

and domestic are similarly impacted by a domestic package, uncoordinated policies tend to be closer to the optimum. Given the level of output and primary deficit in 2013Q1 (compared to the steady state), optima tend to be in the upper left quadrant, which means more fiscal stimulus in the North and more fiscal consolidation in the South than in the baseline scenario. The panels on the right show that for regions weights that are close to the population share, the cooperative equilibrium is sustainable.

By comparison, Figure VI shows the same graphs, with the same calibration but in the case where monetary policy is never constrained by the ZLB. In that case, spillovers are smaller or

Figure VI
Uncoordinated vs cooperative equilibrium outside the ZLB



Note: On the left figures, the euro area aggregate (cooperative) objective being a surface, it is displayed through multiple iso-payoff curves. Uncoordinated strategic interactions are represented by empty squares for best responses. The Nash equilibrium corresponds to the filled square. The cooperative equilibrium using population weights is indicated by the circle. On the right figures, the weight associated to the North region in the aggregate cooperative objective varies from 0 to 1, and the corresponding cooperative equilibrium are still represented by circles. Full circles are sustainable equilibria; empty circles are unsustainable equilibria.
Reading note: Outside the ZLB, considering public spending as the sole fiscal policy instrument for both regions (top panels), the optimal behavior of a euro area wide government is to decrease spending by 2% of GDP in both regions (left panel, filled circle as the global maximum of the objective function whose iso-payoff curves are displayed). The uncoordinated policy is to increase spending by 0.8% of GDP in the North with no action in the South (left panel, filled square corresponding to the intersection of best response curves displayed on Figure V).
Source: Authors' computations. Simulations with the Meleze model.

negative, and best responses are less reactive. Indeed, when foreign actions by the other government do not affect significantly the domestic multiplier, the optimal choice by the domestic government mostly depends on this domestic trade-off between fiscal consolidation and activity fostering policies. Moreover, when spillovers are small or slightly negative, coordinating fiscal policies becomes preferable. Consequently, outside the ZLB and in the spending public case, the uncoordinated equilibrium would be to increase spending by 1% of GDP in the North and do nothing in the South. The North-East location of the cooperative equilibrium with respect to the Nash equilibrium means that both regions would prefer the other region to consolidate more.

Outside the ZLB, the cooperative equilibrium is "far" from the Nash equilibrium. Given negative spillovers of fiscal expansion in one region due to the monetary contraction, each region wishes its partner to consolidate, so as to benefit from the resulting expansionary monetary policy. Coordination would therefore lead to more consolidation by both regions than their natural tendency to do so. Stated in terms of our government objectives, the loss implied by the stronger consolidation in one region will be offset by the partner's stronger consolidation, and therefore be smaller than at the Nash equilibrium. All in all, both regions will be better off at the cooperative equilibrium.

* *
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Using the Mélèze fiscal DSGE model developed at Insee and estimating structural shocks to replicate the conditions where, absent any additional shock, the Euro Area would have been stuck at the ZLB for three year starting in 2013, we have shown that in a monetary union, when monetary policy is constrained by a ZLB episode and the duration of this episode is endogenous, domestic effects of fiscal policy on output are in general much larger than when monetary policy is unconstrained.

Second, spillover effects from fiscal policy are substantially higher at the margin when monetary policy is constrained than when it is not. Increasing with the size of fiscal consolidation measures, spillover effects at the impact can amount up to 15% of the domestic impact in the case of spending-based consolidations, and to 50% of the domestic impact in the case of VAT-based consolidations.

Outside the ZLB, there are gains from fiscal coordination across regions as consolidation in one region benefits to the activity of the other region due to the reaction of monetary policy. At the ZLB however, national objectives tend to be closely related and there are fewer gains from consolidation. The existence of a ZLB and consequently of higher spillovers implying closer regional and union-wide objectives implies that one of the rationales behind coordination of fiscal policies by external fiscal rules such as the Stability and Growth Pact is less stringent in the latest economic environment. However, as the recovery strengthens in the Euro Area, and as the normalization of monetary policy is closing in, divergence across national objectives will gradually increase, as well as gains from cooperation. Therefore, a thorough and in-depth reflection could be engaged on the design and the implementation of fiscal rules in the EU.

This sets path for future research on the means to improve fiscal policies interactions in the euro area. Within the scope of the current paper, future work will focus on the study of more detailed fiscal packages allowing for shocks of different duration across regions, possibly permanent, or for mixed packages combining both tax and spending-based stimulus. One main limit of our analysis is the fact that most structural parameters are calibrated. This could be improved, notably by estimating the share of financially-constrained households, likely to play a significant role in the dynamic during the recession.

Lastly, going beyond the retrospective analysis of the 2008 crisis and going forward, in the latest environment of low growth, focusing on permanent fiscal shocks should also require addressing the impact of the composition of public expenditures and revenues on potential TFP growth. As international organizations are now calling for more public investment expenditure, distinguishing between public consumption and investment in the present model will be key first steps. □

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APPENDIX 1

CALIBRATION

In the linearized form of the model, we identify three sets of parameters: *(i)* structural parameters, *(ii)* policy parameters and *(iii)* reduced-form parameters. First, structural parameters are parameters (technology, preferences, etc.) deemed purely exogenous, accounting for mechanisms outside of the model and not susceptible to change across simulations. Second, policy parameters correspond to discretely chosen parameters by fiscal and monetary authorities such as the inflation target and the tax rates. Lastly, some reduced-form coefficients of the model cannot be calibrated freely and are combinations of actual steady state values of the endogenous variables determined by the steady state equations. These coefficients are solved for a given set of structural and policy parameters.

Most structural parameters are calibrated based on the DSGE literature, and in order to set policy parameters to their observed values.

First, a few structural parameters are calibrated on National Accounting data. That is the case for the headcount of the total employed population $\mathbb{N}$, the respective regional share of this population *n*, the quarterly GDP per capita growth rate *g*, the HICP quarterly inflation Π, and α^i the degree of trade openness. For the latter, intra-area trade flows are explicitly taken into account using bilateral trade data from the CHELEM database. In addition, the technology parameter α is computed as the GDP-weighted average of gross operating surplus to value added ratios, computed at market prices.

However, most structural parameters have no direct real world counterparts. Hence, we proceed to an extensive literature review based on Annicchiarico et al. (2013), Auray et al. (2011), Bayoumi et al. (2004), Cacciatore et al. (2012), Clinton et al. (2011), Coenen et al. (2008), Eggertsson et al. (2014), Erceg and Lindé (2013), Forni et al. (2010), Kaplan et al. (2014), Ratto et al. (2009), Smets and Wouters (2002), Smets and Wouters (2003, 2005), Trabandt and Uhlig (2011), Vogel (2012). Using this review, we then select a value for each parameter that is close to the median of those observed in the literature, which have been estimated using a range of different methods, such as Bayesian methods on macro data or directly on micro data. However, except for the depreciation rate and the elasticity of substitution between goods, we do not have sufficient information to be able to calibrate each structural parameter to a region-specific value. Therefore, we assume that both our region share the same parameter value often based on euro area values. Regarding the other mentioned parameters, the depreciation rate, and the elasticity of substitution between goods, linked to the markup on goods, are calibrated using region-specific data found in D'Auria et al. (2009). A detailed discussion on the differences observed across models/papers for crucial parameters is given in Campagne and Poissonnier (2016a).

However, for an arbitrary calibration of structural parameters, the steady state structure of the model lead to values of the endogenous variables that differ from observed data, for instance the production level. Yet, our model also needs to be able to match some of the main economic indicators as measured in the National Accounts.

As such, having identified a list of structural and policy parameters, targets for some steady state values of endogenous variables are also identified in the National Accounts. In particular, six targets are selected: *(i)* the nominal main refinancing interest rate, *(ii)* the share of public consumption in GDP, *(iii)* the level of GDP, *(iv)* the number of hours worked, *(v)* the terms of trade, and *(vi)* the ratio of nominal GDP between regions. As explained in more details in Campagne and Poissonnier (2016a), the resolution of steady state equations allows to set the value for some structural parameters by reverse inference.

Those six National Accounting targets are calibrated as follows. The nominal main refinancing interest rate target is computed on the 3-months Euribor rate. The share of public consumption in GDP is directly computed using the Eurostat National Accounts at current prices, so as for the level of GDP, and the ratio of GDP between the two regions. The terms of trade are computed as the ratio of Purchasing Power Parities of GDP normalizing the North region to unity. Weights for the aggregation across regions are therefore logically based on regional GDPs. Lastly, the number of hours worked in each region is computed using the Labor Force Survey data. This survey allows to estimate employment in capita terms, the average number of actual weekly hours worked in the main job, the average number of actual weekly hours worked in the second job, and the number of employed persons having a second job. This allows to reconstruct a homogeneous number of hours worked in each region, based on the small approximation that no worker holds more than two jobs.

APPENDIX 2

BASELINE SCENARIO AND ROBUSTNESS CHECKS

Table A2-1
Measures of fit according various calibrations

	Central calibration	Alternative calibrations				
		2	3	4	5	6
Correlation of simulated series and observed data						
Consumption growth (North)	0.74	0.32	0.39	0.34	0.47	0.67
Consumption growth (South)	0.93	0.46	0.54	0.50	0.54	0.94
Investment growth (North)	0.99	0.92	0.88	0.87	0.97	0.99
Investment growth (South)	0.99	0.95	0.96	0.97	0.98	0.99
Output growth (North)	0.98	0.85	0.82	0.67	0.81	0.98
Output growth (South)	0.97	0.88	0.89	0.89	0.91	0.97
Public debt growth (North)	0.99	0.96	0.95	0.91	0.97	0.99
Public debt growth (South)	0.97	0.89	0.90	0.89	0.91	0.98
Inflation (North)	0.46	0.68	0.57	0.46	0.57	0.48
Inflation (South)	0.61	0.20	0.33	0.27	0.49	0.63
Interest rate variation	1.00	0.97	1.00	1.00	1.00	1.00
Interest rate level	1.00	0.94	0.98	0.99	0.97	0.99
Cross-correlation of output and growth						
Data (North)	0.64	0.64	0.64	0.64	0.64	0.64
Simulated series (North)	0.36	0.18	- 0.13	- 0.40	0.14	0.44
Data (South)	0.35	0.35	0.35	0.35	0.35	0.35
Simulated series (South)	0.41	0.38	0.36	0.39	0.34	0.22
Ratio of simulated over observed volatility						
Consumption growth (North)	1.31	1.87	1.39	1.83	1.43	1.36
Consumption growth (South)	1.03	0.96	0.83	0.78	0.62	0.96
Investment growth (North)	1.03	1.18	1.08	1.10	1.06	1.01
Investment growth (South)	1.08	1.09	0.88	0.88	0.93	1.11
Output growth (North)	1.01	1.31	1.14	1.05	0.71	0.98
Output growth (South)	1.00	1.06	1.05	1.00	0.94	1.05
Public debt growth (North)	1.01	1.13	1.08	1.06	0.93	1.00
Public debt growth (South)	1.15	1.18	1.05	1.05	1.01	1.14
Inflation (North)	0.70	0.52	0.64	0.56	0.46	0.74
Inflation (South)	0.55	0.72	0.77	0.84	0.59	0.56

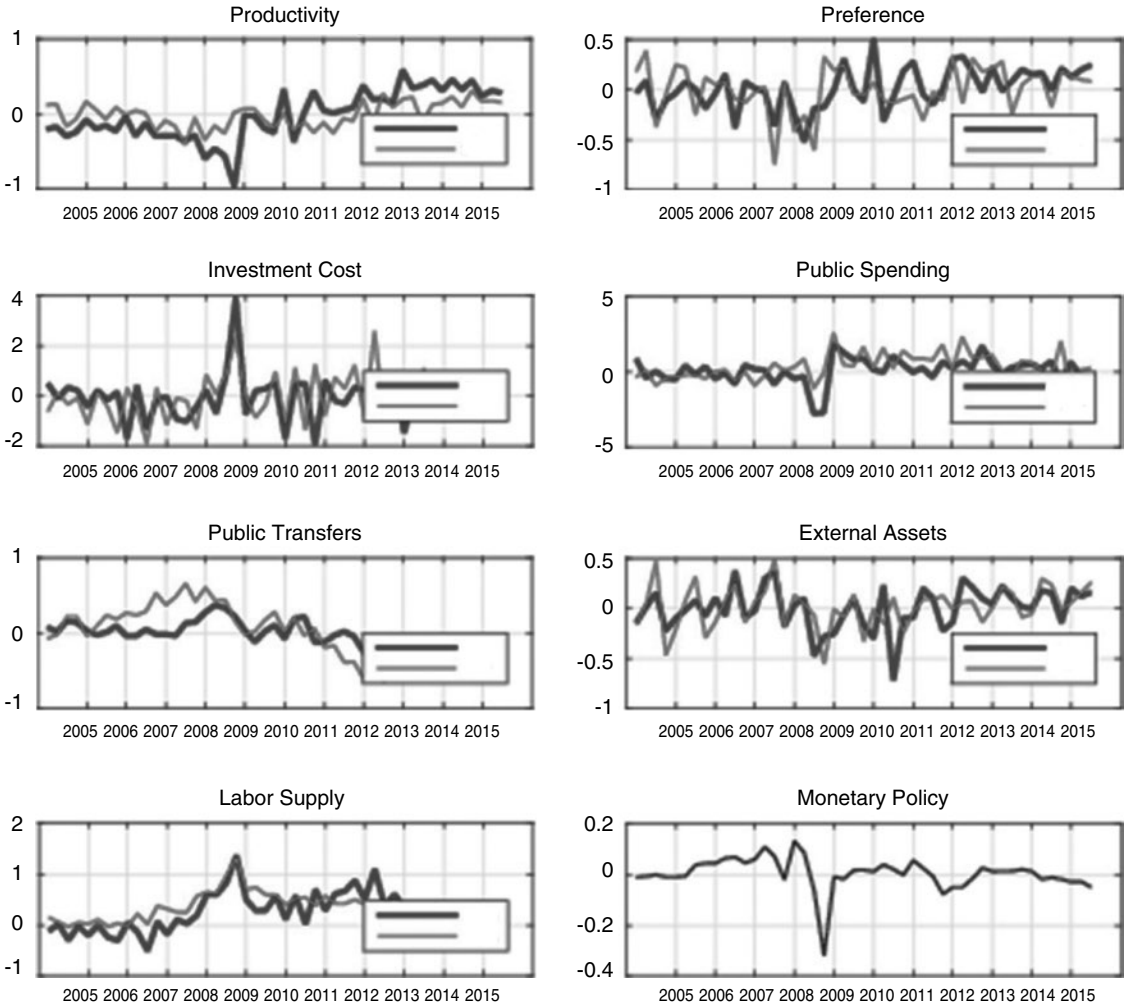
Note: Each column indicates the correlation between observed quarterly data over the period 2004-2015and their simulated counterparts using different calibration of deep parameters.
Central calibration corresponds to parameter values in Table 2, calibration 2 to a low share (μ = 0.15) of Non Ricardian Households in both regions, calibration 3 to a high share (μ = 0.50) of Non Ricardian Households in both regions, calibration 4 to a low (respectively high) share of Non Ricardian Households in the North (respectively in the South), calibration 5 introduces asymmetry in goods elasticity of substitution (θ^N = 3, θ^S = 10), whereas calibration 6 considers asymmetry in labour elasticity of substitution (θ_w^N = 2.5, θ_w^S = 6.5).
Source: Authors' computations. Simulations with the Meleze model.

Table A2-2
Estimated standard deviation and persistence for structural shocks

Shock	Standard deviation		Persistence	
	North	South	North	South
Monetary policy	0.012		0.149	
Productivity	0.028	0.027	0.827	0.532
Preference	0.017	0.018	0.087	0.100
Investment cost	0.027	0.033	0.588	0.790
Public spending	0.020	0.026	0.890	0.991
Transfers	0.029	0.034	0.508	0.888
Net foreign assets	0.026	0.030	0.000	0.000
Labour supply	0.046	0.072	0.994	0.994
Financial spreads	0.016	0.017	0.000	0.000
Public assets measurement error	0.018	0.019	0.000	0.000
Inflation measurement error	0.012	0.012	0.000	0.000

Note: Bayesian estimation of shocks persistence and standard deviation over 2004-2015. Measurement errors are allowed in the inflation and public assets equation in the Bayesian estimation process.
Source: Authors' computations. Simulations with the Meleze model.

Figure A2-I
Underlying standardized structural shocks from 2004 to 2015

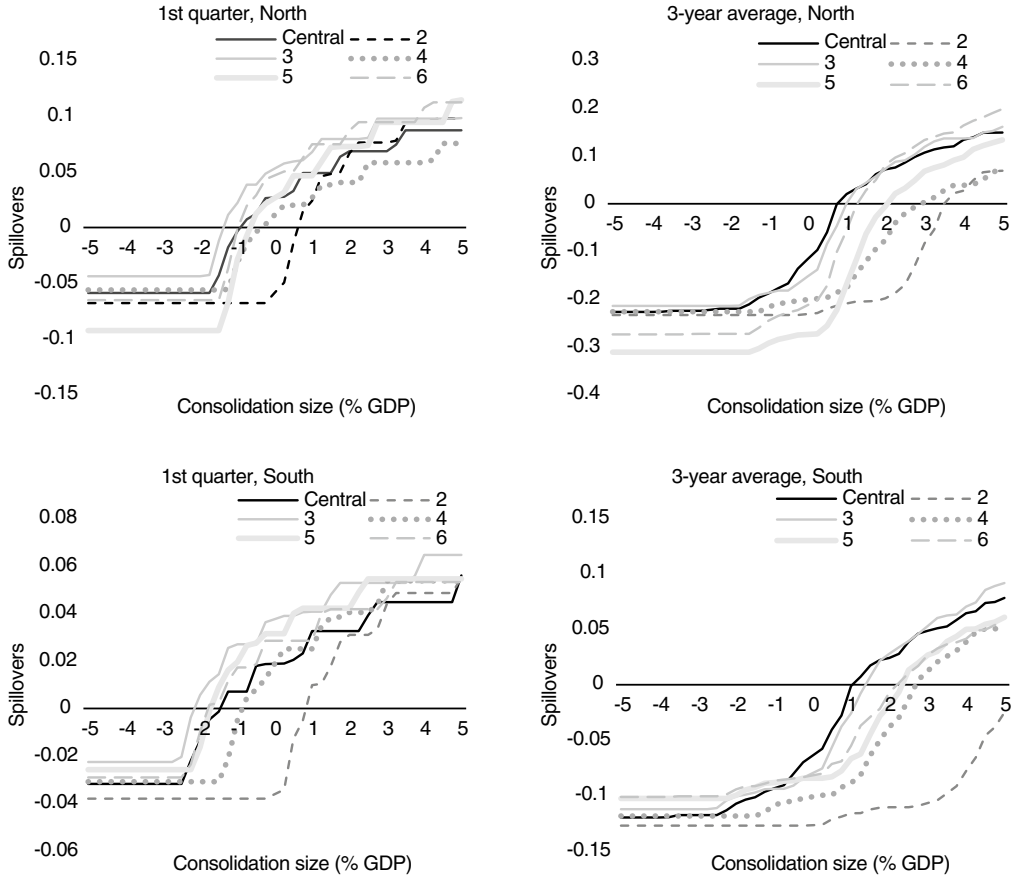


Note: North represents Belgium, Germany, France and the Netherlands, whereas South includes Greece, Ireland, Italy, Spain and Portugal. Shocks are displayed in percent of estimated standard deviation.
Source: Authors' computations. Simulations with the Meleze model.

APPENDIX 3

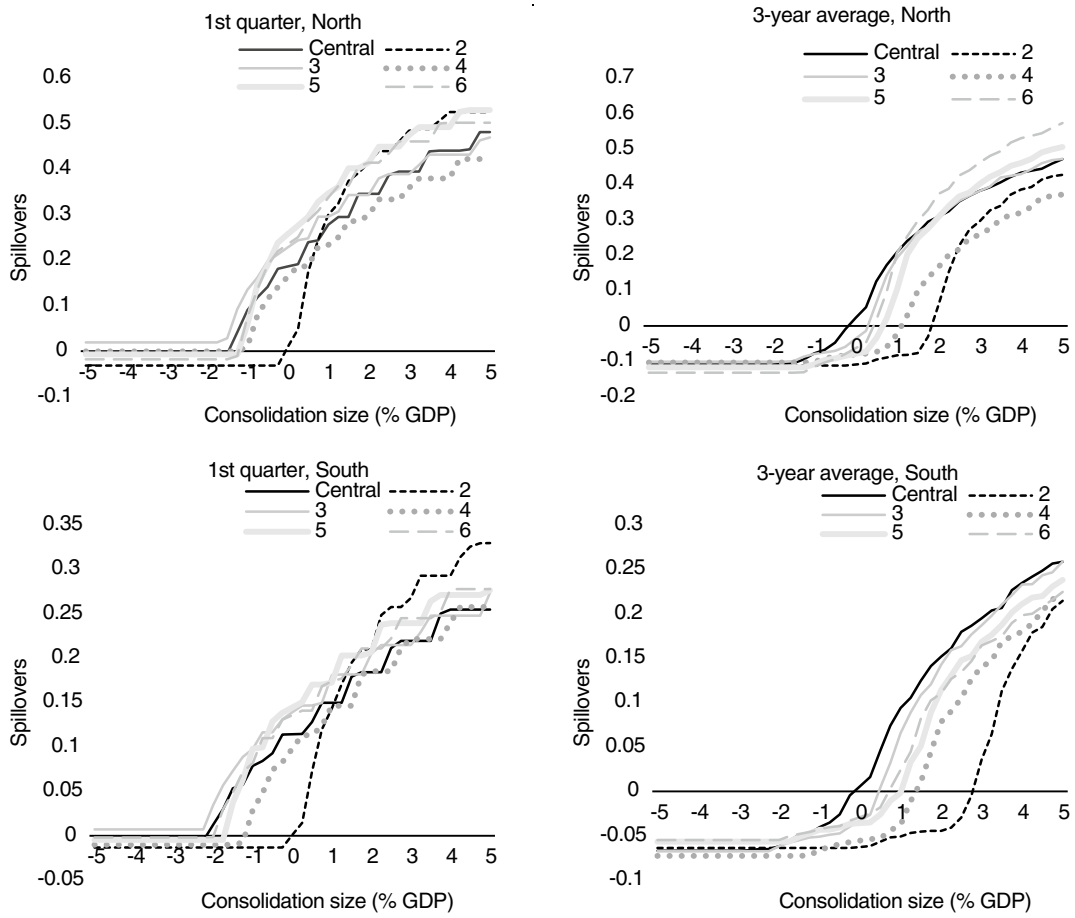
ADDITIONAL FIGURES

Figure A3-I
Spillovers of spending-based consolidation



Note: The x-axis corresponds to the ex-ante spending-based deficit reduction in % of GDP in the North region for top panels and in the South region for bottom panels. Spillovers (y-axis) are computed as the marginal foreign effect of fiscal shocks divided by their marginal domestic effect (that is where the shock occurs). "1st quarter" corresponds to the impact multiplier, whereas "3-year average" corresponds to a multiplier computed over three years.
Central calibration corresponds to parameter values in Table 2, calibration 2 to a low share (μ = 0.15) of Non Ricardian Households in both regions, calibration 3 to a high share (μ = 0.50) of Non Ricardian Households in both regions, calibration 4 to a low (respectively high) share of Non Ricardian Households in the North (respectively in the South), calibration 5 introduces asymmetry in goods elasticity of substitution (θ^N = 3, θ^S = 10), whereas calibration 6 considers asymmetry in labour elasticity of substitution (θ_w^N = 2.5, θ_w^S = 6.5).
Reading Note: for an ex-ante spending-based consolidation of 2% of GDP in the North (top panels), the spillover of 0.05 to 0.1 means that the fiscal shock in the North has an effect in the South reaching from 5% to 10% the size it has in the North during the first quarter (left figures).
Source: Authors' computations. Simulations with the Meleze model.

Figure A3-II
Spillovers of VAT-based consolidation



Note: The x-axis corresponds to the ex-ante VAT-based deficit reduction in % of GDP in the North region for top panels and in the South region for bottom panels. Spillovers (y-axis) are computed as the marginal foreign effect of fiscal shocks divided by their marginal domestic effect (that is where the shock occurs). "1st quarter" corresponds to the impact multiplier, whereas "3-year average" corresponds to a multiplier computed over three years.
Central calibration corresponds to parameter values in Table 2, calibration 2 to a low share (μ = 0.15) of Non Ricardian Households in both regions, calibration 3 to a high share (μ = 0.50) of Non Ricardian Households in both regions, calibration 4 to a low (respectively high) share of Non Ricardian Households in the North (respectively in the South), calibration 5 introduces asymmetry in goods elasticity of substitution (θ^N = 3, θ^S = 10), whereas calibration 6 considers asymmetry in labour elasticity of substitution (θ_w^N = 2.5, θ_w^S = 6.5).
Reading Note: for an *ex ante* VAT-based consolidation of 2% of GDP in the North (top panels), the spillover of 0.3 to 0.4 means that the fiscal shock in the North has an effect in the South reaching from 30% to 40% the size it has in the North during the first quarter (left figures).
Source: Authors' computations. Simulations with the Meleze model.

An assessment of the effects of unconventional monetary policies on the cost of credit to non-financial companies in the eurozone

Désiré Kanga * and Grégory Levieuge *

Abstract - The aim of this paper is to assess the effects of unconventional monetary policies (UMPs) on the cost of credit to non-financial companies in the eurozone. We analyse the direct effects of these UMPs using a multiple linear regression, then we seek to highlight the existence of a complementarity between these policies and the interest rate policy - an indirect effect of UMPs - using an interaction term. We show that the direct effects of UMPs are limited, indeed nil depending on the country, and are always weaker than their indirect effects. After having highlighted the heterogeneity of the indirect effects of UMPs in the eurozone, we offer diverse interpretations – macroeconomic, financial or banking differences, depending on the country – using a Panel Conditionally Homogenous VAR model (PCHVAR). The indirect effects of UMPs, depending on the economies considered, were countered by large public debt, a banking sector in poor health and/or a high level of systemic risk or risk of default.

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Keywords: unconventional monetary policies, credit cost, heterogeneity, direct and indirect effects

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The financial and banking crisis which began in 2007 led in part to an increase in risk and liquidity premiums, and to a decline of financing going to households and companies. In response, central banks aggressively lowered their key interest rate, including the European Central Bank (ECB), albeit in lesser proportions than the American Federal Reserve (Fed).

The reduction of key interest rates was meant to increase the price of assets and reduce the cost of capital, and to recover investment and growth. However, it appeared that this interest rates policy was insufficient, in particular to avoid the differences in the real cost of credit to non-financial corporations (NFCs) in eurozone countries getting wider (cf. online complement C1, figure C1-I). Whereas the average cost of new borrowings was lower than 3% in certain countries (Austria, Germany, Belgium, France, Finland and the Netherlands), it exceeded 6.5% in Greece and Portugal between the start of the 2010s and 2014. The reduction of key interest rates was not enough to regain confidence, especially as the sovereign debt crisis came to add to the financial and banking crisis. The spread between Greece's and Germany's 10 year rate was higher than 10 percentage points (pp) between April 2011 and April 2013 and Portugal's oscillated between 5.85pp and 12pp over the course of this period. The rise in risk premiums on government bonds has weakened banks, whose assets were mainly made up of these bonds, thus making it very difficult for them to refinance themselves and also to lend to economic actors. Specifically, this rise of risk premiums brought on an increase in the cost of external financing for banks, which they have passed on to lending rates and/or by rationing credit[1] (Avouyi-Dovi et al., 2017).

In this situation, in order to improve the economy's financing conditions, central banks adopted, in 2008, so-called unconventional monetary policies (UMPs), that being other than those acting mainly through the choice of key policy rates. Put in place from the start of the subprime crisis in the form of a direct injection of liquidity to banks in order to alleviate the paralysis of the interbank market, they were widened in October 2008. UMPs (unconventional monetary policies) consist of a use of the balance sheet (supply of liquidities at a fixed and/or long-term rate and targeted purchases of securities) intended to affect the prices of assets and financing conditions, in addition to the lowering of key policy rates[2] and the introduction of forward guidance (central bank communication). We will outline, a bit later on, the measures implemented by the ECB. But, before that, it should be noted that UMPs do not include Emergency Liquidity Assistance (ELA) that national central banks generally grant to solvent banks which are no longer capable of refinancing themselves. The ELA was extended during the crisis to the banking system in Greece and Ireland especially in order to ensure their survival, two countries which were receiving financial assistance from the EU and the IMF during the eurozone crisis.[3]

Like the ECB, the Fed also implemented unconventional measures over the course of the crisis. Nevertheless, the implementation of these measures is slightly different in the eurozone compared to the US, notably due to differences in the structures of their economies. Furthermore, the functioning of the American interbank market has been gradually normalised from 2009 onwards while it has remained very disrupted in the eurozone due to the sovereign debt crisis, thus requiring a series of unconventional measures in the eurozone.

The UMP measures are supposed to have direct effects on the economy *via* four transmission channels reproduced in diagram C1 (see online complement C1). Firstly, the massive purchase of public and private bonds and the widening of assets accepted as collateral over the course of open market operations should unblock transactions on target markets and thus lead to a drop in risk premiums. Risk premiums had in fact dramatically increased at the height of the crisis, when investors were reluctant to acquire assets that they then risked not being able to resell (liquidity effect). Also, a reallocation of investors' portfolios is expected from the unconventional measures. In fact, the massive purchase of risk-free assets raises their price and lowers their return, which, on the one hand, reduces the level of interest rates required for new issuances of securities, and on the other hand, encourages investors to turn to other more available and lucrative (private) assets, whose demand will also reduce the required return. The purchases of assets together with supplies of liquidity should encourage banks to grant loans to non-financial companies (NFCs).

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1. The question of pass-through between sovereign credit risk and bank credit was the subject of considerable treatment over the course of these last few years. See for example Bottero et al. (2015) and Popov & Van Horen (2013) for empirical evidence and Bocola (2016) for a theoretical demonstration.

2. With base rates already near zero, the room for manoeuvre had become nil (cf. figure C1-II of the online complement).

3. See Praet (2016).

In fact, other than the purchase of assets, the supplies of liquidity sought to support banks' short-term financing in order to attenuate the potential negative impact of liquidity risk on the availability of credit to households and NFCs in the eurozone. Also, interest rate risk is reduced when the central bank commits to keeping key policy rates low over a long period (duration effect). Finally, these unconventional measures should restore confidence. In particular, the ECB's unlimited fixed-rate allotment coupled with the extension of the maturity of long-term operations ease banks' refinancing conditions and should allow financial institutions to hold liquidity at a low rate over a longer period. Moreover, by buying assets, including those of average quality, central banks are reassuring investors and inciting them to do the same (signalling effect). Duration and signalling effects must reduce risk premiums. Then, by lowering the costs of financing, these measures should stimulate aggregate demand, helped by a depreciation of the exchange rate, until the rate of inflation gets back to its usual level of 2% per year. Then, it would return to a conventional monetary policy regime.

Unconventional policies do not just target direct effects on the economy's financing conditions. They are also meant to support the reduction of the key policy rates –to a level close to zero– so that they regain their influenceover credit conditions, as is the case in normal times (Cour-Thimann and Winkler, 2012; Trichet, 2010). From this angle we speak of the "indirect" effects of unconventional policies, whose objective is also to restore the transmission mechanism of monetary policy.

The ECB has implemented several measures, from fixed-rate full allotment procedure in 2008 to targeted long-term financing operations (TLTRO II) announced in 2016, through massive purchases programmes of public and private bonds carried out each year since the beginnning of the crisis. Indeed, with regards to the different transmission channels mentioned above, the objectives of unconventional monetary policies have been multiple: restoring the effectiveness of rates policy, meeting liquidity needs, lowering sovereign premiums, etc. However, as pressures on allthe markets led to an increase in the cost of for NFCs (cf. figure C1-I of online complement C1), the UMPs should have an impact on the borrowing cost of the NCFs and households. This is an intended objective of the ECB, which through its president has called its interventions as "enhanced credit support"[4] (Trichet, 2009, 2010). Specifically, unconventional measures such as those taken by the ECB should alleviate banks' financing constraints (lowering rates on monetary and interbank markets, providing unlimited fixed-rate liquidity). Then, any lowering of the cost of financing for banks should lead to a lowering of the cost of credit for businesses.

The aim of this article is to evaluate the effects of unconventional monetary policies on the cost of credit to companies in eurozone countries. It can be very hard to analyse the effects of unconventional measures on credit volumes. Typically, Creel et al. (2016) find that the unconventional measures greatly lowered lending rates but that the transmission towards credit volume was weak. Carpenter et al. (2014) found similar results. The historically low level of interest rates has had a negative effect on loan supply. The weak demand of financing may also explain the slow transmission from rates to quantities. Generally, the studies on quantities encounter the usual difficulty of distinguishing between supply and demand effects. For all these reasons, our assessment of the effects of UMPs will focus on the cost of borrowing for NFCs.

The empirical literature attests to the overall effectiveness of unconventional measures in terms of reduction of interest rates on the credit market (Abbassi & Linzert, 2012; Aït-Sahalia et al., 2012; Darracq-Paries & De Santis, 2015; Hesse & Frank, 2009, among others). However, these works often overlook the indirect effects (Creel et al., 2016). Moreover, by providing an average effect, they overlook the heterogeneity of the effects on the eurozone Member States. However, recent studies (*e.g.*, Avouyi-Dovi et al, 2017; Horny et al, 2016) show that the sovereign debt crisis has accentuated the heterogeneity of the transmission of monetary policy in the eurozone. Attempts to estimate the effects of policies by country have recently been initiated without covering a large panel of countries, nor all the programs implemented (Beaupain & Durré, 2016; Gibson et al., 2016; Szczerbowicz, 2015). Finally, they do not explain the potential sources of divergences of the impact across countries. However, we know for example that structural heterogeneity (Leroy & Lucotte, 2016; Mojon, 2001) and cyclical

4. "Enhanced credit support constitutes the special and primarily bank-based measures that are being taken to enhance the flow of credit above and beyond what could be achieved through policy interest rate reductions alone" *(Trichet, 2009).*

factors (Sorensen & Werner, 2006) are sources of divergence in the adjustment of bank rates to changes in policy rates.

Our analysis contributes to be the literature in several respects. First of all, it analyses all the unconventional measures implemented by the ECB (with the exception of forward guidance), until the end of 2014, and covers a panel of 11 countries that is large enough to give an overall view of the existing disparities.[5] Second, we then seek to highlight the existence of a complementarity – called indirect effect – between unconventional policies and interest rate policy. Third, we analyse the indirect effects of unconventional measures, of which the objective is to restore the link between base rates and the cost of credit. Fourth, we attempt to explain the heterogeneity in the transmission of the effects of unconventional policies by using a panel conditionally homogeneous VAR model (PHCVAR).

We find that the direct effects of unconventional policies are much less compelling than the indirect effects. However, these indirect effects are heterogeneous. The asymmetry of the responses is explained, on the one hand, by macro-financial differences between the countries, relative to their growth rate, the probability of default for companies, public debt and systemic risk. It is due, on the other hand, to the heterogeneity of banking sectors, through differences in capitalisation and in non-performing loans. Competition and the concentration of the banking sector would have had a weaker effect on the differences of the transmission of interest rate policy. From this point of view, the effects of unconventional policies would have been greater in Germany and Austria, for example, than in Greece, Italy, Spain or Portugal. Such results lead to a balanced assessment of unconventional policies in Europe. In fact, they reduced the overall cost of financing of companies and banks. They also contained bank and sovereign default risks. But, strictly from the point of view of the cost of credit, they may not have been the most effective where the needs were comparatively greater.

This article is organised as follows. The next section presents a review of the ECB's unconventional measures and of their effects on financing conditions. Then we analyse the direct effects of unconventional policies and their indirect effects, and seek to explain the heterogeneity of the impact of unconventional measures.

A review of the ECB's unconventional measures and of their effects on financing conditions

Typically, exceptional policies led by monetary authorities over the course of the crisis are labelled as unconventional because (i) they do not treat solely the management of short-term interest rates, (ii) the amounts of liquidity injected are considerable, (iii) they substantially modify the structure and size of central banks' balance sheets, et (iv) their transmission channels differ a priori from those of interest rates policy.

Usually, UMPs are classified in two categories: quantitative policies and qualitative policies[6] (Bernanke et al., 2004). A quantitative policy leads to an increase in the size of the balance sheet of the central bank, which is linked to the supply of liquidity to the economy. Qualitative policies consist of modifying the composition of the central bank's balance sheet, without modifying the size. In practice, from the time of the subprime crisis, central banks (Fed, Bank of England, Bank of Japan and ECB) have led both quantitative and qualitative policies, which have increased the size of the balance sheets.

In this section, we present, as an overview, the measures implemented by the ECB between 2008 and 2016 as well as a review of the empirical literature on the evaluations of the effects of these measures.

The unconventional policies put in place by the ECB

The ECB's initiatives, whose chronology is given in table C1-1 of online complement C1, include five large-scale operations that can be labelled as unconventional. The ECB led both quantitative and qualitative measures.[7] The distinction between quantitative and qualitative

5. The 11 countries considered are Belgium, Germany, Ireland, Spain, France, Italy, the Netherlands, Austria, Portugal, Finland, and Greece. They contribute to 98% of the eurozone's annual GDP.

6. In a more general way, unconventional policies draw on a very vast set of measures and propositions. These policies encompass taxation on the holding of monetary assets, (Goodfriend, 2000; Goodhart & Ashworth, 2012; McCallum, 2000), the depreciation of currency (McCallum, 2000) or the targeting of a general price level (for example Eggertsson, 2003, 2006; Eggertsson & Woodford, 2003; Jeanne and Svensson, 2007; Krugman, 1998; Svensson, 2001, 2003). We will focus on the policies implemented from 2008 onwards.

7. For Borio and Disyatat (2010), these interventions are credit policies, a priori *qualitative, since the emphasis was put on bank credit and the ECB has accepted risk assets that it would not before accept as guarantees. However, these interventions were followed by a growth of the ECB's balance sheet.*

measures are not clear and absolute. Therefore, we do not separate them in this article.[8]

Swap agreement: To support the banks which were faced with a constraint on foreign currencies following the fall of Lehman Brothers in September 2008, the ECB implemented measures to ensure the provision of liquidity in foreign currencies from April 2009 onwards.[9] It also supported the provision of liquidity in euros in the banking systems of several non-Member States of the eurozone, with agreement from the Central Banks of these States.

Fixed-rate full allotment (FRFA): It is a main refinancing operation (MRO) of the ECB, of weekly frequency, in which the amount of liquidity requested by the tenderers is fully allocated at the rate fixed by the Central Bank. In other words, banks can finance themselves to an unlimited extent with the Central Bank. This way of proceeding differs from the classic MROs which incorporate a pro-rata adjudication. The main aim of these measures is to support the short-term financing of banks in order to attenuate the negative impact of the illiquidity risk on the distribution of credit to households and businesses. This procedure was announced for the first time on 8 October 2008 just after the fall of Lehman Brothers. It has been regularly renewed since then.

Collateral easing: Another way of increasing the quantities of liquidity consists of facilitating banks' access to refinancing operations, through the collateral easing during MROs (Cheun et al., 2009). The collateral easing was put in place in October 2008, so as to evolve thereafter. These assets concerned the bank bonds negotiated on unregulated markets, instruments of subordinated debts protected by an acceptable guarantee, securities graded below BBB $^-$ (except for asset-backed securities, ABS), and guarantees denominated in foreign currencies (Yen, Pound Sterling, US Dollar) which fulfil all the other usual admission criteria.

Negative rate: In order to encourage banks to use their reserves to conduct activities of intermediation, the ECB has introduced from June 2014 onwards a negative rate on its deposit facilities.

Extension of the maturity of refinancing operations (LTROs and TLTROs): The ECB has extended the maximum maturity (to 48 months) of its operations by allowing banks to hold liquidity over a long period. From 4 September 2008, the ECB decided to conduct three longer-term refinancing operations, of a total value of 125 billion euros. Two of these operations of a value of 50 billion euros each had a three year maturity and the other 25 billion euros had a six month maturity. Moreover, this operation coupled with the procedure of fixed-rate full allotment should maintain the interest rate on the monetary market at a low level and ease refinancing conditions for banks. Other than the extension of the maturity of LTROs (Long Term Financing Operations) and the decision to apply a negative rate to the deposit facility, the ECB decided on 5 June 2014 to conduct two waves of targeted LTROs (TLTROs). The first wave of TLTROs, implemented between September and December 2014, should have allowed banks to borrow from the ECB the equivalent of 7% of their total outstanding amount of loans at 30 April 2014, at the rate of the MROs increased by 10 basis points (that is 0.25%). In the second phase, implemented between March and June 2016, banks were able to borrow extra amounts during the quarterly TLTROs, provided that they iincreased their loan to firms and households. The TLTROs have a maturity of 48 months, with the possibility of reimbursement after two years. By indexing its credit to banks' outstanding amount on loans, the ECB wished to relaunch credit activity.

Asset purchase programmes: The ECB implemented four categories of security purchase programmes. The first dealt with covered bonds. Two covered bonds purchasing operations were conducted. The first (CBPP1), announced 7 May 2009, was implemented between July 2009 and June 2010. The cumulated outstanding amount of the purchases at 30 June 2010 was 60 billion euros. A second purchase programme (CBPP2) was announced on 6 October 2011, to be implemented between November 2011 and October 2012. The targeted total amount of covered bonds to be purchased under this phase was 40 billion euros. It aimed to soften banks and NFCs financing conditions. At the end of the programme (31 October 2012), the cumulated outstanding amount of purchased bonds was estimated at 16.4 billion euros. The last programme (CBPP3) was decided on 4 September 2014, for an initial duration of 2 years.

8. We tried to carry out, in table C1-2 (see online complement C1), a classification of the unconventional measures in order to emphasize on those that aim to affect the borrowing cost of NFCs. Nevertheless, even if the measures do not affect directly the borrowing cost of NFCs, they are not likely to indirectly affect this cost by way of their direct effect on banks' financing.

9. The swap agreements have always existed between the ECB and other central banks. We limit ourselves to operations conducted over the course of the financial crisis of 2007.

The second category (called SMP for Securities Market Programme) phased-in between May 2010 and May 2012 focused on Government and private sector bonds. It was introduced following the sovereign debt crisis and aimed to guarantee the liquidity and depth in dysfunctional bond market segments (Greece, Ireland, Portugal, Spain and Italy). The oustanding amount of the purchases reached to 208.8 billion euros at 14 September 2012.

Outright Money Transactions (OMTs) constitute the third category of purchase programmes. They aimed to buy, under certain conditions,[10] bonds issued by Member States of the eurozone. This programme was announced on 2 August 2012, shortly after Mr Draghi's speech of July 2012 (see further on), to begin in September 2012 and thus put an end to the SMP.

The fourth asset purchase programme was decided on 4 September 2014. It began in November 2014 and consists of buying asset-backed securities (ABSPP for Asset-Backed Securities Purchase Programme). Scheduled to run for two years, it was a joint programme with CBPP3. On 22 January 2015, the ECB decided to conduct an extended asset purchase programme (APP) which encompasses the two ongoing programmes (ABSPP & CBPP3) and a sovereign bond purchase programme (PSPP for Public Sector Purchase Programme). The measures were to be among the most significant since the start of the crisis, as regard to the targeted amount (monthly target of 80 billion euros between April 2016 and March 2017 whereas the monthly target was 60 billion euros between March 2015 and March 2016) and of their duration.[11] At 31 May 2016, the outstanding amount of the purchases is estimated at just over 1,000 billion euros. The programme whose end was initially on the end of March 2017, conditional to inflation returning to around 2%, is being extended until the end of December 2017 or even later, if needs be. The purchases concern in particular bonds issued by European central administrations, agencies and institutions in the eurozone.

As figure C1-III (online complement C1) shows, unconventional policies have modified the size and structure of the ECB's balance sheet. Its size nearly tripled between 2005 and 2013. Two evolutions are particularly pronounced. One took place at the end of 2008 in the aftermath of Lehman Brothers' collapse. The other, even more dramatic, appeared in 2011 with the implementation of the second covered bond purchase programme (CBPP2) and the SMP. Moreover, the composition of the balance sheet follows longer-term refinancing operations between 2009 and 2010 and at the end of 2012. Another important modification concerns the deposit facilities since the start of the rolling out of these easing policies. Banks made great use of the central bank's deposit facility which led to the build-up of reserves, rather than using resources to grow their supply of credit to companies and households. The ECB, then, decided to bring the interest rate on deposits back down to 0% in July 2012 then –0.1% in June 2014. It has been fixed at –0.40% since March 2016. In other words, the central bank taxes banks' deposits in order to encourage them to mobilise their resources to either lend them to firms or invest them in income-generating securities.

In terms of composition, assets other than securities and States' debts have seen considerable evolution since the start of the crisis, which attests to the extension of the range of assets that the ECB has accepted as collateral. Liabilities with regards to financial institutions in the eurozone have also considerably increased, attesting to the role played by the ECB as an actor of the interbank market.

Finally, since the beginning of the crisis, central banks have announced in a more systematic and pronounced way their intentions on key interest rates via forward guidance. In uncertain circumstances, governors' speeches aim to guide the anticipations and behaviour of investors. So, since July 2013, the ECB, through its president Mr Draghi, has announced its intentions for the future of the main policy rate (without however providing a very clear schedule or set of conditions). A year before (July 2012), President Draghi announced the Eurosystem's intention to take all the necessary measures, *"whatever it takes",* to save the euro.

A literature review of the impact of ECB's UMPs on financing conditions

There is, today, an extensive literature on the measure of the effects of unconventional policies on the economy's financing conditions. Due to the lack of historical series, the first

10. The participating countries must be engaged in an adjustment programme via the European Financial Stability Facility or the European Stability Mechanism. Even if no quantitative limit was fixed regarding the size of the program, the purchases focus, in particular, on sovereign bonds with a maturity of one to three years.

11. https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html (visited on 11/06/2016). From March 2015 to March 2016, the targeted monthly sum was 60 billion euros.

works focused on events studies. Aït-Sahalia et al. (2012) conclude, drawing on this technique, with a decline of the risk and liquidity premiums on the interbank market following the announcement 1) of the lowering of base interest rates, 2) of liquidity injection and 3) of foreign currency swaps. By definition, this technique only allows for the evaluation of the effects of the announcements, and the size of the window plays a crucial role to the extent that, when it increases, it becomes difficult to attribute the measured effects to the targeted policies. Other methods have been used to overcome this shortcoming. Certain authors have used term structure models (*e.g.*, De Pooter et al., 2015; Fourel & Idier, 2011) to assess the effect of unconventional policies on the price of assets and on the risk and liquidity premiums. Others have estimated models with one equation (Abbassi & Linzert, 2012; Eser & Schwaab, 2016; Gambacorta & Marques-Ibanez, 2011; Gibson et al., 2016; Szczerbowicz, 2015), or used VAR models (Abbassi & Linzert, 2012; Beaupain & Durré, 2016; Creel et al., 2016; Darracq-Paries & De Santis, 2015; Fourel & Idier, 2011; Gambacorta et al., 2014; Giannone et al., 2012; Hesse & Frank, 2009; Lenza et al., 2010; Peersman, 2011). Overall, these studies conclude with an effectiveness of UMPs in terms of reduction of interest rates on the credit market thanks to their effects on risk and liquidity premiums. The UMPs would have limited the collapse of bank lending (Gambacorta & Marques-Ibanez, 2011).

However, most of these works give an average measurement of the effects of these policies, without taking into account the heterogeneity in the eurozone. Even if some models are estimated over a panel of countries, controlling for fixed effects does not take into account the specific responses of a given country to monetary poly impulses. It is to alleviate this shortcoming that some recent studies have tried to estimate the effects of policies on certain countries within the eurozone (Beaupain & Durré, 2016; Fourel & Idier, 2011; Gibson et al., 2016; Szczerbowicz, 2015) or have used models with heterogeneous coefficients estimated over a panel of countries (Eser & Schwaab, 2016). Nevertheless, these works focus on a reduced number of programmes and countries. For example, Eser and Schwaab (2016), Fourel and Idier (2011) and Gibson et al. (2016) focus exclusively on asset purchase programmes (SMP and CBPP) whereas Beaupain et Durré (2016) analyse the effects of the FRFA procedure. Szczerbowicz (2015) analyses a wider panel of unconventional measures but is limited to six countries (Spain, France, Greece, Ireland, Italy, Portugal).

We contribute to this literature in four ways. Firstly, our analysis covers a panel of 11 countries in the eurozone which are Germany, Austria, Belgium, Spain, Finland, France, Greece, Ireland, Italy, the Netherlands and Portugal. To our knowledge, only Carpenter et al. (2014) and Darracq-Paries and De Santis (2015) have studied as many countries. But their analyses remain aggregated.

Secondly, we cover almost all of the unconventional policies measures initiated by the ECB before 2014. Moreover, we evaluate the effects of each of these policies on the cost of borrowing in each country, highligting the heterogeneity of the transmission of these policies' effects.

Thirdly, we highlight the complementarity between unconventional policies and interest rate policy. With the exception of Antonin et al. (2014) and Creel et al. (2016), nearly all the studies analyse either conventional monetary policy, or unconventional monetary policies. But, as we outlined in the introduction, unconventional policies also (and maybe especially) aim to restore the functioning of the traditional channels of monetary policy. It is therefore necessary to evaluate the effects of UMPs by taking into account this dimension.

The study of heterogeneity in the transmission of the effects of unconventional policies makes up our fourth contribution. Generally, a vast literature exists showing that the heterogeneity in the eurozone might be at the origin of the asymmetry in the transmission of the effects of rates policy (e.g. Angeloni et al., 2003). Likewise, the structural heterogeneity of the eurozone could explain the asymmetrical effects of unconventional measures, all the more so since this heterogeneity has led to financial fragmentation (strong heterogeneity in the financing conditions of banks and companies). This is why, after analysing the direct and indirect effects of UMPs, we will use a conditional model in order to determine that factors likely to explain the heterogeneity of the effects between the countries.

Direct effects of unconventional policies on the cost of credit

In this section, we analyse the direct effects of unconventional policies on the cost of borrowing

for NFCs in the eurozone. This empirical analysis is based on the estimation of the following equation for each country.[12]

$$\Delta Y_t = \alpha + \beta PNC_{t-1} + \gamma C_{t-1} + \sum_{n=1}^{N} \eta_n \Delta Y_{t-n} + \varepsilon_t \quad (1)$$

where Y_t is the real cost of credit to companies, PNC_t is the set of unconventional policies, C_t is a set of control variables and ε_t is the residual term. We focus on the changes in financing conditions, as first difference (Δ). This allows for work on stationary series. The cost of credit is a composite indicator based on lending interest rates, calculated by the ECB. This measure is used to evaluate the costs of borrowing for non-financial companies. It is useful for international comparisons.

In terms of indicators of unconventional monetary policy, there are few alternatives. The size of the Central Bank's balance sheet constitutes an imperfect measure. It could lead one to believe that the ECB has been much less resourceful since the end of 2013 (cf. figure C1-III, online complement C1) but this is not the case (it all depends on the needs of investors). Furthermore, such an indicator does not fully reflect the impact of qualitative measures such as the collateral easing. Additionally, the shadow rate,[13] sometimes used in the literature, is not useful to our analysis in that it is meant to reflect the monetary conditions inclusing both conventional monetary policy and unconventional policy measures. But, with our objective being to identify the direct and indirect effects, it is important here to properly distinguish between the two types of policy. Finally, to only consider the outstanding amount of LTROs or MROs, as it is sometimes the case in the literature, would be reductive. That is why we preferred to represent each measure of unconventional policy through dummy variables which take the value 1 over the course of the period of their implementation. The dates corresponding to each announcement and implementation are given in table C1-1 (online complement C1).

The control variables are used in equation (1) to limit the bias of omitted variables. We consider the EONIA (Euro OverNight Index Average) and other variables related to the different crises or the vulnerability of the eurozone (Crisis, Public Deficit, Public Debt) and aggregate demand (BLS, IPI). All control variables are lagged in order to limit simultaneity bias.

The list of variables, their definitions and their sources are given in table 1. Table C1-3 (in online complement C1) provides summary statistics relating to the variables considered in this article. The estimations cover the period from January 2003 to December 2014 over the 11 countries. Equation (1) is estimated by the ordinary least squares method on monthly data,[14] with an adjustment of the variance of the estimators using the Newey-West approach. Over the course of the estimation period the EONIA varied between –0.03% and 4.3% with an average of 1.62%.

An unconventional policy measure is said to be effective if $\beta' = \beta / \left(1 - \sum_{n=1}^{N} \eta_n\right)$ is negative. This hypothesis reflects the fact that unconventional policies relax the financing conditions of economic investors. If the opposite occurred the unconventional policies is not effective in terms of reducing the borrowing cost.[15]

The results of our estimations are given in table 2. We find that only four programmes were effective, in six countries. A significant effect arises from the procedure of fixed-rate full allotment (FRFA), longer-term refinancing operations (LTROs), the collateral easing (Collateral) and the purchase of covered bonds (Covered). The most effective programmes are the FRFAs and LTROs. These two measures have helped to reduced the real cost of credit in Belgium, Germany, Spain, Greece, Ireland and Portugal. The collateral easing has been effective only in Spain. Furthermore, the purchase of covered bonds has had the expected effects in Portugal. However, there is no visible impact, in terms of reducing the cost of credit, of foreign currency swaps, Outright Monetary Transactions (OMTs), nor of the purchase programme of public and private assets (SMP).

According to these results, on the one hand, the provision of liquidity (LTROs and FRFAs) are the most effective with regards to reducing

12. Simplified writing: β includes the respective effect of each instrument of unconventional policy (UMP); likewise for γ relative to each control variable C.

13. The shadow rate is a theoretical rate based on a modelling of the yield curve incorporating a short term rate which could be negative (Wu & Xia, 2016). By design, this rate reports on both unconventional policies and rates policy.

14. The quarterly variables, namely the indicator of BLS demand, public deficit and public debt, are presumed to be consistent over the course of the months making up the quarter.

15. Sometimes even the implementation of certain programmes played a revelatory role regarding the gravity of the situation. So much so that the effect of a measure may be contrary to the expected signal. This is if the signalling (cf. online complement) was reversed.

the real cost of credit. On the other hand, Spain and Portugal have benefited the most from the programmes relating to the reduction of the real cost of borrowing to NFCs.

A priori, the other programmes did not appear to have a significant impact on the reduction of the cost of financing to NFCs. This is notably the case for collateral easing (with the exception of Spain). It is important to note, however, that foreign currency swaps targeted less credit conditions than banks' cross-border activities. Likewise, the SMP and OMT programmes, put in place to fight the sovereign debt crisis in the eurozone, aimed to reduce sovereign spreads.

The finally very limited effect of unconventional policies on the cost of financing explains why the ECB needed to implement different measures and programmes. Then, whereas the Fed began to shift away from the UMPs in 2016, the ECB announced new measures (TLTRO II). However, we have so far only considered the direct effects of unconventional measures. Yet these measures also aim to restore the transmission of (conventional) rates policy, starting with zero rates policy (Antonin et al., 2014). Therefore, they could have had indirect effects which we test next.

Indirect effects of unconventional policies on the cost of credit

To measure the indirect effects, equation (1) is modified so as to take into account the extra effect of the EONIA on financing conditions, conditional to the implementation of unconventional policies. This conditionality is modelled in the form of an interaction in the following estimated equation:

$$\Delta Y_t = \alpha + \beta_0 \Delta R_{t-1} + \beta_1 \Delta R_{t-1} * B_{t-1} + \gamma C_{t-1} + \sum_{n=1}^{N} \eta_n \Delta Y_{t-n} + \varepsilon_t \quad (2)$$

where B_t is the central bank's balance sheet growth rate (in % of GDP).

The endogenous and exogenous variables are the same as those presented in table 1. The coefficient β_0 captures the direct effect of the EONIA interest rate (written as R_t) on Y_t.

Table 1
Definitions and sources of variables

Variable	Definition	Sources
Dependent variable (*Y*)		
Y	Difference between "Cost of Borrowing" and "Inflation"	ECB
Explanatory variables		
UP		
FRFA	Dummy = 1 during the implementation of the policy of fixed-rate full allotment	Cf. Table C1-1
LTRO	Dummy = 1 during the implementation of the policy of longer-term financing operations, otherwise 0	idem
Swap	Dummy = 1 during the implementation of the policy of provisions in foreign currency, otherwise 0	id.
Collateral	Dummy = 1 during the implementation of the policy of easing of guarantee conditions, otherwise 0	id.
SMP	Dummy = 1 during the implementation of the Government and private sector securities purchases, otherwise 0	id.
OMT	Dummy = 1 during the implementation of the policy of Outright Monetary Transactions	id.
Covered	Dummy = 1 during the implementation of the policy of covered bond purchases, otherwise 0	id.
Control variables (*C*)		
EONIA	Euro OverNight Index Average (daily rate)	Macrobond
Crisis	Dummy showing banking and sovereign debt crises	Szczerbowicz (2015)
BLS	Bank Lending Survey demand	ECB
Deficit	Public Deficit/Surplus (in % of GDP)	Eurostat
Debt	Public debt in % of GDP	Eurostat
IPI	Industrial Production Index	Eurostat

Note: This table presents the dependent variable and the explanatory variables of equation (1), their definitions, the abbreviations retained in the empirical analysis, and their sources. The cost of borrowing is a harmonised indicator constructed by the ECB and inflation is calculated as the monthly growth rate of the Harmonised Index of Consumer Prices.

The parameter β_1 measures the extra effect of the EONIA daily rate, attributable to the expansion of the central bank's balance sheet. Firstly, in order to ensure that we are properly capturing in this way the indirect effects of unconventional measures, relation (2) is estimated over two sub-periods which correspond to two distinct regimes of monetary policy: the period before the implementation of unconventional policies (January 2003-March 2007) and the period corresponding to the implementation of unconventional measures (January 2008-December 2014). Also, with the objective being to highlight the complementarity between unconventional policies and rates policy, only the parameter $\beta_1^{'}$ defined as $\beta_1^{'} = \beta_1 / \left(1 - \sum_{n=1}^{N} \eta_n\right)$ will be shown in table 3. According to the hypothesis of restoring the effects of unconventional monetary policy, the expected signal of $\beta_1^{'}$ is positive.

According to the first two columns ("Before" and "After" in table 3), it arises that before 2008 the size of the balance sheet does not influence the impact of the interest rate on financing conditions. This is consistent with the absence of unconventional policy. The balance sheet then had no active role. However, from January 2008 (cf. "After" column), the central bank actively used its balance sheet (size and composition) to guide its low-rate policy. The additional effect of the size of the balance sheet is greater in Spain, the Netherlands and Portugal. It is less significant in Belgium and Germany. Except for Finland, France and Ireland, the size of the balance sheet therefore played a role in the transmission of rates policy during the crisis. We thus validate the existence of indirect effects in their entirety.

Now, by following the same method as in the preceding section, we will evaluate more specifically the indirect effects of each of the

Table 2
Indirect effects of unconventional policies on the real cost of credit

	FRFA	LTRO	Swap	Collateral	OMT	SMP	Covered
Austria	-0.088	-0.023	0.060	0.006	-0.020	0.024	0.030
	(0.076)	(0.051)	(0.080)	(0.068)	(0.038)	(0.038)	(0.042)
Belgium	-0.007	**-0.086***	0.102	0.018	0.039	0.071**	-0.001
	(0.032)	**(0.048)**	(0.066)	(0.039)	(0.037)	(0.035)	(0.026)
Germany	**-0.126****	**-0.087****	0.067	-0.028	-0.002	0.029	-0.014
	(0.057)	**(0.040)**	(0.060)	(0.044)	(0.032)	(0.026)	(0.027)
Spain	**-0.363*****	**-0.205****	0.175	**-0.230***	0.176*	0.013	-0.036
	(0.116)	**(0.102)**	(0.119)	**(0.125)**	(0.094)	(0.069)	(0.075)
Finland	-0.023	0.035	0.062	0.036	0.039	0.012	-0.025
	(0.048)	(0.073)	(0.075)	(0.041)	(0.048)	(0.029)	(0.034)
France	-0.146	-0.054	0.104**	0.013	-0.023	0.047*	0.012
	(0.108)	(0.045)	(0.050)	(0.035)	(0.050)	(0.028)	(0.030)
Greece	**-0.273****	-0.074	0.153*	-0.043	-0.084	0.133**	-0.048
	(0.116)	(0.097)	(0.086)	(0.091)	(0.085)	(0.064)	(0.045)
Ireland	**-0.170***	-0.122	0.108	-0.020	0.020	0.029	-0.032
	(0.101)	(0.076)	(0.070)	(0.056)	(0.057)	(0.036)	(0.043)
Italy	0.002	-0.070	0.179*	-0.029	-0.134	0.112	0.058
	(0.138)	(0.086)	(0.105)	(0.103)	(0.162)	(0.084)	(0.073)
The Netherlands	-0.008	-0.029	0.125**	0.036	0.057	0.045	-0.062
	(0.075)	(0.050)	(0.059)	(0.057)	(0.060)	(0.042)	(0.041)
Portugal	**-0.202*****	**-0.101***	0.066	0.019	-0.075	0.115**	**-0.069***
	(0.074)	**(0.059)**	(0.082)	(0.066)	(0.075)	(0.046)	**(0.037)**

Note: This table reports the coefficients β' in each country and for each instrument of unconventional monetary policy. A negative and significant value of β' validates the direct effects of the measure concerned in the country concerned. The estimations are carried out over the period January 2003 to December 2014 by using the Newey-West approach with a lag of order $N = 3 \equiv [T^{0.25}]$. The standard errors are indicated in brackets. *** Significant at 1%, ** Significant at 5%, et * Significant at 10%.
Sources: Authors' estimations.

unconventional effects. To this end, we proceed with the estimation of the following relation:

$$\Delta Y_t = \alpha + \beta_0 \Delta R_{t-1} + \beta_1 \Delta R_{t-1} * PNC_{t-1} + \beta_2 PNC_{t-1} + \gamma C_{t-1} + \sum_{n=1}^{N} \eta_n \Delta Y_{t-n} + \varepsilon_t \quad (3)$$

The endogenous and exogenous are the same as those presented in table 1. The coefficient β_0 captures the direct effect of the EONIA interest rate (written as R_t) on Y_t, whereas β_1 measures the extra effect of the EONIA daily rate, attributable to the implementation of unconventional measures. The results of the estimations are detailed in the columns from "FRFA" to "Covered" in table 3.

We notice (in comparison with table 2) that the indirect effects are more compelling than the direct effects. Each measure has had a significant effect on the costs of borrowing in at least one country. Specifically, the FRFA procedure has helped to reduce the cost of credit in Austria, Belgium, Germany, Spain and Portugal. The effects are comparatively greater in Portugal. The effectiveness of this measure could be explained by its duration. It was introduced in October 2008 and has been regularly renewed to this date in order to bring in the necessary liquidity to the banking sector. Our result is in the same line as those of Antonin et al. (2014) and Creel et al. (2016).

The policies of asset purchasing (SMP and Covered) have also contributed to the decline of the borrowing cost (in Austria, Germany, Spain, Finland, France, Greece, Italy) with more considerable effects in countries such as Spain and Italy. These measures, by further relaxing banks'

Table 3
Indirect effects of non-conventional policies on the real cost of credit

	Before	After	FRUA	LTRO	Swap	Collateral	OMT	SMP	Covered
Austria	-0.148	**0.702***	**0.119***	0.016	**0.164****	**0.210****	**2.327*****	**0.646****	**0.543****
	(0.656)	**(0.406)**	**(0.067)**	(0.050)	**(0.076)**	**(0.099)**	**(0.805)**	**(0.316)**	**(0.265)**
Belgium	0.224	**0.446*****	**0.100***	-0.030	0.094	**0.241*****	0.271	0.283	0.100
	(1.527)	**(0.157)**	**(0.057)**	(0.042)	(0.060)	**(0.075)**	(0.624)	(0.238)	(0.240)
Germany	0.235	**0.376*****	**0.111*****	0.007	0.083	**0.185*****	0.188	**0.479****	**0.303***
	(0.808)	**(0.107)**	**(0.035)**	(0.026)	(0.062)	**(0.057)**	(0.538)	**(0.204)**	**(0.171)**
Spain	2.157	**1.888*****	**0.132***	0.080	0.029	**0.207***	1.702	**1.351****	**1.212*****
	(2.001)	**(0.680)**	**(0.069)**	(0.060)	(0.106)	**(0.113)**	(1.124)	**(0.560)**	**(0.428)**
Finland	-0.653	0.169	-0.033	-0.051	0.001	**0.144****	0.395	-0.149	**0.641*****
	(1.127)	(0.379)	(0.092)	(0.063)	(0.121)	**(0.056)**	(0.659)	(0.284)	**(0.248)**
France	-0.557	0.291	0.076	-0.036	0.094*	0.118	-0.111	0.062	**0.539*****
	(0.797)	(0.195)	(0.050)	(0.046)	(0.057)	(0.076)	(0.636)	(0.239)	**(0.203)**
Greece	-0.439	**0.705***	0.081	0.024	0.039	0.092	-2.160	**0.931****	0.945
	(1.578)	**(0.388)**	(0.054)	(0.034)	(0.094)	(0.136)	(1.412)	**(0.395)**	(0.664)
Ireland	2.003	0.086	0.045	0.009	0.043	-0.044	-0.329	0.435	0.054
	(1.475)	(0.740)	(0.051)	(0.053)	(0.063)	(0.068)	(0.705)	(0.296)	(0.228)
Italy	-0.815	**0.892****	0.180	**0.134****	-0.050	0.041	**4.249****	**0.960***	**1.240****
	(1.474)	**(0.381)**	(0.125)	**(0.062)**	(0.071)	(0.258)	**(1.751)**	**(0.550)**	**(0.603)**
The Netherlands	2.499	**1.322*****	-0.052	-0.025	0.085	**0.299*****	-1.174	0.154	0.256
	(1.527)	**(0.302)**	(0.111)	(0.032)	(0.058)	**(0.109)**	(0.955)	(0.361)	(0.304)
Portugal	5.342	**1.635****	**0.241*****	0.025	0.074	**0.261*****	0.284	0.434	-0.114
	(3.257)	**(0.698)**	**(0.040)**	(0.068)	(0.058)	**(0.068)**	(1.124)	(0.350)	(0.197)

Note: This table reports the coefficients β_1 in each country and for each instrument of unconventional monetary policy. The two columns "Before" and "After" present the coefficients β_1 taken from equation (2) estimated respectively over the periods January 2003-March 2007 and January 2008-December 2014. The other columns report the coefficients β_1 taken from equation (3) estimated over the period January 2003-December 2014. A positive and significant value of β_1 indicates that the expansion of the balance sheet or the unconventional measures mentioned have helped to restore the transmission of rates policy. All the coefficients are obtained by using the Newey-West approach with a lag of order $N = 3 \equiv [7^{0.25}]$. The standard errors are indicated in brackets. *** Significant at 1%, ** Significant at 5%, et * Significant at 10%.
Sources: Authors' estimations.

financing constraint, allowed them to more quickly adjust downward the costs of borrowing for companies. The collateral easing (Collateral) was one of the most effective measures with regards to the transmission of monetary policy, while the effects of LTROs and OMTs are limited to a few countries. Also, by facilitating access to liquidity, the relaxation of guarantee conditions helped the transmission of rates policy in the eurozone. We see that certain countries, such as Greece, the Netherlands, Portugal and Ireland, have benefited less from the effects of the measures of unconventional monetary policy. In fact, in Greece and Ireland, the banking system has survived thanks to liquidity provisions granted by the national central banks within the Emergency Liquidity Assistance framework.

How might the heterogeneity of the effect of unconventional measures be explained?

The structural differences within the eurozone have already explained divergences of reactions to the "conventional" monetary policy impulse. These divergences typically concern the periods of adjustment of bank rates (Leroy & Lucotte, 2016; Mojon, 2001). The most liquid or best-capitalised banks adjust their rates more slowly (Sorensen & Werner, 2006), whereas those exposed to very high credit risk adjust more quickly (Valverde & Fernández, 2007). The short-term economic characteristics (growth, housing price inflation, credit growth) also tend to influence the adjustment of bank rates (Sorensen & Werner, 2006).

From this viewpoint, we study in an original way the heterogeneity of the indirect effects of unconventional policies. The idea is precisely to evaluate the impact of rates policy conditional to certain structural and short-term characteristics of the economies studied, when unconventional measures are being implemented. To this end, we used a panel conditionally homogeneous VAR model (PCHVAR), following the method proposed by Georgiadis (2014). This model is written in the following way:

$$y_{it} = \delta_i + \sum_{j=1}^{p} A_j\left(z_{it}\right) y_{i,t-j} + u_{it} \qquad (4)$$

where y_{it} = [*Real cost of credit*, *EONIA*]' is the 2×1 vector of the endogenous variables, δ_i represents the fixed effects, u_{it} is the vector of the residuals that follow a normal distribution with zero mean and of variance $\Sigma_{u,i}$, $i = 1, \ldots, N$ represents the country and $t = 1, \ldots, T$ the time.

The originality of the approach lies on to the fact that the 2×2 matrix of parameters $A_j(z_{it})$ of the VAR depend on conditioning variables, z_{it}. As the latter are different from one country to another, and also change over time, the parameters $A_j(z_{it})$ of the VAR themselves are country specific and are time-varying. This conditionality of the parameters $A_j(z_{it})$ to the variables z_{it} allows for the measurement of the potential heterogeneity of the transmission of unconventional monetary policy instruments. So, generally, if the realisations z_{it} and z_{jt} are identical for two countries i and j, we shall say that the dynamic in the transmission of monetary policy is conditionally homogeneous in these two countries.

The procedure applied is the following. The VAR model specified in equation (4) is estimated for a given variable z_j. The matrices of the estimated parameters $\hat{A}(.)$ depend on z_j. We suppose that each element of $a_{j,sm}(z_{it})$ of $A_j(.)$ can be written in the form $a_{j,sm}(z_{it}) \approx \pi(z_{it})\gamma_{j,sm}$, with s and m respectively the lines and columns of $A_j(.)$, π is a polynomial of order one in z and γ the associated coefficient. The vector moving average (VMA) form of the model, which defines the impulse response functions (IRFs) of the model, is thus also conditional to z_j. It is possible, then, to plot the IRFs conditional to several values taken successively in the distribution of z_j; we focus particularly on its minimum value, its median value, and to the value corresponding to the last decile. We can also more closely examine whether the responses of the cost of credit to an increase of a standard deviation of the EONIA are sensitive to the characteristic z_j considered. The orthogonal impulse responses follow Cholesky's decomposition method.

Table 4 presents the conditioning variables (z) used and their sources. Summary statistics of these variables are provided in table C2-1 (online complement C2). The estimations cover the period September 2008 - December 2014. So, as well as considering the variables of conditioning z_j, the responses obtained must be understood conditionally to the ECB's implementation of unconventional measures of monetary policy over this period. In line with the results from the preceding section, the response functions offer interpretations to the heterogeneity of the indirect effects of unconventional policy measures. Finally, in general, the responses to the monetary policy shock (IRFs) are appreciated with regards to their magnitude and the number of periods during which they are significantly different from zero.

Influence of the macro-financial environment

Firstly, we examine the sensitivity of the indirect effects of the ECB's unconventional monetary policy to the economic outlook. In this respect, figure I presents the responses of the total cost of borrowing, in a period of crisis, following a monetary policy shock, dependent on GDP growth. These responses are framed by a confidence interval at 95%.

The first dial represents the response of the cost of credit to a shock of + 1 standard deviation of the EONIA rate, when the growth rate corresponds to the minimum observed over the course of the estimation period. The second (third) dial conveys the same information, but this time when the growth rate corresponds to the median value (the third one, respectively to the last decile) observed between September 2008 and December 2014. We notice that the higher the economy's growth rate, the greater the response of the cost of credit to the EONIA rate. Unconventional monetary policies would have thus benefited more the economies less affected by the crisis in terms of growth. De Bondt (2002) and Leroy and Lucotte (2016) also find a degradation of the pass-through in a time of bad economic outlook.

The probabilities of default constitute another factor likely to affect pass-through. In fact, the greater the probabilities of default in the economy, the more banks will tend to lend less (potentially going as far as rationing) rather than to pass the short rate variations on lending rates (Leroy & Lucotte, 2016). Figure II actually shows that the impact of monetary policy is declining, in magnitude and duration, as companies' probability of default increases.

With regard to the period covered, the influence of public debt is worth consideration. We observe that the response of the cost of credit to the EONIA rate decreases in magnitude with the level of debt on GDP (see figure III). The link is even broken between EONIA and the cost of credit for the levels of public debt which correspond to the last decile.

In other words, unconventional monetary policy measures would have been less effective where public debt was high, like in Greece or Italy. In this case, all other things being equal, they would not have been enough to connect the cost of credit to the short-term interest rate. In the same line of thinking, figure C2-I (in online complement C2) indicates that the response of the borrowing cost to monetary

Table 4
Definitions and sources of conditional variables

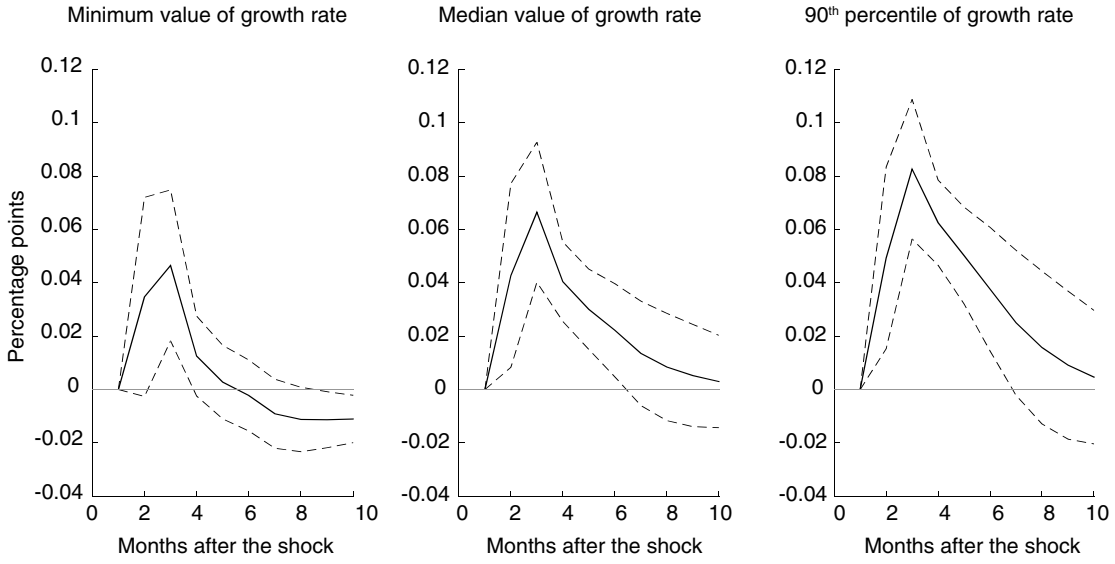
Indicator	Description	Sources
Macro-financial environment		
Debt	Public debt (% of GDP)	Eurostat
Growth	Economy's growth rate	OECD
Premium	Sovereign premium	*Macrobond*
PD	Economy's probability of default	CRI
CISS	Composite Indicator of Systemic Stress	ECB
Importance of the health of the banking sector		
Capitalisation	Banks' Capital and Reserves over GDP	ECB
Size	Total company credit (% of GDP)	ECB
Liquidity	Total household deposits over GDP	ECB
NPL	Banks' non-performing loans (% of total loans)	GFDD
Financial structure of economies		
Concentration	Herfindahl-Hirschman index	ECB
Competition	Lerner index	GFDD
Stock market capitalisation	Value of listed shares (in % of GDP)	GFDD

Note: This table presents the conditional variables used successively in equation (4), their definitions, their abbreviations and their sources.
The sovereign premium is defined by the spread of the national 10 year rates with the German rate of the same maturity. For Germany, the reference is the American 10 year rate.
The series of GDP have been split into months drawing on Denton's proportional method (see chapter 6 of Bloem et al., 2001). We consider the year-on-year growth rate. The economy's probability of default corresponds to the aggregate probability of default for all the companies: banks, financial establishments and industrial businesses.

policy impulse declines with the level of sovereign premiums, defined by the spread of national 10 year rates with the German rate of the same maturity. A similar result was obtained by Leroy et Lucotte (2016) with an Interacted Panel VAR (IPVAR).

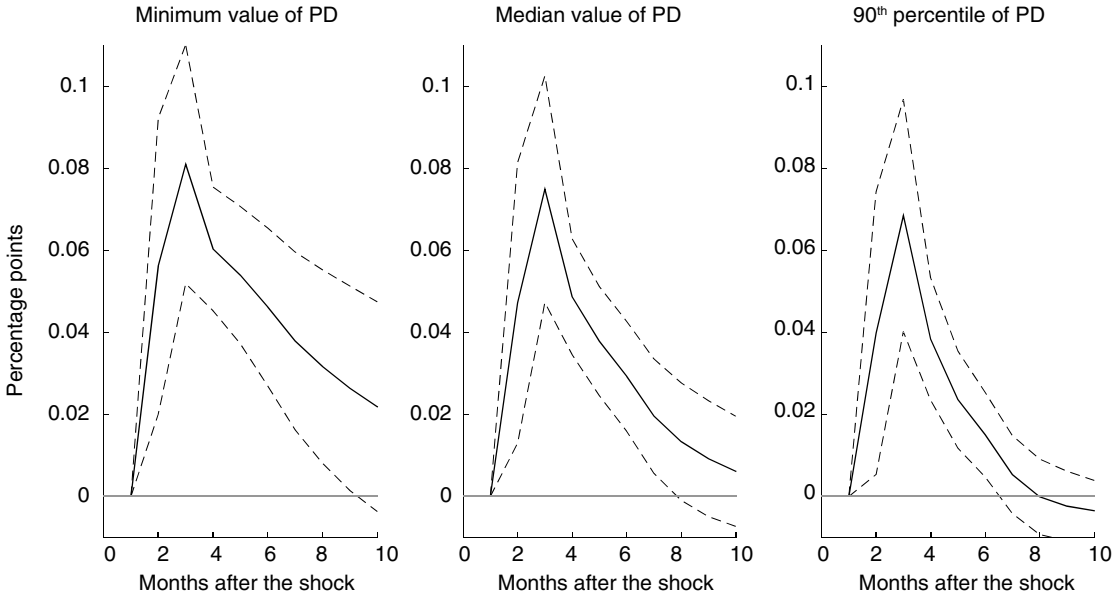
Finally, the effects of monetary policy were influenced by the level of systemic risk (Altunbas et al., 2009, 2010), measured here by the composite indicator of systemic stress, CISS (which grows with overall risk), constructed by the ECB. Again, we observe that the

Figure I
Responses of the borrowing cost to an EONIA shock and conditional to economic growth



Note: These graphs represent the responses of the real borrowing cost following a shock of +1 standard deviation of the EONIA rate conditional to GDP growth. Model (4) is estimated over the period September 2008 to December 2014. We consider the minimum value, the median and the 90th percentile of GDP growth rate over the estimation period. The solid line corresponds to the estimated response while the dotted lines represent the 95% confidence interval.

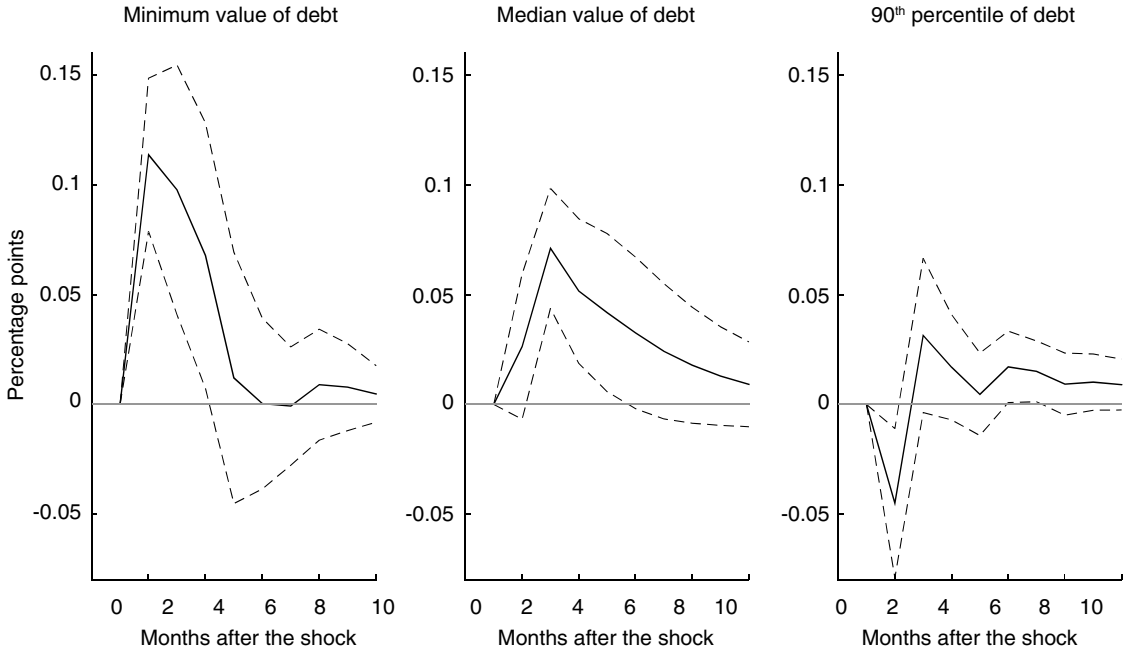
Figure II
Responses of the borrowing cost to an EONIA shock conditional to the probability of default



Note: These graphs represent the responses of the real borrowing cost following a shock of +1 standard deviation of the EONIA rate conditional to the aggregate probability of default for all the companies. The model is estimated over the period September 2008 to December 2014. We consider the minimum value, the median and the 90th percentile of the probability of default over the estimation period The solid line corresponds to the estimated response while the dotted lines represent the 95% confidence interval

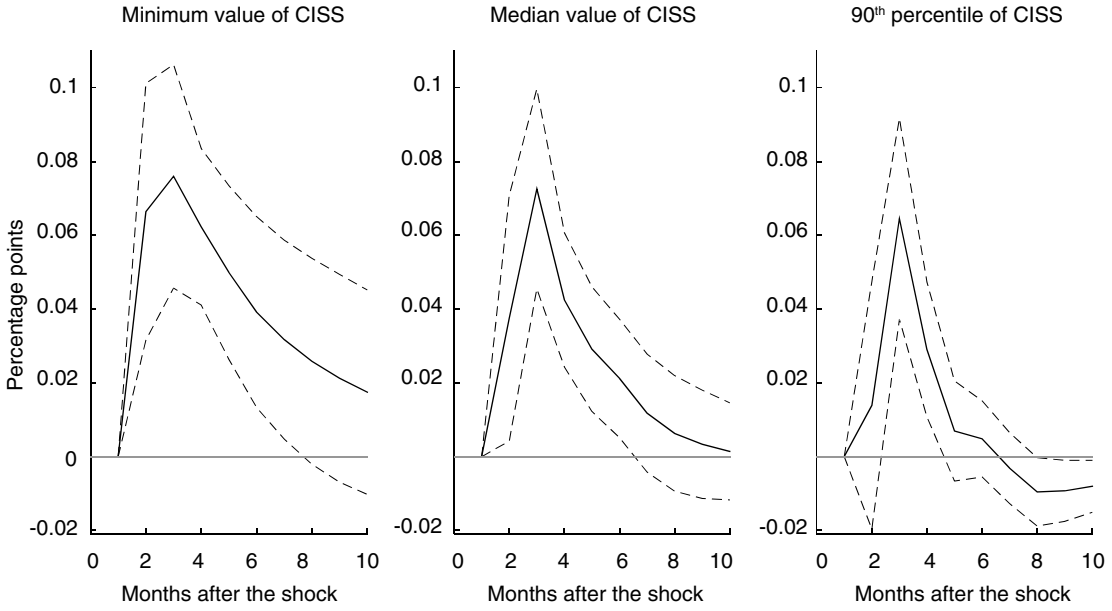
responses are not homogeneous with respect to the systemic risk. The higher the systemic risk, the more pass-through is weakened (figure IV). Banks' level of exposure to risk might have acted negatively on their propensity to grant loans (Gambacorta & Marques-Ibanez, 2011),

Figure III
Responses of the borrowing cost to an EONIA shock conditional to public debt



Note: These graphs are the responses of the real borrowing cost following a shock of +1 standard deviation of the EONIA rate conditional to the ratio of public debt over GDP. The model is estimated over the period September 2008 to December 2014. We consider the minimum value, the median and the 90th percentile of the ratio of public debt over GDP over the estimation period. The solid line is the estimated response while the dotted lines represent the 95% confidence interval.

Figure IV
Responses of the borrowing cost to an EONIA shock conditional to systemic risk



Note: These graphs are the responses of the real borrowing cost following a shock of +1 standard deviation of the EONIA rate conditional to systemic risk, measured by the composite indicator of system stress (CISS). The model is estimated over the period September 2008 to December 2014. We consider the minimum value, the median and 90th percentile of CISS. The solid line is the estimated response while the dotted lines represent the 95% confidence interval.

notably because of the worsening of the problems of asymmetry of information, which turn to reduce the transmission of monetary policy. From this point of view, the effects of unconventional measures would have been more limited in countries such as Greece, Spain and Portugal, comparatively to less risky countries like Germany and Austria.

Impact of the health of the banking sector

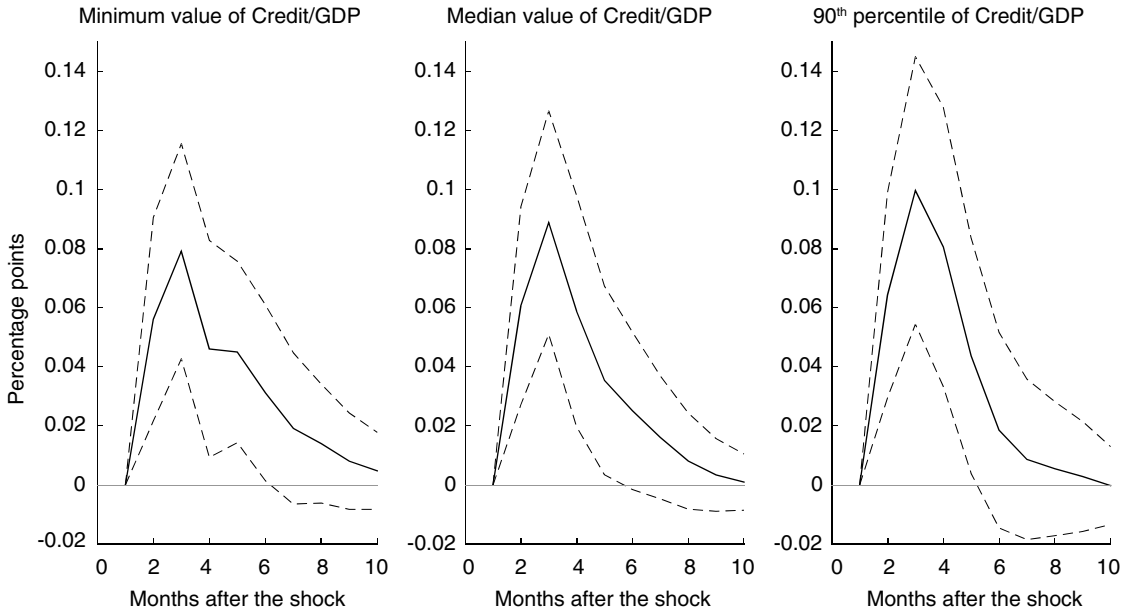
The characteristics relating to the banking sector may influence the effectiveness of monetary policy. This is what we examine first of all by considering the size of the banking sector as a conditionning variable , measured by the ratio of credit to GDP. Figure V shows that the bigger the size of the banking sector, the stronger the link between the EONIA and the borrowing cost. Banks play a critical role in the transmission of monetary policy. However, this transmission may be influenced by the banking sector's health.

In this regard, we examine first of all the influence of the banking sector's liquidity and capitalisation. We observe barely any difference in responses of the cost of credit to a shock to the EONIA, at a time when unconventional monetary policy measures are being implemented, whether bank liquidity is considerable or not (we just about see a slight long-lasting response when the liquidity ratio is very high; see figure C2-II of online complement C2).

However, the responses of the cost of credit are not homogeneous in terms of bank capitalisation (measured by banks' capital and reserves over GDP) (figure C2-III of online complement C2). In fact, the higher the capitalisation, the more the pass-through of the EONIA rate to the cost of credit is weakened. This result is usual: the best-capitalised banking sectors adjust less quickly and less completely the monetary policy impulses on to lending rates. Well capitalised banks have easier access to market financing; they are therefore less sensitive to monetary policy shock.

Finally, we note that the greater the non-performing loans, the more the pass-through is disrupted (figure C2-IV, online complement C2). All other things being equal, monetary policy shocks might not have the desired effects where the ratio of non-performing loans is high (like in Greece, Italy and Ireland). The cleaning-up of balance sheets is a necessary condition so that unconventional monetary policy may achieve its objectives. Especially given that in the countries where banks have been the most affected,

Figure V
Responses of the borrowing cost to an EONIA shock conditional to the size of the banking sector



Note: These graphs are the responses of the real borrowing cost following a shock of +1 standard deviation of the EONIA rate conditional to the size of the banking sector size measured by the ratio Credit/GDP. The model is estimated over the period September 2008 to December 2014. We consider the minimum value, the median and the 90th percentile of the ratio of credit on GDP over the estimation period. The solid line is the estimated response while the dotted lines represent the 95% confidence interval.

non-standard measures of monetary policy have been employed to satisfy liquidity needs rather than to lower the lending rate, at least at first glance (Saborowski & Weber, 2013).

Influence of the financial structure of economies

The literature on the determinants of the pass-through of monetary policy often highlights the negative effect of the financial architecture.[16] The latter, characterised in its most usual sense by bank competition, the concentration of banks and stock market capitalisation, could also influence the indirect effects of unconventional monetary policy.

The conditional responses of the real borrowing cost appear rather homogeneous with the level of competition (measured by the Lerner index)[17], as well that of concentration in the banking sector (measured by the Herfindahl-Hirschman index) (see figures C2-V and C2-VI, online complement C2).

Finally, we show in figure VI the pass-through of the indirect effects of monetary policy conditional to the ratio of stock market capitalisation on GDP. This variable is of course a measure of financial development, but it does at the same time highlight the importance of markets in the overall financial system. Put in another way, it constitutes a measure of the level of market-based systems in contrast with bank-based systems (Mojon, 2001). The development of financial markets is meant to positively contribute to the transmission of monetary policy impulses, since it bolsters competition from the point of view of loanable funds. The positive effect of competition might therefore have more impact on the financial system as a whole than in the sole banking sector.

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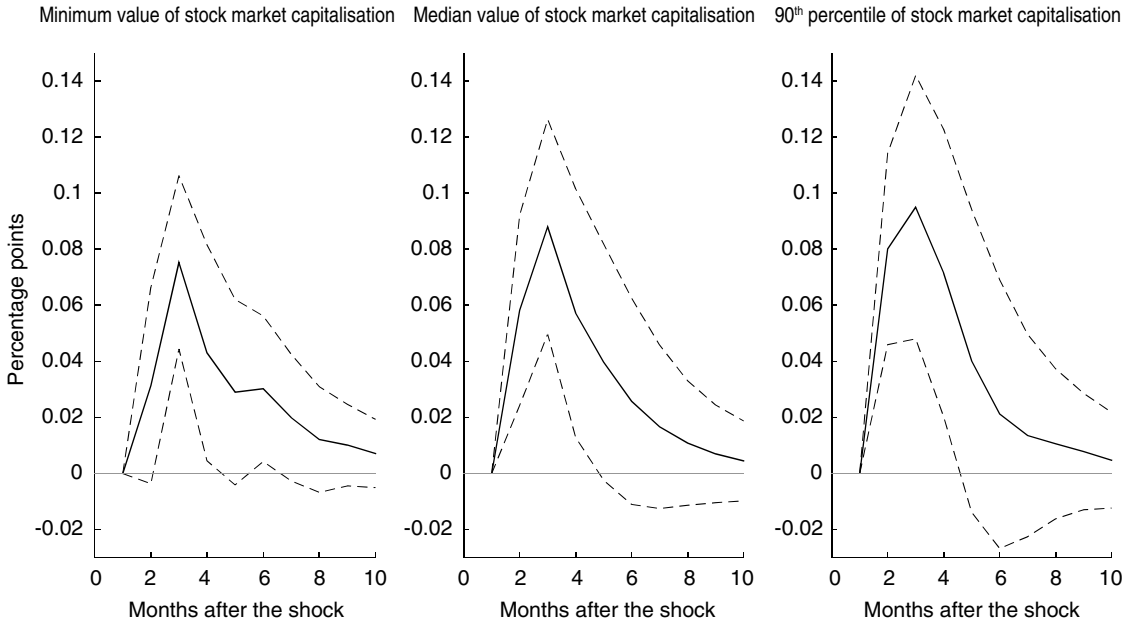
This article proposed to assess the effects of unconventional monetary policies on the cost of credit in the eurozone. With regards to the existing literature, our contribution is original in several respects: we consider all the

16. *See for example Leroy & Lucotte (2015), Sorensen & Werner (2006), Van Leuvensteijn et al. (2013).*
17. *The higher the Lerner index, the weaker the competition.*

Figure VI
Responses of the borrowing cost to an EONIA shock conditional to stock market capitalisation



Note: These graphs are the responses of the real borrowing cost following a shock of +1 standard deviation of the EONIA rate conditional to stock market capitalisation. The model is estimated over the period September 2008 to December 2014. We consider the minimum value, the median and 90th percentile of stock market capitalisation. The solid line is the estimated response while the dotted lines represent the 95% confidence interval.

unconventional measures put in place by the ECB (up until 2014), we study their impact on 11 countries in the eurozone, we distinguish their direct effects from their indirect effects, and we seek to explain the asymmetry of their impact in the member States of the eurozone.

Firstly, we describe the measures implemented by the ECB since 2008 as well as the transmission channels of UMPs. We stress that it is important to distinguish the direct effects from the indirect effects of these measures on the cost of credit. The indirect effects come down to the fact that UMPs are, also and overall, measures to accompany (low) interest rates policy. From this point of view, these measures are meant to draw the link – broken at the height of the crisis – between base interest rates and credit conditions. They should restore the functioning of the usual transmission channels of conventional monetary policy.

Our empirical analysis shows that the direct effects are very limited. More specifically, the operations of foreign currency swap, of relaxing guarantee conditions, as well as asset purchase programs (OMT, SMP and CBPP), have not had any direct impact on the cost of credit. Only the fixed-rate full allotment (FRFA) and of long-term refinancing operations (LTROs) have had significant direct effects. Also, Austria, Finland, France, the Netherlands and Italy would not have benefited from any direct effect, whatever the measure considered. The indirect effects are more compelling. Our econometric results validate the presumed complementarity between unconventional measures of monetary policy and zero rate policy. Each measure had an indirect effect on at least one country. However, some countries benefited less than others (this is the case for Ireland, for example).

This observation leads us finally to study the causes of this heterogeneity of the impact of the indirect effects of unconventional measures. Specifically, we seek to evaluate the impact of policy rates conditional to certain structural and short-term economic characteristics of the economies under study, in a time when unconventional measures of monetary policy are being implemented. We use a panel conditionally homogeneous VAR model (PCHVAR). We find that the asymmetry of the responses to a policy shock in the eurozone is explained, on the one hand, by macro-financial differences: growth rate, probability of default, public debt and systemic risk. They are explained, on the other hand, by the heterogeneity of the banking sectors, through differences in capitalisation and the size of non-performing loans. Competition and financial concentration would have had a lesser effect on the differences of transmission. So, from this point of view, and overall, the effects of unconventional policy implemented by the ECB have been greater in Germany and Austria, for example, than in Greece, Italy, Spain or Portugal.

Indeed, unconventional monetary policies have overall contributed to the reduction of the cost of credit in Europe. But high public debt, high systemic risk, weak growth, strong probability of default and a high proportion of non-performing loans have somehow reduce their impact. Therefore, these measures are not sufficient to reduce the risk of fragmentation. From this point of view, unconventional monetary policies have not necessarily been the most effective where the needs were comparatively the greatest in terms of the cost of credit. First of all, over the course of the financial crisis, we saw a bank credit rationing in certain countries. Then, with the sovereign debt crisis, the cost of bank financing increased, aggravating the difficulties in financing NFCs and consequently their default risk. All these developments increased the heterogeneity in the transmission of monetary policy.

However, these observations do not mean that the unconventional measures have been useless. As the ECB highlights, *"unlimited provision of central bank liquidity to banks at a fixed rate exerted significant downward pressure on money market rates and bank lending rates. Consequently, interest rates on short-term loans declined steadily. Likewise, overall financial market volatility decreased substantially."*[18] But complementary measures, on the national level, such as budget support, the creation of defeasance structures, public debt restructuring and/or structural reforms, would have been (or are still) necessary for the most affected countries. □

18. Arguments put forward by José Manuel González-Páramo, Member of the Board of Directors of the ECB during the conference organised by Cámara de Comercio de Málaga [Malaga Conference Room] and the University of Malaga in Malaga on 18 June 2010.

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Monetary policy, illiquid collateral and bank lending during the European sovereign debt crisis

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Abstract – This paper assesses the effect on banks' lending activity of accepting illiquid collateral at the central bank refinancing facility in times of wholesale funding stress. We exploit original data on the loans granted by the 177 largest euro area banks between 2011m1 and 2014m12 and on the composition of their pool of collateral pledged with the Eurosystem. During this period, two-thirds of the banks in our sample experienced a sizable loss of wholesale funding. Panel regression estimates show that the banks that pledged more illiquid collateral with the Eurosystem reduced their lending to non-financial firms and households less: a one standard deviation increase in the volume of illiquid collateral pledged corresponded to a 1.1 % increase in loans to the economy. This result holds for banks that were and were not run. Our finding thus suggests that the broad range of collateral eligible in the euro area may have helped to mitigate the credit crunch during the euro debt crisis.

JEL Classification: E52, E58, G01, G21
Keywords: collateral, loans, central bank, euro crisis

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Banks extract profits from maturity and liquidity mismatches in their balance sheet: they fund long-term and illiquid claims on the asset side (*e.g.* loans), with shorter-term and more liquid debt on the liability side (*e.g.* interbank deposits) – see Kashyap et al. (2000) and Gorton and Winton (2003) for a survey. They face a risk that these resources are withdrawn before their asset side matures, which threatens their liquidity position. This situation is often referred to as a bank run. Bryant (1980) and Diamond and Dybvig (1983) formalize this risk, usually associated with the role of banks in transforming short-term liabilities into longer-term financing. It is well known since Thornton (1802) that in a situation of financial crisis, the appropriate response for a central bank is to increase its volume of refinancing. Bagehot (1873) added that this lending must be unlimited and guaranteed by collateral of good quality in normal time. Since Friedman and Schwartz (1961) and Bernanke (1983), it has been established that bank runs can evolve into a credit crunch, during which the aggregate balance sheet of banking sector shrinks and eventually contracts its supply of loans to the economy, thus depressing macroeconomic activity.

Fighting financial panics is a key role of central banks. The academic literature usually referred to this role as the lender of last resort function of central banks. The goal is to replace the lost funding of banks by central bank reserves in order to avoid the transmission of the financial stress created by illiquidity to other agents. Because the central bank needs to be protected against counterparty and credit risk, operations of lending of last resort are secured by collateral, which means that banks have to pledge eligible assets against the central bank refinancing. The range of eligible collateral varies considerably across time and central banks, and the Eurosystem[1] accepts one of the broadest set of assets as collateral for its refinancing operations, from government bonds to credit claims.

There is some discrepancy between the understanding of lending of last resort tools in the academic debate and within central banks. Within the Eurosystem of central banks (or ECB as it is often inappropriately referred to), a first set of instruments labelled as lending of last resort instruments comprises the Marginal Lending Facility and the Emergency Liquidity Assistance[2]. Both are designed to fight a particular funding shock on a specific or restricted number of financial institutions. We do not deal with those instruments in this paper. We focus on the second set of instruments that central banks used as part of the implementation of their monetary policy and that is aimed at addressing the threat posed by systemic risk, and notably systemic bank runs, on macroeconomic outcomes. Some of those instruments are specifically designed to counteract a specific financial crisis and are usually grouped under the heading of "unconventional monetary policy tools" while others are part of the normal operational framework of central banks[3]. Both are aimed at fulfilling the mandate of the Eurosystem as defined by the Treaty of the Functioning of the EU, and hence are used to mitigate the threat posed by financial risk on the evolution of macroeconomic outcomes and notably the inflation rate. Unconventional tools have attracted a lot of attention, maybe to the detriment of the evaluation of how the operational framework can help to mitigate a financial crisis. We focus our paper on the contribution of a specific provision of the collateral framework of the Eurosystem and ask whether this provision may have contributed to smooth the consequences on credit supply of the European sovereign debt crisis.

The period of the sovereign debt crisis is well suited to inform on the impact of the central bank collateral framework on the economy. First, the period is characterized by a sharp reduction in money market funding and hence an increased reliance on central bank borrowing. The reduction in funding resulted in part from the reduction of the dollar funding of European banks by U.S. money market mutual funds (see Correa et al., 2013, and Ivashina et al., 2015). As we document in this paper, this run was also accompanied by a sharp reduction in euro-denominated wholesale funding, which was apparent in the reduction of the activity in the euro area interbank market. In our data at least some banks of

1. The Eurosystem is composed of the European Central Bank (ECB) and the national central banks that implement monetary policy.

2. The main difference between the Emergency Liquidity Assistance (ELA) and the Marginal Lending Facility (MLF) is the determination of who is bearing the residual risk in case of default of the counterparty. Because the ELA aims to refinance solvent banks that face temporary liquidity problems outside of normal Eurosystem monetary policy operations, this assistance falls to the national central bank after the authorization of the governing council. Among other reasons, the ELA may be used to refinance banks constrained on the collateral defined in the general list of the Eurosystem.

3. This paper does not deal with many other crucial issues related to unconventional monetary policy measures undertaken during the crisis. Interested readers can refer to Claeys (2014) and Marx et al. (2016) for surveys.

all countries were hit by a wholesale funding shock. Second, macroeconomic risk and the anticipation that some countries might have to exit the euro area reduced the market value of some European government bonds, which are the main source of liquid marketable assets in the euro area. The countries most hardly hit by the sovereign debt crisis are (with no particular order) Spain, Italy, Portugal, Greece and Ireland. Third, securitization – which can be used by banks to convert illiquid loans into more liquid asset-backed securities and covered bank bonds – was of little help during this period: the securitization activity was already small before 2007, and shrank further in the wake of the subprime crisis. All in all, wholesale funding stress increased the demand for central banks reserves and put pressure on collateral availability. The acceptance of illiquid collateral by the Eurosystem could thus have helped banks to sustain their lending activity or reduced the incentive to cut lending to the economy.

This paper studies the lending of last resort function of the Eurosystem in a time of bank funding stress, from the perspective of its collateral policy. We show that the collateral policy of the Eurosystem that allows banks to pledge credit claims of good quality as collateral boosted lending activity for banks that suffered and did not suffer a bank run during the euro debt crisis[4]. As documented in section 2, the ability to pledge credit claims is part of the regular operational framework of the Eurosystem since the creation of the Eurosystem and was only slightly modified with the crisis.

To show this result, we exploit three bank-level datasets at a monthly frequency. The first dataset reports all refinancing operations with the Eurosystem. The second dataset details the pool of collateral pledged by each bank as a guarantee for these refinancing operations. The third dataset reports the evolution of euro area banks' balance sheets. The final database consists of information on the 177 largest euro area banks at monthly frequency between January 2011 and December 2014. We construct a measure of interbank funding loss, and define a run variable at the bank level. For each bank, we also compute the volume of illiquid assets pledged with the Eurosystem as a share of its balance sheet. We interpret this share as a measure of a bank's ability to liquefy the most illiquid part of its balance sheet.

We estimate panel regressions in which the dependent variable is the lending activity to non-financial corporations and households, scaled by balance sheet size over the 2011-2014 period. We explain this variable by the intensity of the run that affected the bank, and by the total volume of collateral and the volume of illiquid collateral pledged. We crucially control for banks' specificities (capital ratio, ratings and bank fixed effects) and for common fluctuations of loans at the country level.

Our main result is that an increase in the share of illiquid assets pledged was associated with greater resilience of lending activity. More concretely, a one standard deviation increase in the volume of illiquid collateral pledged with the Eurosystem corresponded to a 1.1 % increase in loans to the economy. This effect was due equally to a quantitative effect of collateral –an increase in the outstanding volume of collateral increased the supply of loans– and a composition effect –a shift from liquid to illiquid collateral was associated with an increase in loans for a given volume of collateral pledged with the central bank. This result, which also holds for banks that were run, is important as the transmission of monetary policy in the euro area relies mostly on bank lending, which represents an overwhelming share of non-financial firms' financing.

Our result also suggests that bank runs were associated with a reduction in loans. A one standard deviation increase in the intensity of the run led to a 0.9 % drop in the loan supply. This drop was smaller for banks with a higher volume of collateral, irrespective of its liquidity class. Finally, we find that an increase in the equity ratio was associated with more loans.

Our paper is related to four parts of the literature. First, we investigate the impact of the degree of liquidity of the assets held by banks on the implementation of monetary policy. Kashyap and Stein (2000) have shown that banks holding less liquid assets tend to reduce their lending to the economy more when hit by an adverse funding shock (which they identify as an increase in the interest rate). As explained before this paper shows that the more illiquid the collateral banks can pledge with the central bank, the more resilient to bank runs lending activity is. Second, we contribute to

4. In the rest of the paper, unless specified, we use non-marketable assets, credit claims, illiquid assets or loans interchangeably to describe the loan portfolio of a bank that is pledged or pledgeable as collateral with the central bank. We describe in details the operational framework and the properties of the eligible collateral in section 2.

the theoretical literature by providing empirical evidence on the instruments central banks can use to mitigate the real effect of bank runs, notably through the lender of last resort (see Diamond & Dybvig, 1983; Diamond & Rajan, 2005). Third, our paper contributes to the literature that shows that the technicalities of the implementation of monetary policy are keys in crisis time and specifically show that the type of collateral that a central bank must accept is not neutral (Bindseil & Papadia, 2006; Bignon & Jobst, 2017). We emphasize the importance of the ability to pledge good quality but illiquid collateral. Fourth, we provide empirical evidence to support the theoretical argument according to which the central bank has a (very) long horizon because of its monopoly on the creation of reserves and banknotes. This allows the central bank to hold assets that the market would not be ready to hold, as argued by Bindseil (2014), Bindseil & Jablecki (2013) and Bindseil (2013).

The rest of the paper is structured as follows. Firstly, we describe the collateral framework of the Eurosystem of central banks, and present the data. Then we discuss the empirical evidence on the runs on euro area banks and add further evidence on the quantitative importance of the loss of wholesale market funding by European banks for the period between 2011 and 2014. Finally we present the main specification and our main results on the relation between collateral liquidity and the supply of bank loans.

Eurosystem refinancing operations and collateral framework

The Eurosystem issues central bank money and refinances the euro area banking system through regular "open market operations" (see Bindseil, 2014). They take the form of temporary loans of reserves against collateral. All credit institutions, defined as financial intermediaries that receive deposits and grant loans, are eligible if they fulfill the Basel capital ratio[5]. The Treaty on the Functioning of the European Union forbids the Eurosystem to discriminate against counterparties on the basis of their quality –for example the equity ratio– or business model.

The maturity of refinancing operations ranges from one week to four years. Before 2008, regular operations were conducted every week and every month; their maturity was progressively extended with the unfolding of the crisis events to 3, 6, 12, 36 and finally 48 months and designated as longer-term refinancing operations (LTROs). The issue of the maturity must however not be overemphasized as banks can borrow unlimited amounts of reserves since October 2008.

To insure against counterparty default risk, the Eurosystem requires each borrower to pledge collateral. Since October 2008, the Eurosystem has been lending to credit institutions at a fixed interest rate and satisfies all bids submitted by banks. With this policy of fixed rate and full allotment and given the low interest rates, the implication is that the only relevant upper bound on the issuance of reserves is the total value of banks' eligible collateral.

Among central banks, the Eurosystem accepts one of the broadest range of assets as collateral (see ECB, 2013a and BIS, 2013)[6]. The set of eligible assets is larger than the set of collateral eligible with central clearing counterparties, the main operators of the private interbank market[7]. As part of the tools used to counteract the financial stress triggered by the failure of Lehman brothers in September 2008, the Eurosystem has expanded a number of times the list of assets eligible as collateral, but only one of those instances relates to the illiquid collateral (ECB, 2013b).

As a general rule, no asset with a default probability greater than 0.4% at a one-year horizon is eligible as collateral with the Eurosystem. Some securities are permanently accepted ("General framework"), while some other securities are accepted only temporarily ("Temporary framework"), as part of the measures taken by the Eurosystem to cope with the financial crises. The temporary list includes assets that have a default probability greater than 0.4% but lower than 1.5% at a one-year horizon. A single list of all the securities eligible as collateral for the whole of the euro area is published on the ECB's and national central banks' websites. The collateral is pledged at the desk of one of the national central banks. Although this makes a refinancing operation resemble a repurchase agreements (repo), it is

5. Basel III capital requirements as defined in http://www.bis.org/publ/bcbs189.htm.

6. All the operational details described in this section have been in place from October 2008 to the date of the publication of this paper.

7. For example, Eurex CCP accepts a list of 11,000 eligible marketable securities (see Mancini et al., 2015) while the Eurosystem's single list of collateral comprises about 40,000 different marketable securities.

more accurate to describe it as a collateralized loan, as the assets pledged are –apart from a few exceptions– generally not earmarked to a specific operation[8]. The assets are rather deposited in a pool to secure any of the potential operations of the bank with the Eurosystem. It is also noteworthy that ownership of the assets is transferred to the Eurosystem only in case of default.

The collateral framework of eligible assets comprises two categories: marketable assets – assets that are traded in organized markets– and non-marketable assets –mostly credit claims such as mortgages and loans to non-financial companies of sufficiently low credit risk.

The marketable collateral consists of a set of between 35,000 to 45,000 unique securities identified by their International Securities Identification Number (ISIN). Eligible securities are classified into one of the five following categories. The first category consists of the most liquid assets: euro area government bonds, quasi-central banks reserves, i.e. fixed-term deposits (deposits of banks at the ECB, due to the early sterilization of the Securities Markets Programme) and cash. The second category comprises the bonds issued by supranational, public agencies, local and regional government, and "Jumbo" covered bonds with an outstanding amount greater than EUR 1 billion. The third category comprises covered bank bonds and corporate bonds, while the fourth consists of unsecured bank bonds. The fifth category comprises asset-backed securities. Any security must have a minimal rating of BBB– and must be issued in the European Economic Area.

The non-marketable collateral mainly comprises loans, referred as credit claims (CC). Credit claims have been accepted as collateral since the creation of the Eurosystem, but have been included in the general collateral framework with the introduction of the single (harmonized) list of collateral in 2007. A credit claim is eligible if it has a fixed and unconditional principal amount and if its interest rate is such that it prevents the occurrence of any negative cash flows (Tamura & Tabakis, 2013). It is also required that the default probability of the loan is estimated to be lower than or equal to 0.4% in the Basel definition of a default probability. Only credit claims issued by euro area debtors are eligible.

The acceptance of a credit claim as collateral depends on the regulation defined at the euro area member state level, notably depending on the obligation or not to notify the debtor of the mobilization of its loan in the collateral pool (Sauerzopf, 2007). It also depends on the existence of a minimum threshold amount[9]. In December 2011, the ECB's Governing Council allowed national central banks to temporarily accept loans with the same characteristics as the loans acceptable in the General Framework but with a default probability between 0.4% and 1.5% (Bignon et al., 2016). This temporary extension is known as the "Additional credit claims" measure (ACC hereafter) and is reviewed every year by the Governing council of the Eurosystem. Eight national central banks participate in this programme (see ECB, 2012). Credit claims and additional credit claims (in value terms after haircut) amounted to a maximum of 27% of the total value after haircut of the collateral pool in 2012q4 or 670 billion of Euro (see Figure I).

As long as there is a reliable market price, collateral is priced at market value, but in some cases –*e.g.* asset-backed securities– the Eurosystem operates its own model-based pricing capabilities (the "Common Eurosystem Pricing Hub"). Credit claims are valued at residual outstanding amount. A haircut is deduced from the market or model value or from the outstanding amount. As a general rule, the haircut is asset-specific and does not depend on the counterparty. It varies with the credit risk associated with the securities, as measured with the principle of first best rating (second best rating for ABS). Ratings can be taken from one or more authorized rating agencies and in some cases from ICAS (the Internal Credit Assessment System)[10]. The haircut also varies with the residual maturity of the asset (typically, the longer the residual maturity, the higher the haircut), with the liquidity risk (typically, the more illiquid the security is, the higher the haircut) and with coupon type. Table A-3 in Appendix details the valuation haircut grid used by the Eurosystem in the case of credit claims. By way of illustration, the haircut of certain credit claims can be as high as 65%. The sum of all after-haircut value of the assets

8. The Banco de España still authorizes earmarking as an option (see Tamura & Tabakis, 2013).

9. EUR 500,000 is the minimum threshold for cross-border loans, while the minimum amount is at the discretion of each national central bank for other loans.

10. See for instance: https://www.ecb.europa.eu/paym/coll/risk/ecaf/html/index.en.html.

pledged by a counterparty defines the maximum amount of borrowing for a given bank with the Eurosystem.

It is noteworthy that on aggregate, there is no evidence of collateral scarcity during the period under study. The total outstanding amount of the eligible marketable securities (valued at market prices) increased from EUR 11 to 14 trillion from 2008 to 2014. This is more than ten times larger than the maximum of EUR 1 trillion in refinancing borrowed by banks.

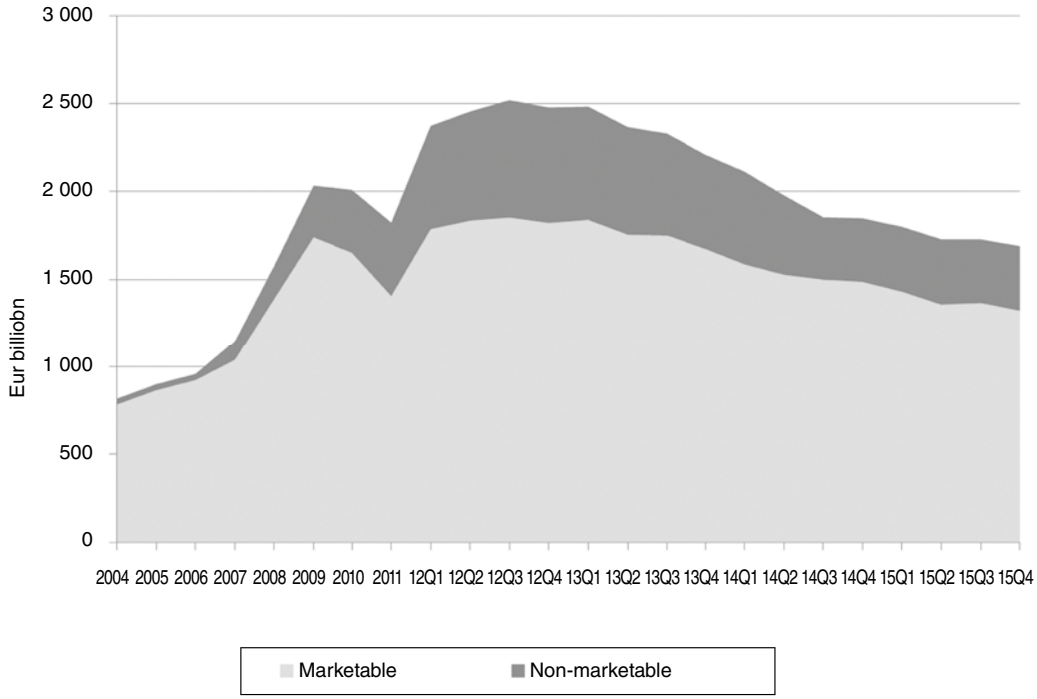
However, the collateral constraint –defined as the ratio of the reserves borrowed to the value of the pool of collateral after haircuts– may have been binding at the bank level. In June 2012, at the onset of the crisis, 11% of the banks in our database had a utilization rate of their collateral pool greater than 90%, while 20% had a utilization rate greater than 80%. These levels are especially high if one remembers that the collateral pool is also used to secure the intraday payments made by banks using the Eurosystem-operated payment system that is known as Target 2. A bank can thus be collateral-constrained for its refinancing operations well below the 100% threshold. Moreover, eligibility criteria may matter even for banks that are over-collateralized. The eligibility of certain assets as collateral is likely to impact their relative degree of liquidity compared with non-eligible assets and hence to alter the incentive to hold them.

Data and construction of variables

We construct and merge three databases at the bank level. The first database reports the evolution of banks' balance sheets. The second provides the composition of the collateral pool pledged by each bank with the Eurosystem. The third gives the volume of refinancing operations of each bank with the Eurosystem.

Presentation of the databases. The first database is the Individual Balance Sheet Items dataset (IBSI), which includes data on the balance sheets of the 255 biggest banks in the euro area since 2007 at a monthly frequency. It is compiled by the ECB and national central banks, and is made available to Eurosystem researchers on a confidential basis. The sample of reporting banks has been chosen to include the 150 largest euro area banks by total assets, to reflect the representativeness of the euro area countries' banking systems and to reflect banks'

Figure I
Collateral pledged with the Eurosystem since 2004 after valuation and haircut



Coverage: All banks that have maintained a collateral pool with one central bank of the Eurosystem.
Source: Authors' computations using Eurosystem data on collateral pledged with the Eurosystem by the euro-area banking system.

participation in refinancing operations and the diversity of their business models. The banks in the IBSI dataset account for almost 70% of both the total main assets of the euro area banking sector and the total credit supply to euro area residents, as shown in Table 2.

We clean the database for mergers and acquisitions. To this end, we first search for large abnormal changes in the size of banks' balance sheets. When we are unable to find any meaningful explanation for this change using publicly available information, we drop the bank. When this abnormal change corresponds to the month of a bank merger or acquisition, we split the series into two parts to build a pre-merger and a post-merger series. We choose to clearly identify a merger to allow the new and the old entities to display possibly different characteristics. We also drop banks that do not lend to households or non-financial corporations, and exclude banks that never borrow either in the interbank market or from the Eurosystem, i.e. banks that are unconcerned about posting collateral[11]. In the end, our final database consists of 177 banks. This is equivalent to the number of banks included in other papers using IBSI data (see for instance de Haan et al., 2015). The 177 banks represent half of the banking activity of the euro area (see Table 2).

The second database provides the composition of the collateral pool pledged by banks with one of the Eurosystem national central banks from January 2011 to December 2014. This proprietary database is typically used for operational purposes in the implementation of monetary policy refinancing operations. On average, 1,650 banks have maintained a collateral pool with the Eurosystem, with a minimum of 500 banks and a maximum number of 1,850 banks. The dataset comprises the composition of each pool at the security or loan level. The database comprises 8,174,320 observations of pledged credit claims, i.e. an average of 50,603 loans per bank and month. We use this database to extract information at the monthly frequency on the total value of the collateral pool after haircut and on the total value after haircut of credit claims pledged by each bank.

The third proprietary database reports each refinancing operation made by individual banks with the Eurosystem, from the 1-week horizon in the context of the Main Refinancing Operations (MROs) to the Long-Term Refinancing Operations (LTROs), which have a 1-month

11. This feature is rare and signals a specific business model that is not comparable to other banks.

Table 1
Banks' balance sheets in the Individual Balance Sheet Items database

Assets	Liabilities
Loans to households (HH)	Capital and reserves
Loans to non-financial corporations (NFC)	Debt
Loans to monetary and financial institutions (MFI)	Deposits HH
Loans to government	Deposits NFC
	Deposits MFI
Bonds (government and corporate)	
Stocks	
External assets	External Liabilities

Table 2
Coverage of the Individual Balance Sheet Items sample, as of end-2014m12

	EA	IBSI sample	Final sample	Coverage (Final/EA)
Number of monetary and financial institutions (MFI)		255	177	
Total assets (Eur bn)	27,825	19,010	15,084	54%
Total loans (Eur bn)	17,094	11,789	9,175	54%

Source: ECB Individual Balance Sheet Items monthly report.

to 4-year horizon[12]. We construct a monthly series of the stock of refinancing of each bank, taking into account that some of these operations were repaid early. On average, 524 banks participated in the refinancing operations each month, with a minimum of 144 banks and a maximum of 997 banks a given month.

Merging these three databases gives a population of 177 banks at the monthly frequency between January 2011 and December 2014. Banks are not necessary present all the time in the sample and we run our regressions on 8221 observations[13].

Construction of the variables. We construct, for each bank at each date, the following variables. First, we construct the stock of loans to the economy as a share of the total bank balance sheet one period before. We label this variable *Loans* while the total of the balance sheet is labelled as *Assets*. It includes both loans to households and to non-financial corporations, but we exclude loans to other monetary and financial institutions to avoid capturing a feedback loop between banks. The latter is reported under the *Interbank lending* heading.

Then, we construct the share of illiquid collateral pledged by each bank with the Eurosystem by computing the ratio of the value after haircut of all credit claims pledged with the Eurosystem scaled by the size of the bank balance sheet one period ahead. For each bank, we use the end-of- month value of credit claims and additional credit claims. We label this variable *Illiq collat*. Similarly, we compute *Liq collat*, the share of liquid collateral, defined as government and corporate bonds. The sum of these two ratios is *Illiq + Liq collat*.

Finally, we construct a measure of the reliance of each bank on wholesale funding. We label this variable *Interbank* Because the refinancing of the Eurosystem is recorded under the heading deposits from MFI, we subtract from the variable *Deposits MFI* on the liability side of a bank's balance sheet the stock of the bank's refinancing with the Eurosystem. The reason is that from an accounting point of view, a central bank is a bank, and hence the borrowing from it is part of *Deposits MFI* item. To properly measure the funding loss from the interbank market, we therefore construct a measure of interbank funding net of central bank refinancing. Another item of wholesale funding external to the euro area (and hence including from the US money market mutual funds) is accounted for under the heading *External Liabilities*. By adding these two items, we obtain a measure of gross wholesale funding for each bank. In the rest of the paper, we label this variable –with a slight abuse of language– *Interbank borrowing*. We use gross wholesale funding to construct a measure of the bank run that we define in the next section. Finally, we also measure net exposure to wholesale funding by subtracting the amount of interbank lending on the asset side of the bank's balance sheet to obtain the *Net interbank position*.

Bank financing and the run on European banks

Banks are traditionally reliant on short-term funding sources such as interbank loans or money market mutual funds deposits[14]. Market funding can be either unsecured or secured with collateral (repos), but the unsecured segment almost disappeared in the euro area with the subprime crisis in 2007[15]. This paper studies the aggregate volume of interbank and money market funding rather than studying a specific money market instrument. This allows us to take into account both the European banks' borrowing from U.S. money market mutual funds and total European –mostly secured– interbank lending. The drying-up of the external short-term funding of euro area banks from U.S. money market mutual funds (MMFs hereafter) has been documented by Correa et al. (2013), Chernenko and Sunderam (2014) and Ivashina et al. (2015). Mancini et al. (2015) have documented the partial substitution between unsecured and secured money market funding by European banks. Pérignon et al. (2017) focus on wholesale funding raised through certificates of deposit since 2007, showing that the aggregate volume did not vary significantly and that some banks suffered from a sharp reduction

12. LTROs comprise also: TLTRO, targeted long-term refinancing operations through which banks can borrow only if they achieved a certain target of lending and VLTRO, very long term refinancing operations that are unconditional to the use of the refinancing.

13. 3,559 observations of banks never run+4,840 observations of banks run at least once at the monthly frequency (see tables 3 and 4) -177 observations = 8,222 (as we run regression with a right-hand side lagged-value variable) and one bank has missing values missing during one month.

14. See for example Chapter 3, "Changes in bank funding patterns and financial stability risks", of the 2013 IMF Global Financial Stability Report, pp. 105–148.

15. The various issues of the ECB's yearly money market survey document the sharp reduction in funding on the unsecured segment of the interbank market, starting with the subprime crisis in 2007.

while other did not. By focusing on an aggregate measure of wholesale funding, we therefore avoid the difficulties associated with the treatment of the substitution across different short-term funding sources.

There are two narratives of the euro debt crisis in terms of what caused the drying-up of banks' wholesale funding. Some papers describe the euro crisis as a run on banks caused by their holdings of too much (risky) domestic sovereign debt (see for example Acharya & Steffen, 2015). Others emphasize the macroeconomic origin of the crisis: The expectations of the breakup of the euro area triggered a sharp reduction in cross-border wholesale funding, for fear of counterparty risk. We do not take a position in this debate but instead construct two types of measures of the euro area wholesale funding run that may reflect either one or the other potential causes of runs. We first compute the average funding loss of banks and describe the construction of the variables.

Measuring the run. We construct a measure of the loss of wholesale funding by defining a run in terms of two aspects. The first aspect is a *duration* variable measuring the time during which a bank suffered from a reduction in wholesale funding. The second aspect is a variable measuring the *size* of the run. We multiply the *duration* variable by the *size* variable to obtain the *Run* variable. The *duration* variable is a dummy that is set equal to 0 during the period in which the bank had a stable interbank funding. For a bank, a run starts if its *Interbank funding* variable decreases by at least 10% on a month-on-month basis over the 2010m1-2014m12 period[16].

For any bank that has breached the 10% funding loss, we then run a break test in level of one unknown break to decide the date of the end of a run. We set equal to 1 the *duration* variable in all months between these two dates. Otherwise, we set it equal to 0.

The *size* variable measures the size of the run suffered by the bank. The loss is measured as a cumulative loss of wholesale funding computed as the percentage change in wholesale funding between the first and the last month of the run as a percentage of total assets at the bank level.

16. We have checked that all 10% drops in our sample –when they occur– are greater than one standard deviation of the month-on-month changes in interbank funding.

More precisely:

$$size = \frac{Interbank^{last}}{Assets^{last}} - \frac{Interbank^{start}}{Assets^{start}} \qquad (1)$$

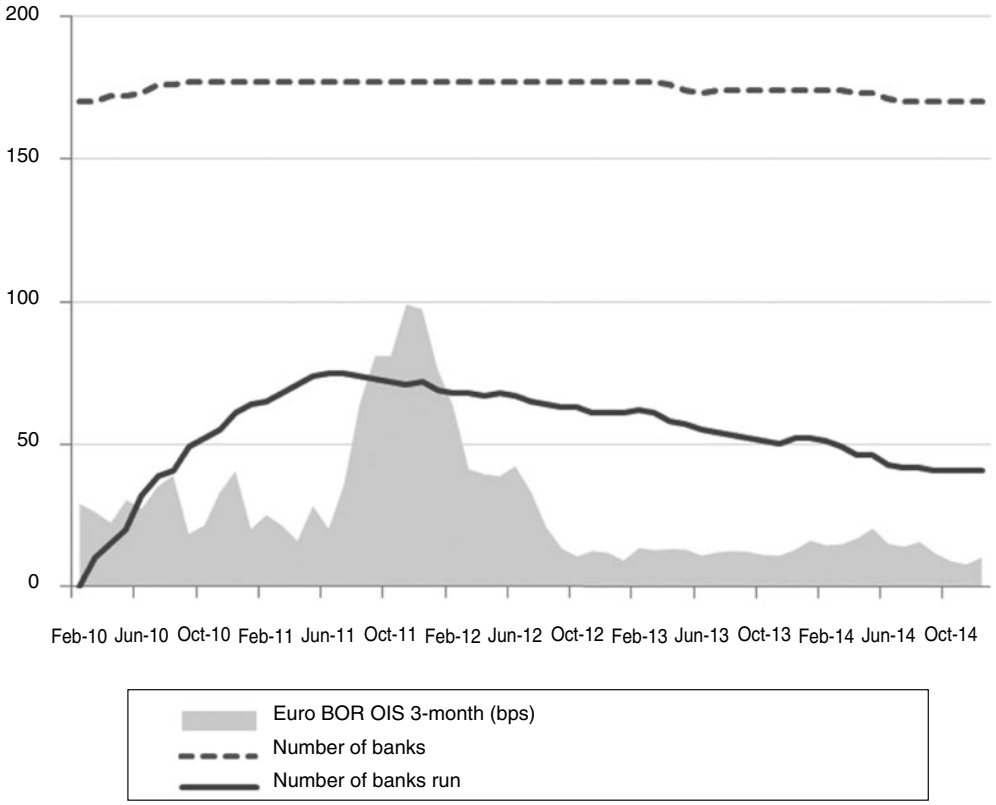
where the subscript *start* (*last*) indicates the first (last) month of the run. The *Interbank* and *Assets* variables denote the amount of wholesale funding and the total assets of the balance sheet of a bank respectively.

Figure II plots the number of banks that were run according to our definition of a run. It shows that a maximum of 77 banks were simultaneously run during the summer of 2011, among the 177 banks of our sample. We also overlaid a measure of interbank market stress, the "BOR-OIS" spread between unsecured 3-month interbank loan (Euribor 3-month) and the same tenor overnight-indexed swap (OIS) in which the principal is never exchanged and thus considered as almost risk-free rate. Interestingly, our measure on the number of bank runs increases continuously and reaches its maximum before the greatest peak of the interbank market stress measure of the Fall of 2011, suggesting that the aggregate outcome in terms of interbank stress is preceded by individual difficulties in the wholesale funding market.

We exploit the IBSI database to describe the main differences between the banks that were run and those that were not. More precisely, Tables 3 and 4 give the average value of the main balance sheet items for banks never run, and the same statistics for banks run at least once over the 2011m1-2014m12 period. The "*Run*" variable shows that the 102 bank runs correspond to an average wholesale funding loss equivalent to 6% of the bank's total liabilities. At the 95% percentile, this average loss amounts to 19%.

The banks that were run do not seem to differ otherwise on average from the banks that are not run, based on their balance sheet composition. The share of lending to the economy over total assets is 54% *vs.* 53% respectively. Similarly, the share of interbank lending to the other banks –with 14% *vs.* 17% respectively– or the share of securities held –with 17% *vs.* 15% respectively– are identical for the two groups of banks. On the liabilities side, the equity capital and the debt issued by the two types of banks stand at similar levels, although the capital ratio of banks that are run is slightly higher –at 8% *vs.* 7% for banks that are not run. The banks run do not differ in terms of the share of long-term debt (bonds) as a percentage of their total liabilities

Figure II
Total number of banks and of banks run Jan 2010 - Dec 2014



Note: For the exact definition of the run, see the text.
Coverage: 177 banks from the IBSI database of the Eurosystem, see table 1 and text for details.
Source: Authors computation using the *IBSI* data on euro-area banks' balance sheet, see text for formulas.

Table 3
Summary statistics, banks never run (2011m1-2014m12)

Variable	Obs.	Mean	Std. Dev.	P5	P95
Run	3,559	0	0	0	0
Illiq collat	3,559	.8	1.6	0	3.1
Liq collat	3,559	4.1	5.4	0	14.1
Tot collat	3,559	4.9	5.8	0	15.2
Bonds held	3,455	15.4	9.5	1.1	31.7
Loans	3,559	53.1	21.1	10.4	82.2
Debt issued	3,559	15.3	17.7	0	44.2
Interbank lending	3,559	17.7	15.8	1.9	48.4
Interbank borrowing	3,559	28.6	22.4	3.6	79.3
Net interbank position	3,559	- 11	21.6	- 54.3	22.3
CB refinancing	3,559	1.8	3.8	0	11.3
Capital ratio	3,559	8	4.2	2.5	14.7
Rating	1,944	5.8	2.9	1	12

Note: All variables as a % of total assets except Rating for which 1=AAA and an increment of 1 corresponds to one notch.
Reading: Among banks that never experienced a run during our period under review, the mean of bonds held normalized by the total asset was 15.4% between 2011m1 and 2014m12.
Source: IBSI database, Banque de France and authors' computations.

Table 4
Summary statistics, banks run at least once (2011m1-2014m12)

Variable	Obs.	Mean	Std. Dev.	P5	P95
Run	4,840	5.4	8.9	0	20.3
Illiq collat	4,840	1.2	2	0	5.3
Liq collat	4,840	6.9	10.2	0	19.3
Tot collat	4,840	8	10.3	0	20.8
Bonds held	4,791	18.2	10.5	.7	37.6
Loans	4,840	54.6	18.1	25.1	79
Debt issued	4,840	15.5	17	0	49.7
Interbank lending	4,840	13.3	11.5	1.6	32.9
Interbank borrowing	4,840	21	17.3	2.9	57.5
Net interbank position	4,840	- 7.7	16.3	- 35.3	13.1
CB refinancing	4,840	3.5	5.5	0	15.4
Capital ratio	4,840	8.8	6.3	2.1	19.1
Rating	2,435	6.8	3.2	3	13

Note: All variables as a % of total assets except Rating for which 1=AAA and an increment of 1 corresponds to one notch.
Reading: Among banks that experienced at least one period of run during our period under review, the mean of bonds held normalized by the total asset was 18.2% between 2011m1 and 2014m12.
Source: IBSI database, Banque de France and authors' computations.

(15% *vs.* 16%) either. On average the banks that were run tend to pledge more collateral with the Eurosystem, which is consistent with a greater reliance on the Eurosystem refinancing (3.5% against 1.8% of CB refinancing). Finally, the two groups of banks do not differ in terms of the average share of credit claims that they pledge with the Eurosystem, with an average equal to 1% of total assets in both cases. Credit ratings, available for a subset of banks in our datasets, do not display major differences, with the average rating of banks run being lower by less than one notch than the ratings of banks never run.

Tables A2 and A3 in the appendix report the same statistics but as of 2011m1, that is at the beginning of the period of study, to allow a comparison at the same date. This statistic only gives an incomplete picture of the statistics of the average bank run as only half of the banks run had started already by January 2011. Yet the averages are strikingly similar to those in table 4 and 5. The comparison of tables A1 and A2 shows that the average reliance of banks on the interbank market is similar across bank categories: in January 2011, the banks that are run are not more reliant on the interbank market. The statistics also confirm that banks are similar in terms of level of loans granted or bonds held, suggesting that there was no striking difference between the average bank that was run and the average bank that was not run in January 2011.

We now turn to compare whether the banks that pledge more than 1% of their balance sheet in illiquid collateral differ from those that pledge less than 1% (Tables 5 and 6). Banks that pledge more than 1% of their assets in illiquid collateral tend to have marginally fewer loans in their balance sheet, and rely more on debt issuance to fund their assets. They are more active in intermediating the interbank market, both borrowing and lending more to other banks. They borrow 31% and lend 20% of their balance sheet to other MFIs. By contrast, those pledging less than 1% have the same net interbank position, at -11%, but borrow only 26% and lend 14% of their balance sheet. Interestingly, the central bank refinancing secured by the former is lower than the borrowing of the latter. This suggests that banks that are the most reliant on Eurosystem refinancing do not use more illiquid collateral.

Specification and results

We present the specification of the regressions used for the impact of the composition of banks' collateral pools on their lending activity, then we discuss the results.

Specification and identification strategy

We hypothesize that the composition of the collateral pools pledged with the central bank

Table 5
Summary statistics, banks pledging less than 1% of their balance sheet in credit claims, as of 2011m1

Variable	Obs.	Mean	Std. Dev.	P5	P95
Run	133	3.8	8.2	0	18.4
Illiq collat	133	.1	.2	0	.7
Liq collat	133	5.2	8.1	0	14.9
Tot collat	133	5.3	8.1	0	14.9
Bonds held	129	16.6	9.8	1.3	31.4
Loans	133	56.1	19.8	16.9	83.9
Debt issued	133	14.2	15.3	0	45.9
Interbank lending	133	14.3	12.8	2	40.5
Interbank borrowing	133	25.5	19.9	4.3	65.9
Net interbank position	133	-11.3	19.5	-51.7	11.8
CB refinancing	133	2	5	0	11.7
Capital ratio	133	7.7	4.2	1.7	14.8
Rating	60	5.4	2	2.5	9

Note: All variables as a % of total assets except Rating for which 1=AAA and an increment of 1 corresponds to one notch.
Reading: Among banks that used to pledge less than 1% of their total asset in credit claims with the Eurosystem as of 2011m1, the mean of bonds held normalized by the total asset was 16.6% as of 2011m1.
Source: IBSI database, Banque de France and authors' computations.

Table 6
Summary statistics, banks pledging more than 1% of their balance sheet in credit claims, as of 2011m1

Variable	Obs.	Mean	Std. Dev.	P5	P95
Run	44	2.4	4.8	0	14.3
Illiq collat	44	2.7	1.8	1.1	6.1
Liq collat	44	4	4.6	0	10.6
Tot collat	44	6.7	4.7	1.5	12.6
Bonds held	44	15.9	9.4	1.4	30.8
Loans	44	47	19.4	17.5	79.1
Debt issued	44	23.4	21.6	.5	86.2
Interbank lending	44	19.9	15.4	5.3	47
Interbank borrowing	44	31.4	18.7	5.3	64.3
Net interbank position	44	- 11.5	18.9	- 44.3	3.7
CB refinancing	44	.9	1.7	0	4.6
Capital ratio	44	6.8	3.2	3.2	13.6
Rating	28	4.5	1.7	1	7

Note: All variables as a % of total assets except Rating for which 1=AAA and an increment of 1 corresponds to one notch.
Reading: Among banks that used to pledge more than 1% of their total asset in credit claims with the Eurosystem as of 2011m1, the mean of bonds held normalized by the total asset was 15.9% as of 2011m1.
Source: IBSI database, Banque de France and authors' computations.

matters for the supply of loans to the economy. More precisely, we are interested in determining whether the share of marketable versus non-marketable assets is neutral on banks' behavior. This may matter for two reasons. First, the cash-equivalent of marketable assets is pro-cyclical, *i.e.* the cash that can be obtained by selling or collateralizing those assets varies with the market price. The implication is that when the price decreases, the value of the asset as collateral also decreases. This is the financial accelerator mechanism highlighted by Kiyotaki and Moore (1997). By contrast, non-marketable assets are less pro-cyclical since their valuation only depends on their default probability (*supra*). Therefore, the ability to pledge non-marketable assets insures against price variations. Second, marketable assets have alternative uses such as the ability of being repo-ed on the securitized interbank market or sold quickly

on demand. By contrast, credit claims are mainly useful as collateral for central bank refinancing operations, as selling credit claims is costly and lengthy since this requires securitizing them in the form of asset-backed securities or covered bonds. In other words, the opportunity cost of pledging such assets is lower than for other marketable securities. Therefore, when accepting credit claims as collateral, the central bank is relaxing the borrowing constraint of banks (Ahn et al., 2016).

In the absence of an active European securitization market, a run on a sufficient number of banks leads to an aggregate loss of wholesale funding which may trigger a credit crunch. In such a situation, the collateral framework –with respect to quantity and composition– is likely to matter as banks are increasing their demand for central bank reserves. In such a situation, the collateral framework may impact on banks' decision to lend in two cases. In the first case, a bank that is run may decide to pledge more credit claims with the central bank in order to maintain its lending to the economy. In the second case, when competitors are run and the wholesale funding market is frozen, well-capitalized banks that are not run may increase their refinancing with the central bank in order to secure the resources necessary to increase their lending activity to the economy and eventually increase their market share. In a nutshell, by making credit claims eligible collateral, the Eurosystem modifies the incentives to lend to the economy in a period during which holding illiquid assets is less desirable than holding liquid assets.

To test this hypothesis on our subsample of 177 euro area banks from Jan-2011 to Dec-2014, we regress the loans to non-financial agents (households and non- financial corporations) on the intensity of the variable measuring the run and the variables measuring the composition of the collateral pledged with the central bank. We are primarily interested in determining whether the coefficient of the illiquid variable is significantly greater than zero, *i.e.* whether a bank's ability to pledge more illiquid collateral increases its lending to the economy. The regression equation reads as follows:

$$\begin{aligned} &Loans_{bk,t} = \\ &\rho Loans_{bk,t\text{-}1} - \alpha Capital\ ratio_{bk,t-1} + \\ &\beta Illiq + Liq\ collat_{bk,t} + \epsilon\ Illiq\ collat_{bk,t} + \\ &\gamma Run_{bk,t\text{-}1} + \delta\left[Run^{*}_{bk,t\text{-}1} \quad Illiq + Liq\ collat_{bk,t} \right] + \\ &\xi\left[Run^{*}_{bk,t\text{-}1} \quad Illiq\ collat_{bk,t} \right] + FE_{bk} + FE_{country,t} + \varepsilon_{bk,t} \end{aligned} \tag{2}$$

where the index *bk*(t) denotes a bank (the date, month and year).To account for the inertia in loan creation, we also include the lagged dependent variable as an explanatory variable. All of the variables are computed as a share of the lagged total assets of the bank to take account of the fact that banks vary in size and to make them comparable.

We focus on the variables $Tot\,collat_{bk,t}$ and $Illiq\,collat_{bk,t}$ which stand for the total volume of collateral and the volume of illiquid assets pledged with the central bank respectively. The coefficient β measures to what extent the volume of collateral pledged by a bank increases its loan supply. The coefficient ϵ assesses whether credit claims play an additional role in determining lending decisions. We expect both to be positive. The variable $Run_{bk,t-1}$ stands for the intensity of the run at the bank level for the previous month (see Section 4 for details). We expect its coefficient γ to be negative.

We also include interactions between this $Run_{bk,t-1}$ variable and each collateral variable to allow for a non-linear impact of collateral in times of wholesale funding loss. Note that the pledging of illiquid collateral takes time and comes with significant legal costs like the physical delivery of credit documentation to the central bank in some jurisdictions (Tamura & Tabakis, 2013)[17]. It is therefore very unlikely that newly originated loans are pledged as collateral with the Eurosystem over the couple of months that follow their origination. We believe that a contemporaneous positive and significant relationship between loans and illiquid collateral can hardly result from the pledging of newly originated loans.

We finally include some control variables to account for potential confounding factors in the regression. The variable FE_{bk} denotes the inclusion of bank fixed-effects to account for the heterogeneity of banks' business models. The variable $FE_{country,t}$ corresponds to the country-time fixed effects. They capture potential country-specific shocks on the banking sector

17. *See Tamura and Tabakis (2013):* "The relatively high operational costs of the use of credit claims as collateral can also be seen in the additional eligibility and operational requirements for credit claims that are not required for marketable assets (see Table A1). The requirements relate to: (i) ex ante notification of the debtor about mobilisation (in some jurisdictions); (ii) physical delivery of related loan documents; (iii) transferability of credit claims; and (iv) reporting requirement of counterparties regarding the existence of credit claims. These conditions which are directly required by national legislations (e.g. i and iii) or reflect central bank policies (e.g. iv) imply that credit claims are not normally assets which are expected to trade with high frequency."

as well as common shocks affecting demand for loans. The underlying assumption is that banks face relatively homogenous demand for loans in a specific country. We also control for the quality of banks by including the capital ratio (computed as the ratio of equity to lagged total assets). Residuals are clustered at the bank level to allow for heterogeneity in the distribution of shocks at the bank level. The residual of the regression is denoted by $\varepsilon_{bk,t}$.

Results

Table 7 reports the main regression estimates in which we introduce one explanatory variable after another. The results show that an increase in the volume of illiquid collateral pledged with the central bank is associated with a significant increase in loans to the economy. The coefficient of $Illiq\,collat_{bk,t}$ shows that a 1 percentage point increase in the volume of illiquid collateral pledged with the central bank (as a percentage of the bank's total assets) leads to about a 0.3 percentage point increase in the loans-to-total-assets ratio. This is economically significant as a one standard deviation increase in the volume of illiquid collateral leads to a 0.6 percentage point increase in the loans-to-total-assets ratio or to a 1.1% increase of lending activity, which is consistent with our hypothesis that the eligibility of illiquid collateral boosts bank lending activity. If the increase in the volume of illiquid collateral is temporary, the corresponding 0.6 percentage point increase of lending activity is also short-living and disappears exponentially at the rate of 23% each month according to our estimates.

We also find a positive correlation between the total volume of collateral pledged (irrespective of its liquidity) and loans. Our main contribution is to stress, for a given level of collateral pledged, the importance of the liquidity composition of the collateral pool for lending activity. Eligible credit claims, with low default probability, are unlikely to raise moral hazard issues. In addition, to account for the quality of banks, we include the capital ratio in the estimates. The capital ratio is positive and significant suggesting that an increase in the capital ratio is associated with more loans to the economy.

The wholesale funding loss as measured by $Run_{bk,t-1}$ has a significant and negative impact on bank lending. The impact is significant. For a 1 standard deviation of the run intensity for banks that are hit by a run at least once in our sample –*i.e.* a 9% loss of wholesale funding– the bank reduces its loans-to-total-assets ratio by 0.5 percentage point or the total lending by around 0.9%. The impact of the loss of wholesale funding on loans is attenuated when banks pledge more collateral with the central bank: the interaction between the intensity of the run and the total volume of collateral is positive and

Table 7
Bank loans and collateral liquidity

	(1) Loans	(2) Loans	(3) Loans	(4) Loans	(5) Loans	(6) Loans
Loans (t-1)	0.774*** (0.0443)	0.771*** (0.0451)	0.771*** (0.0446)	0.772*** (0.0446)	0.769*** (0.0454)	0.765*** (0.0457)
Capital ratio	0.425*** (0.119)	0.430*** (0.119)	0.439*** (0.128)	0.443*** (0.128)	0.447*** (0.128)	0.446*** (0.128)
Tot collat	0.0250*** (0.00737)	0.0230*** (0.00807)		0.0266*** (0.00693)	0.0245*** (0.00729)	0.0265** (0.0119)
Illiq collat		0.282*** (0.0881)			0.277*** (0.0862)	0.279*** (0.0868)
Run			- 0.0235 (0.0245)	- 0.0261 (0.0244)	- 0.0252 (0.0242)	0.0564** (0.0249)
Run × Tot collat						0.248** (0.101)
Run × Illiq collat						- 0.265 (0.609)
Adjusted R^2	0.662	0.664	0.662	0.663	0.664	0.666
Observations	8,221	8,221	8,221	8,221	8,221	8,221

Standard errors in parentheses. All variables at the bank level.
Note: Panel regression with residuals clustered at bank level, time, bank and country-time fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

significant in most specifications (including in Table A5 when we control for banks' ratings).

Robustness check

We also conduct robustness exercises. The first robustness exercise consists in replacing the variable $Illiq\,collat_{bk,t}$ in equation (2) by the difference between the volume of illiquid assets pledged and the volume of liquid assets pledged $Illiq - Liq\,collat_{bk,t}$. The coefficient in front of this variable can be interpreted as the impact of increasing the share of illiquid assets in the collateral pool while keeping the total volume collateral unchanged.

The second robustness check removes the last semester from the estimation period. Indeed, some may be concerned by the fact that the Targeted Longer-Term Refinancing Operations (TLTROs) launched in June 2014 may have altered the relationship between bank lending and the refinancing activity of the bank.

The third robustness check consists in including the bank's rating as an additional control variable for the quality of banks. Given that ratings are available only for a subset of banks, it substantially reduces the sample size.

Table 8 gives the result of changing the specification of the variable measuring the impact of illiquid collateral on bank lending. The result shows that there is a clear composition effect, as the coefficient of the variable $Illiq - Liq\,collat_{bk,t}$ is positive and significant. Finally, the results are unchanged when we exclude the last semester from the estimation period in Table A4 or when we control for bank ratings in Table A5.

Table 8
Bank loans and collateral liquidity

	(1) Loans	(2) Loans	(3) Loans	(4) Loans	(5) Loans	(6) Loans
Loans (t-1)	0.774*** (0.0443)	0.771*** (0.0451)	0.771*** (0.0446)	0.772*** (0.0446)	0.769*** (0.0454)	0.765*** (0.0457)
Capital ratio	0.424*** (0.119)	0.430*** (0.119)	0.439*** (0.128)	0.442*** (0.128)	0.447*** (0.128)	0.446*** (0.128)
Tot collat	0.0250*** (0.00745)	0.164*** (0.0439)		0.0265*** (0.00697)	0.163*** (0.0431)	0.166** (0.0443)
Illiq - Liq collat		0.141*** (0.0440)			0.139*** (0.0431)	0.140*** (0.0434)
Run			- 0.0235 (0.0246)	- 0.0262 (0.0243)	- 0.0252 (0.0242)	0.0564** (0.0249)
Run × Tot collat						0.115 (0.299)
Run × Illiq - Liq collat						- 0.133 (0.304)
Adjusted R^2	0.662	0.664	0.662	0.663	0.664	0.666
Observations	8,221	8,221	8,221	8,221	8,221	8,221

Standard errors in parentheses. All variables at the bank level.
Note: Panel regression with residuals clustered at bank level, time, bank and country-time fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

* *
*

We study the impact of banks' ability to pledge illiquid collateral on their lending activity during the European sovereign debt crisis. By doing so, they were able to convert illiquid loans into liquid reserves at the central bank. To identify the beneficial impact of the (il)liquidity of collateral on the loan supply of individual banks, we make use of the differences in the share of illiquid collateral banks are able to pledge. This proportion varies both in the cross-section and in the time series. We then show that banks that pledged more illiquid assets against central bank reserves were those that reduced their lending to the economy less. □

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Table A1
Haircut grid applicable to credit claims used as collateral, as a %

Residual mat.	Valuation (1)		Valuation (2)		RMB debt (3)
	AAA to A	BBB+ to BBB-	AAA to A	BBB+ to BBB-	AAA to A-
<1y	10	17	12	19	39.5
1-3y	12	29	16	34	39.5
3-5y	14	37	21	46	39.5
5-7y	17	39	27	52	39.5
7-10y	22	40	35	58	39.5
10y	30	42	45	65	39.5

Note: Valuation (1) and Valuation (2) are based on a theoretical price assigned by the NCB and on the outstanding amount assigned by the NCB respectively; last column (3) is for non-marketable residential mortgage-backed debt.
Source: ECB (https://www.ecb.europa.eu/mopo/assets/risk/liquidity/html/index.en.html).

Table A2
Summary statistics, banks never run, as of 2011m1

Variable	Obs.	Mean	Std. Dev.	P5	P95
Run	75	0	0	0	0
Illiq. collat	75	.7	1.4	0	2.8
Liq. collat	75	3.4	3.3	0	10.7
Tot. collat	75	4.1	3.6	0	10.8
Bonds held	72	15.3	8.9	1.4	29.3
Loans	75	53.3	21.2	11.9	87.4
Debt issued	75	16.9	17.9	0	46.5
Interbank lending	75	17.3	15.7	2.2	47.4
Interbank borrowing	75	28.5	21.8	4.3	76.6
Net interbank position	75	- 11.1	21.5	- 53.1	19.8
CB refinancing	75	1	2.3	0	6.9
Capital ratio	75	7.4	3.6	2.4	14
Rating	40	4.8	1.7	1	7.5

Note: All variables as a % of total assets except Rating for which 1=AAA and an increment of 1 corresponds to one notch.
Reading: Among banks that never experienced a run during our period under review, the mean of bonds held normalized by the total asset was 15.5% as of 2011m1.
Source: IBSI database, Banque de France and authors' computations.

Table A3
Summary statistics, banks run at least once (2011m1-2014m12), as of 2011m1

Variable	Obs.	Mean	Std. Dev.	P5	P95
Run	102	6	9.1	0	18.6
Illiq collat	102	.8	1.5	0	4.1
Liq collat	102	6	9.1	0	18.3
Tot collat	102	6.8	9.1	0	18.3
Bonds held	101	17.3	10.1	.3	33.2
Loans	102	54.2	19.2	21.9	79.1
Debt issued	102	16.1	17.3	.1	54.8
Interbank lending	102	14.5	12	1.7	34
Interbank borrowing	102	25.9	18.1	4.7	59.1
Net interbank position	102	- 11.4	17.5	- 44.3	7.3
CB refinancing	102	2.4	5.4	0	12.2
Capital ratio	102	7.6	4.3	1.7	14.1
Rating	48	5.4	2.1	2	9

Note: All variables as a % of total assets except Rating for which 1=AAA and an increment of 1 corresponds to one notch.
Reading: Among banks that experienced at least one period of run during our period under review, the mean of bonds held normalized by the total asset was 17.3% as of 2011m1.
Source: IBSI database, Banque de France and authors' computations.

Table A4
Bank loans and collateral liquidity, subsample 2011m1-2014m6

	(1) Loans	(2) Loans	(3) Loans	(4) Loans	(5) Loans	(6) Loans
Loans (t-1)	0.754*** (0.0499)	0.751*** (0.0506)	0.750*** (0.0505)	0.751*** (0.0505)	0.749*** (0.0511)	0.746*** (0.0515)
Capital ratio	0.464*** (0.135)	0.469*** (0.135)	0.490*** (0.149)	0.491*** (0.149)	0.494*** (0.148)	0.498*** (0.151)
Tot collat	0.0291*** (0.00856)	0.0271*** (0.00948)		0.0315*** (0.00744)	0.0295*** (0.00810)	0.0297** (0.0126)
Illiq collat		0.291*** (0.102)			0.280*** (0.0980)	0.285*** (0.0988)
Run			- 0.0295 (0.0276)	- 0.0334 (0.0269)	- 0.0319 (0.0268)	- 0.0626** (0.0291)
Run × Tot collat						0.239*** (0.0941)
Run × Illiq collat						- 0.197 (0.666)
Adjusted R^2	0.628	0.629	0.628	0.629	0.630	0.632
Observations	7,206	7,206	7,206	7,206	7,206	7,206

Standard errors in parentheses. All variables at the bank level.
Note: Panel regression with residuals clustered at bank level, time, bank and country-time fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5
Bank loans and collateral liquidity when controlling for credit rating

	(1) Loans	(2) Loans	(3) Loans	(4) Loans	(5) Loans	(6) Loans
Loans (t-1)	0.628*** (0.0881)	0.619*** (0.0885)	0.629*** (0.0890)	0.628*** (0.0886)	0.620*** (0.0887)	0.616*** (0.0889)
Capital ratio	0.543** (0.238)	0.550** (0.235)	0.609** (0.265)	0.614** (0.261)	0.611** (0.258)	0.668** (0.283)
Rating	- 0.00034 (0.00208)	- 0.00088 (0.00210)	- 0.00012 (0.00213)	- 0.00012 (0.00216)	- 0.000650 (0.00216)	- 0.000734 (0.00224)
Tot collat	0.0425* (0.0254)	0.0319 (0.0287)		0.0489** (0.0228)	0.0383 (0.0253)	0.0182 (0.0341)
Illiq collat		0.499*** (0.156)			0.459*** (0.143)	0.463*** (0.147)
Run			- 0.0527 (0.0508)	- 0.0576 (0.0499)	- 0.0502 (0.0501)	- 0.106* (0.0623)
Run × Tot collat						0.846** (0.333)
Run × Illiq collat						- 0.512 (1.302)
Adjusted R^2	0.560	0.565	0.561	0.563	0.567	0.571
Observations	4,290	4,290	4,290	4,290	4,290	4,290

Standard errors in parentheses. All variables at the bank level.
Note: Panel regression with residuals clustered at bank level, time, bank and country-time fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Can better capitalised banks be more profitable? An analysis of large French banking groups before and after the financial crisis

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Abstract – The article studies the effect of French banks' capitalisation on their profitability. It contributes to the debate which has emerged, following the financial crisis, on the impact of the tightening of the regulation of capital (Basel III). Our econometric results show that over the period of 1993-2012, beyond the general trend of profitability which is weaker after the crisis, banks which increase their capital ratio more than the average improve their profitability, without it being possible to distinguish between voluntary increases and those imposed by regulation. All else being equal, a 100 basis point increase of the different capitalisation measures leads to a 3 to 10% increase in the average return on equity (ROE), depending on the measures considered, and to a 7 to 30% increase in the average return on assets (ROA). The positive impact of an increase of capitalisation on ROA is less significant when it is done by issuing shares.

JEL Classification: G21, G28
Keywords: ROE, ROA, solvency ratios, capital, banking regulation, Basel III

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The financial crisis has highlighted the need to tighten the regulation and supervision of the banking sector in order to strengthen its ability to absorb negative shocks. The Basel III reform, whose outline was announced in 2010, has brought particular attention to the role of banks' capital, since numerous highly leveraged financial institutions have failed or have had to be bailed out by public authorities. The social cost of bank failures justifies the capital requirements for financial institutions (Berger et al., 1995; Admati et al., 2011, Calomiris, 2013). According to the Governor of the Bank of England, Mark Carney, *"only well-capitalised banks can serve the needs of the real economy and promote strong, sustainable growth. [...]. Where capital has been rebuilt and balance sheets have been repaired, banking systems and economies have prospered."* (Carney, 2013 a and b).

The Basel III Accords propose a strengthened framework in terms of capital requirements for banks. This reform imposes an improvement of the quality of capital by requiring higher levels of common equity. It also provides for a minimum leverage ratio[1] (see box 1). These capital requirements risk, however, to have differentiated effects across the economy. Banks often contend that the increase of these requirements risks reducing their profitability: for example, their overall funding costs could increase greatly due to the higher level of capital. This increase of costs could thus have a negative knock-on effect on the distribution of credit and reduce banks' profitability. However, economic theory does not allow for conclusions to be drawn since no consensus is emerging with regards to the effect of capital on banks' performance. Drawing on the perfect market hypothesis, Modigliani and Miller (1958) conclude that decisions linked to the capital structure do not have an impact on companies' market value, especially banking companies (Miller, 1995). However, another strand of literature highlights that debt, by limiting managers' freedom to act with regards to shareholders, can have positive effects on the value of firms (cf., for example, Hart & Moore, 1995; Diamond & Rajan, 2001). Capital

1. The leverage ratio relates an indicator of capital to a measure of total assets and off-balance sheet exposures. It aims to guarantee the holding of a minimum level of capital to cover the bank's unexpected losses.

Box 1 – **Regulation of bank capital**

The banking regulation of international banks is defined by the Basel Committee, an international authority now composed of 28 jurisdictions. In 1988, the so-called "Basel I" Accords, focusing mainly on credit risk, introduced a minimal solvency ratio called the "Cooke ratio" which relates capital to a measure of assets. In 2004, the "Basel II" Accords reformed the international prudential rules by proposing a more exhaustive approach of banking risks and a finer calculation of credit risk which until then was determined on the basis of a uniform weighting for each large asset class. This calculation can now be made using internal models developed by banks under the control of the supervisor or a standard approach which employs the counterparties' ratings made by rating agencies. The internal banking models have been validated in most countries and notably in France as from 2008, the regulator authorising a limited reduction of capital requirements for banks which implement better internal risk management.

Nevertheless, the subprime crisis and its consequences reveal the need to revise Basel II in order to better take into account the risks associated with the banking system. The banking activity has in fact evolved and new risks such as those borne from securitisation have emerged. Regarding Basel II, the United States adopted a different approach, by distinguishing the large systemic banks from the smaller ones, without, however, formally implementing the whole framework. The Basel Committee revised its legislation in 2009 and 2010, to better account for securitisation and market risk, with a set of recommendations sometimes referred to as "Basel 2.5". These rules entered totally into force in France on 31 December 2011. The Basel Committee published the main orientation of the "Basel III" agreements in 2010, and the details on the reform were subsequently discussed. The Committee retained a stricter definition of the instruments eligible to regulatory capital for the calculation of the regulatory capital ratios (Common Equity Tier 1, Tier 1 and total regulatory capital ratios) A non risk-weighted ratio called the "leverage ratio" has been defined and major advances relating the management of liquidity risk have been made.

In Europe, the transposition of the Basel III Accords (by the CRD IV directive and CRR regulation) entered into force on 1 January 2014 and applies to all credit institutions of the Union, both on a solo and consolidated basis. Nevertheless, phase-in arrangements will run into 2019. Impact studies led by the Basel Committee have revealed that French banks have gradually anticipated from 2010 onwards the introduction of Basel III requirements.

increases, by reducing constraints on managers, could thus turn out to be detrimental to performance. Finally, a third theoretical trend contends that capital should on the contrary have a positive effect on performance (for example, Holmstrom & Tirole, 1997). Actually, capital increases limit the moral hazard which exists between shareholders and creditors, which in turn facilitates the improvement of banks' performance.

Our empirical strategy consists of assessing the role of banks' capitalisation measures on their profitability (see online complement C2, for an analysis of the main channels likely to lead to a change in profitability). We proceed in several stages. Firstly, we demonstrate the significant positive relationship between capitalisation and profitability. Secondly, we test the delayed impact of capitalisation. Thirdly, we evaluate whether the effect depends on the way the bank increases its capitalisation (for example, by issuing new shares). When there is an asymmetry of information, the decision to issue new shares could be perceived by investors as a bad signal for the firm's prospects (Myers & Majluf, 1984) and negatively affect its value. Then, we evaluate whether this relationship is different for banks with a smaller capital buffer. The level of this buffer depends on both total capital requirements including additional requirements from the "pillar 2"[2] and the bank's choice to hold capital at a level close or above such regulatory requirements. Banks with smaller buffers could be considered to face a higher risk of breaching the regulatory capital requirements. Finally, we examine the channel through which banks' capitalisation influences profitability.

This study contributes to the literature in several ways. First of all, we use a new confidential database on French banking groups, including their subsidiaries in foreign countries, compiled by the French Prudential Supervision and Resolution Authority. In comparison with other available public data, this database contains more harmonised indicators, since all banking groups submit their financial information in the same regulatory format for a given year. We consider different capitalisation measures, which correspond to different forms of capital, and commonly referred to in the economic literature and by the supervisory authorities. These measures take into account, depending on the case, risk-weighted and non-risk-weighted assets, as well as banks' on- and off-balance sheet exposures. They therefore reflect the logic of the new Basel III standards which combines all of these characteristics. By using confidential supervisory data relating to the additional capital requirements from the "pillar 2" for each bank, we can calculate a more accurate indicator of capital requirements. Then, our sample of large French banks, which represent more than 90% of the total assets of French banks in 2012, allows us to study one of Europe's largest banking systems and to focus on significant institutions for which the prudential regulation is the most relevant. The relatively long 1993-2012 analysis period allows us to cover several economic cycles, which in turn enhances the robustness of our results.

We test the impact of capital on profitability using fixed effect regressions, in which the capital ratios are lagged in order to reduce possible biases linked to the endogeneity caused by simultaneous capital measures and profitability. In addition, we run Granger causality tests which lead us to reject the endogeneity hypothesis. Our econometric strategy relies on these Granger causality tests; still, even if it shelters us from biases linked to certain types of reverse causality (for example, the impact of profitability on capital at a given date), it does not allow us to avoid others (banks which anticipate a better future return now raise more capital) or those linked to omitted variables such as the quality of management (better managed banks now raise more capital and are more profitable after a few years). However, additional tests show that these potential biases do not hamper the robustness of our results.

Our results show that beyond the general trend of profitability, banks which increase their capital ratio more than the average improve their profitability, without it being possible however to distinguish between voluntary increases and those imposed by regulation.[3] In fact, it is important to note that voluntary increases allow for a larger capital buffer and facilitate the seizing of investment opportunities. However, the data available over the whole period do not accurately distinguish between these two types of capital increases. All else being equal, a 100 basis points increase of the

2. In the "Basel II" and "Basel III" regulatory frameworks (see box 1), "pillar 2" refers to the additional bank-specific capital requirements, which come on top of the requirements imposed on all institutions ("pillar 1").
3. The online complement C2 provides a few empirical elements which show that the positive relationship between capitalisation and profitability might be explained by improved banking efficiency.

different capitalisation measures leads to a 0.31 to 1.12 percentage point increase of the ROE, depending on the type of capital ratio considered (that is, a 3 to 10% increase of the average ROE). This impact ranges between 0.04 and 0.18 percentage points for the ROA (that is, a 7 to 30% increase of the average ROA). In relative terms, the effect on ROA therefore appears to be economically more significant than on ROE.

This effect of a capital increase on profitability is stronger when the lag is longer, generally when it reaches two years, which shows that time is needed for this to affect performance. As a result, we reject the hypothesis of a negative effect of capital on profitability. The increase of capital requirements can certainly have deterrent effects beyond a certain threshold (Calomiris, 2013), and when institutions do not have reasonable time to meet them, but our results do not highlight this.

Additionally, in general, the increase of share capital, by means of issuing shares, tends to reduce the positive impact of capitalisation on ROA. The existence of issuing costs and information asymmetries actually makes issuing shares more costly.

Finally, the positive impact of capital increases on profitability is stronger for those banks which have *ex ante* smaller capital buffers. In this case, capital increases seem to be highly targeted, and aim more to seize investment opportunities than to build a simple safety buffer.

The article is structured as follows: firstly, the existing literature is reviewed, followed by the formulation of the hypotheses; then the data and methodology are detailed; then come the results; finally the complementary investigations on the results[4] are presented, followed by the conclusion.

Examination of the existing literature and hypotheses

There is a considerable theoretical literature on the effect of capital on the value of firms, in particular banks. Three distinct theories come to different conclusions. In Modigliani and Miller's framework (1958), sources of financing do not have an effect on cash flows generated by the assets. Changes in the relative shares of equity and debt therefore have no effect on the value of the company. The cost of equity is a function of asset risk and debt and, in order to keep the weighted average cost of capital constant, it decreases when the share of equity increases. This effect explains why the funding structure is neutral for a company's value. Miller (1995) contends that nothing prevents the application of this framework to the banking sector.

The two other theories diverge from Modigliani and Miller's propositions (1958) and predict that the relative levels of capital have an effect on the value of companies, and banks in particular. The second theoretical trend relating to corporate finance addresses the disciplinary role of debt as a way to reduce managers' freedom to act with regards to shareholders (see for example Hart & Moore, 1995), which reduces the risk that they invest in businesses which do not increase profitability. Managers can seek to attenuate market discipline by building up a capital buffer, which would reduce their incentive to increase effort and would therefore be detrimental to profitability. Debt can also present advantages with regards to capital due to the existence of asymmetries of information. Managers might have confidential information relating to the company's profitability prospects or to investment opportunities. By issuing debt, the company would reveal to external investors its ability to reimburse the principal and debt interest and highlight its soundness (Ross, 1977; Leland & Pyle, 1977). Banks could also decrease liquidity creation when capital is too high (Diamond & Rajan, 2001).

The third strand of the literature claims, on the contrary, that a capital increase will have a positive effect on the value of banks, which is explained by two main channels based on the moral hazard between shareholders and creditors. The first channel is based on the risk premium demanded by creditors. Shareholders' potential losses are capped due to the limited liability of the shares. However, gains increase with risk-taking, encouraging excessive risk-taking to the detriment of other stakeholders. Creditors anticipate this behaviour and demand an extra premium to finance banks. As a consequence, market discipline coming from debtors forces banks to hold positive amounts of capital (Calomiris & Kahn, 1991). The second channel rests on the monitoring effort exerted by the bank. This (costly) effort depends on the bank's capital: When it is higher, it internalises

4. The online complement C3 presents a certain number of robustness checks.

potential losses attributable to a lack of monitoring. In this channel, the funding structure has an effect on asset cash flows, with monitoring affecting the return from loan portfolios (Chemmanur & Fulghieri, 1994; Holmstrom & Tirole, 1997; Boot & Thakor, 2000; Mehran & Thakor, 2011; Allen et al., 2011). As "delegated monitors" (Diamond, 1984), banks need incentives to act in the interest of their creditors. In fact, higher levels of capital and the concentration of shareholders increases banks' incentives to make a bigger effort to monitor their borrowers since shareholders would have more to lose in the event of failure. They can then have higher expected returns on assets.

Empirical studies have already seeked to assess the impact of an increase of capital on banks. Berger (1995) highlights a positive effect of capital ratios on ROE for the US banking sector. Mehran and Thakor (2011) examine how capital ratio influences the price of the target in the case of bank acquisitions in the US over the period 1989-2007. They show that buyers pay a higher price for targets with a higher capital ratio considering the fair value of assets and goodwill. Berger and Bouwman (2013) test the way in which capital ratio has influenced banks' performance during the financial crises from 1984 to 2010 in the US over extensive quarterly bank data from 1984 to 2010 which distinguishes between banks according to their size. Small banks with higher capital ratios have shown a higher probability of survival and have presented relatively larger market shares and higher profitability levels (ROE) both in "normal" periods and during financial crises. These results are valid for large banks, but only during times of crisis. With regards to Berger and Bouwman (2013), our contribution lies in the analysis of the effect of heterogeneity between banks, looking at the capital buffer held by each bank. This buffer corresponds to the excess capital beyond the minimum required by regulation. It is a relevant question at a time when regulation for large banks is getting tougher. Cohen and Scatigna (2016) show that banks with higher capital ratios or strong profitability were more likely, after the crisis, to support credit activity.

Another trend in the literature studies more specifically the effects of an increase of capital requirements on credit activity. Francis and Osborne (2012), by taking into account the capital requirements specific to UK banks, study their impact on capital, loan activity and banks' balance sheet management. They demonstrate in particular that banks which hold a surplus of capital, being above the target level, show higher loan activity and balance sheet growth. Aiyar et al. (2016) study the impact of capital requirements, monetary policy, and their potential interactions on banks' credit supply in the UK over the period 1998-2007, drawing on quarterly bank data from more than 80 regulated banks (48 British banks and 40 subsidiaries of foreign banks), achieving broad coverage of the domestic credit activity. The authors show that the increase of capital requirements reduces credit supply. With capital constraints already being hard-hitting and the issuing of shares costly, banks reduce their weighted assets subject to credit risk in order to meet the additional requirements. Fraisse et al. (2015) measure over the period 2008-2011 the impact of capital requirements on banks' credit activity. They take advantage of the heterogeneous methods used by banks in calculating these requirements, since under Basel II banks may use their own internal models to measure the credit risk stemming from exposures to non-financial corporations. The authors highlight a negative effect of higher capital requirements on credit activity. Over a longer period, 1993-2012, our work studies the link between banks' capitalisation and future profitability.

Data and econometric strategy

Data

Our sample covers the period running from 1993 to 2012 for 17 French banking groups on a consolidated basis. We use a new database held by the French Prudential Supervision and Resolution Authority, which contains confidential accounting and supervisory data relating to the French banking groups. These data give access to balance sheet and off-balance sheet items, as well as prudential information over the course of this long period. The selection criteria include banks which are significant in the sense of the definition retained by the European Single Supervisory Mechanism. The banking groups with total assets above or close to 30 billion euros are included. Our sample is an unbalanced panel of 135 yearly observations (see Box 2).

The banking groups' profitability is measured here by two ratios: return on equity (ROE) and return on assets (ROA) which are

bank net income over capital and over total assets respectively.

We consider different capitalisation measures. We first calculate three non-weighted ratios: the "Capital ratio", the "Tier 1 / Tangible Assets" ratio and the "Tier 1 / Tangible and Off-balance Sheet Assets" ratio. Capital ratio refers simply to capital over total assets. The Tier 1 / Tangible Assets ratio is based on the leverage ratio implemented by the US bank regulator within the framework of the Federal Deposit Insurance Corporation Improvement Act of 1991. It is calculated as follows: (Tier 1 capital - intangible fixed assets) / (total assets - intangible fixed assets). The Tier 1/Tangible and Off-balance Sheet Assets ratio is close to the Basel III definition of leverage ratio. It corresponds to Tier 1 capital over total assets to which are added off-balance sheet exposures weighted by a conversion factor in terms of credit. These exposures' weightings follow the Basel III framework: a weighting of 10% is applied to all the exposures that a bank can withdraw at any moment with no conditions. All other exposures are weighted at 100%. For what is off-balance sheet, we include only the items which relate to credit risk, since regulatory changes prevent us from consistently measuring the exposure to market risk over the whole period. We also use two solvency capital ratios defined within the Basel I framework. The Tier 1 regulatory ratio is calculated as regulatory Tier 1 capital over risk-weighted assets (Basel I). Total regulatory ratio is calculated as follows: Tier 1 capital + Tier 2 capital + Tier 3 over risk-weighted assets (Basel I). We prefer to use the Basel I framework over the whole period in order to remain consistent knowing that Basel II has introduced significant changes in the calculation of the risk weighted assets. Even after 2007, banks report minimal capital requirements according to the Basel I definition, which allows us to calculate risk-weighted assets in accordance with the Basel I definition for the period from 2008 to 2012.

In the estimations, we introduce different variables deemed to have an influence on profitability indicators. They take into account the bank's business model, as well as the assets' risk levels, considering the usual risk-return trade-off. "Asset diversification" is defined as the Herfindahl-Hirschmann (HH) index which is calculated on the basis of four asset classes: cash, interbank loans, loans to non-financial corporations and other interest-bearing assets. The higher values of the index indicate a strong concentration of asset classes and therefore lower diversification. Diversification is often calculated using the HH index (cf. for example Thomas, 2002; Stiroh & Rumble, 2006).

"Loan share" represents the amount of loans over all interest-bearing assets. In the same way, Berger and Bouwman (2013) use the share of assets available for sale. Loan share measures the significance of traditional credit activities: it differentiates between banks according to the business model, which meets respectively different profitability requirements. For example, investment banks displayed on average higher ROEs than traditional banks before the financial crisis. This scenario has however reversed over the course of the financial crisis (European Central Bank, 2010).

The "Safety net" is calculated as the amount of deposits over total assets. Deposits have been insured in France since 1980; banks which have a higher proportion of deposits therefore could benefit from more government guarantee. In the same vein, Berger and Bouwman (2013) take into account the core deposit-to-assets ratio. The safety net is supposed to influence risk-taking (Merton, 1977; Keeley, 1990). Moreover, deposits can turn out to be a less costly source of financing.

In a portfolio approach, average return must be explained by risk. We therefore add the variable "Portfolio risk". According to Berger (1995) and Berger and Bouwman (2013),

Box 2 – **Processing of bank mergers in the database**

The unbalanced structure of the database is explained by mergers and acquisitions over the sample period and data availability constraints. For example, after the 2008 merger of the Banques Populaires and Caisses d'Épargne, these two banking groups disappeared from the database and were replaced by the BPCE Group. The other main mergers and acquisitions processed over the sample period are: the acquisition by Banque Nationale de Paris of Compagnie financière de Paribas in 2000 (the two banks were distinct before the merger and the new group BNP Paribas then appeared in the database with a new identification number); and Crédit Lyonnais's exit from the database in 2003 after it was taken over by the Crédit Agricole Group.

portfolio risk is calculated as risk-weighted assets (according to Basel I) over total assets. It reflects the allocation of assets into four classes of weighting (0, 20, 50 and 100%) defined in the Basel framework. The use of this measure allows us to monitor the effects of the portfolios shifts on their profitability. Again, we prefer to use the Basel I definition of risk-weighted assets, in order to remain consistent over the whole period.

Finally, we also include a "Liquidity ratio". It corresponds to the French regulatory liquidity ratio calculated as available liquid assets over liquid liability requirements. Berger and Bouwman (2013) also take into account liquidity, albeit in a more basic manner, by including in their model cash and other liquid assets divided by total assets. Banks which have more liquidity have a smaller chance of being in dire straits. However, liquid assets are generally less risky and therefore have a lower expected return.

Table 1 presents descriptive statistics on our sample's variables. With an average ROE of 10.71%, French banks have displayed strong profitability of capital over the course of the period. ROA has in turn been at 0.61% on average. Our different capital ratios reveal relatively contrasting situations between banks and over time. The first decile of the Capital ratio is at 2.68%, while the last decile is at 10.10%. Figures I-A and I-B below demonstrate furthermore the evolution of the median value of ROE and ROA, Tier 1 / Tangible and Off-balance Sheet Assets and the Tier 1 regulatory ratio. Tier 1 / Tangible and Off-balance Sheet Assets covers all banking activity by taking into account off-balance sheet items and the Tier 1 regulatory ratio only takes into account Tier 1 regulatory capital which has a better ability to absorb losses. We observe a rising trend of banks' median profitability up to 2000 (Figure I-A). It drops considerably over the periods corresponding to the take-off of the internet bubble and to the subprime crisis with regards to the period before. The indicators of capitalisation increase over the whole period, in particular after the triggering of the financial crisis (Figure I-B). Banks have started to strengthen their solvency and to anticipate the increase of capital requirements imposed by the new Basel III regulatory framework. In fact, even if the Basel III regulatory framework was not yet mandatory, the main outline of the new framework was known (following the publication of the consultative Basel III document in 2010) and both the financial markets and supervisors were monitoring banks' levels of preparation to transfer to Basel III. All in all, we began to observe a more significant increase in retained earnings. Banks also have different business models: the first decile of asset diversification is at 0.39 (high level of diversification) and the last decile at 0.79 (very high level of concentration). The same observation can be made for loan share (from the first decile at 28.5% to the last decile at 88.37%) and for portfolio risk (from the first decile at 21.01% to the last at 90.29%), which reveals that the banks in our sample choose different business models.

Econometric strategy

To assess the effect of bank capitalisation on profitability, we conduct fixed-effect regressions. Standard errors are adjusted in terms of heteroscedasticity and autocorrelation by using the Newey-West standard errors. We include lagged values of the capitalisation measure. Our reference model is as follows:

Equation 1

$$Y_{i,t} = \alpha_i + \theta_t + \beta_1 \, Capitalisation_{i,t-j} + X_{c,i,t}\,\beta_c + \varepsilon_{i,t}$$

where i is an index for the ith bank, t for the tth period and $j \in \{1,2\}$ for estimations taking into account only one lag and $j \in \{1,2,3\}$ for estimations including two lags. α_i and θ_t are, respectively, the fixed effects by bank and by period. $Y_{i,t}$ represents, respectively, ROE or ROA. The variable called $Capitalisation_{i,t-j}$ is one of the five bank capital ratios described above. $X_{c,i,t}$ is a vector of the following independent variables: asset diversification, loan share, safety net, portfolio risk and liquidity ratio. β_1, and β_c are parameters to be estimated. $\varepsilon_{i,t}$ is the error term.

We use lagged values for all our capitalisation measures because contemporaneous capital ratios are endogenous to banks' profits (undistributed profits automatically increase banks' capital). We test the endogeneity of these lagged values. To do so, we run a Granger causality test which includes fixed effects by bank and by period and we test the null hypothesis according to which the past values of the profitability measures do not explain the capitalisation measures. The Wald test does not reject the null hypothesis that each of the coefficients associated with the lagged values of ROE and ROA are equal to zero. Finally, we do not reject the null hypothesis that the sum

of these coefficients is equal to zero. Including a lag of one and two years respectively, the lagged values of ROE and ROA do not bear information, in the sense of Granger causality,[5] on the explanation of our bank capitalisation measures beyond what is provided by the past values of the capitalisation measures themselves.[6] This test does not take into account the fact that the banks which anticipate better future returns raise more capital. We conduct complementary tests in order to test the existence of a relationship between future values of the indicators of profitability and the present values of the capitalisation measures. The results do not highlight any significant relationships. Furthermore, an alternative method to the lag of explanatory variables to avoid endogeneity bias would be to turn to instrumental variables methods. However, the relatively small size of the sample due in part to the concentration of the banking system does not allow for a correct implementation of the generalised method of moments. Berger and Bouwman (2013) identify endogeneity issues which require the use of instrumental variables for small banks only. We therefore introduce the capital ratios with a lag of one and two years respectively in the specifications which explain the ROE and ROA. The results remain consistent when we explain the ROA by one year lagged values of capital ratio. In an augmented model, we consider two lags of capitalisation measures to test the hypothesis of a gradual effect of capitalisation on profitability.

5. The Granger test is based on the hypothesis that the future does not "cause" the past. In certain cases, predictions can play an important role in the determination of present values.
6. The results are presented in the on line complement C1.

Figure I-A
Profitability of French banking groups (median)

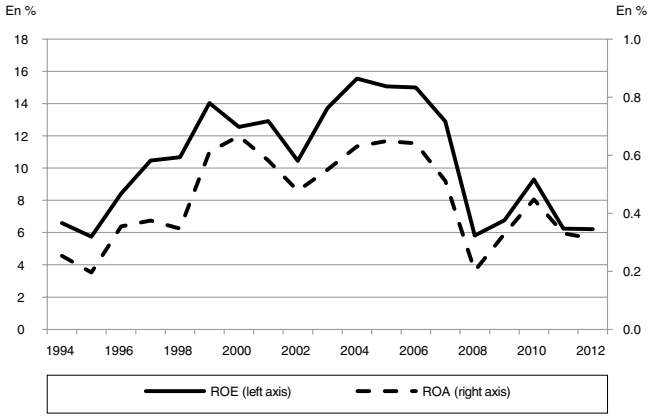
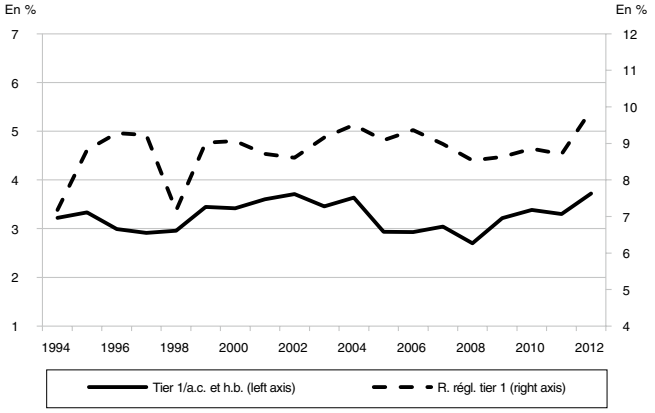


Figure I-B
Capitalisation of French banking groups (median)



Note: ROE: Net income/capital; ROA: Net income/Total Assets; Tier 1/TA and OBS: Tier1/Tangible assets and off-balance sheet assets; Tier 1 reg. r.: Tier 1/Basel I risk-weighted assets.
Source: Data drawn from the accounting and prudential database of the French Prudential Supervision and Resolution Authority; unbalanced panel of 17 French banking groups over the period 1993-2012; calculations by the authors.

Table 1
Descriptive statistics on the different variables of profitability, capitalisation measures and other indicators relating to large French banking groups over the period 1993-2012

Variables	Definition	Number	Average	Standard deviation	1st decile	Median	9th decile
ROE (%)	Net income over total equity	135	10.71	5.84	4.23	10.82	17.77
ROA (%)	Net income over total assets	135	0.61	0.47	0.14	0.46	1.33
RORAC (%)	Net income over 8% of risk-weighted assets (according to the Basel I methodology).	135	14.45	8.34	3.82	13.83	24.95
Efficiency	Net operating income over administrative expenses	132	1.95	0.74	1.4	1.63	3.3
Capital ratio t 1 (%)	One year lagged value of balance sheet equity over total assets.	135	5.56	2.93	2.68	4.58	10.10
Tier 1/tangible assets t-1 (%)	One year lagged value of tier 1 regulatory capital minus intangible fixed assets over total assets minus intangible fixed assets	135	5.00	2.60	2.40	4.01	8.96
Tier 1/tangible and off-balance sheet assets t-1 (%)	One year lagged value of tier 1 regulatory capital over the sum of total assets and off-balance sheet weighted credit risk exposures	135	4.28	2.57	1.88	3.17	8.81
Tier 1 regulatory ratio t-1 (%)	One year lagged value of tier 1 regulatory capital over risk-weighted assets (according to the Basel I methodology)	135	9.20	2.28	6.86	8.87	11.96
Total regulatory ratio t-1 (%)	One year lagged value of total regulatory capital over risk-weighted assets (according to the Basel I methodology)	135	11.39	2.16	9.15	11.18	14.22
Asset diversification	Herfindahl-Hirschmann index of 4 different asset classes: cash, interbank assets, loans and other earning assets.	135	0.53	0.15	0.39	0.47	0.79
Loan share (%)	Loans to non-financial entities over total earning assets	135	54.06	22.31	28.50	49.65	88.37
Safety net (%)	Deposits over total assets	135	22.48	16.16	1.39	25.02	39.98
Portfolio risk (%)	Risk-weighted assets (according to the Basel I methodology) over total assets	135	51.47	23.91	21.01	46.63	90.29
Liquidity ratio	Available liquid assets over liquid liability requirements	135	1.95	1.75	1.18	1.41	2.99

Sources: Annual data drawn from the accounting and prudential database of the French Prudential Supervision and Resolution Authority; unbalanced panel of 17 French banking groups over the period 1993-2012; authors' calculations.

Main results

Bank capital and profitability

Table 2 takes into account the results of fixed effect regressions of ROE and ROA on our capitalisation measures. Capitalisation ratios are lagged by one and two years respectively to explain ROE and ROA (variant A of Equation 1). For all specifications, the coefficient of the capitalisation variable is positive. For estimations which explain the ROE, the coefficients are statistically significant for the Tier 1 / Tangible and Off-balance Sheet Assets ratios, the Tier 1 regulatory ratio and the total regulatory capital ratio (columns 3, 4 and 5). For ROA, all the coefficients associated with the capital ratios are highly significant. Profitability tends to increase on average after an increase of capitalisation. Our analysis therefore supports the "positive vision": the increase of capital intensifies the bank's monitoring effort, hence leading to a greater return on assets. Among the regulatory ratios, the magnitude of the coefficient is weakest for the total regulatory ratio. This result is consistent with the fact that this ratio comprises other forms of capital such as long-term subordinated debt and certain hybrid instruments. These forms of capital should influence less the monitoring effort conducted by the bank since only core capital allows to fully benefit from the improvement in monitoring. These results are consistent with those of Berger and Bouwman (2013) who show in particular that capital generally improves bank profitability. For small banks, this result is valid both at normal times and in times of crisis while this positive effect is observed in times of crisis for large banks.

We also demonstrate a significant impact of asset diversification and loan share on ROE. For ROA, this effect is mainly highlighted only for specifications which integrate the regulatory capital ratios (columns 9 and 10). The positive coefficient on asset diversification indicates that banks whose activities are more concentrated tend on average to have higher profitability. This can reflect the higher risk profile of banks which choose to concentrate their activities in one sector, which generates more profits on average. This result can also be explained by the know-how and expertise developed in several market segments. The negative sign of the loan share coefficient might be explained more by a mechanical effect of the variation of market activities in earning assets. The reduction in market activities has been accompanied by a drop in profitability during the crisis period.

Consideration of lags of two periods in the capital measures

The different specifications relating to variant A of Equation 1 presented in table 2 consider that capital ratio affects profitability with only one lag. If the positive effect rests on an improvement of the effectiveness of investment choices made by the management under the control of the shareholders, more time is undoubtedly needed for the bank to fully profit from an increase of capitalisation. In order to test this, we estimate the effect of capitalisation by including two lags. Table 3 displays results when one and two-year lagged capital measures are included in the model which explains the ROE, and two- and three-year lagged measures in the model which explains the ROA (variant B of Equation 1). We conduct a test of joint significance on the sum of the coefficients of the lagged variables. According to our results, the capitalisation measures mainly involve a two-year lag. Their coefficients are significant in models 1 to 3 which explain the ROE and models 6 to 8 for the ROA. The one-year lag capitalisation variables are never significant in the ROE estimation models. Those lagged by three years are never significant in the ROA estimation models. The null hypothesis that the coefficients of the lagged capitalisation variables sum to zero is rejected, with the exception of the specifications which explain the ROE by regulatory capital ratios (Table 2, columns 4 and 5).

Overall, capitalisation has a positive effect on a bank's profitability. The effect is particularly significant two years after the initial capital increase. The empirical data therefore broadly confirm the "positive vision" of the effect of capital on banks' performance.

The economic effect of increases of capital

The results show that capitalisation has a statistically positive effect on profitability. The magnitude of the effect is also significant from an economic point of a view. In Table 2, which considers only one lag for the capitalisation measures, all else being equal, an increase by 100 basis points of capitalisation triggers an increase of the ROE ranging from 0.31% to 1.12% according to the capital ratio

considered. This represents thus at maximum around 10% of the average ROE observed over the period. This effect ranges between 0.04% and 0.18% for the ROA, which represents at maximum nearly 30% of the average observed over the period. The magnitude of the effect is more significant on the ROA. This might be explained by the mechanical impact on the ROE (an increase of the denominator of the ROE ratio) when capital increases. If we include two lags in the same specification (cf. Table 3), the average effect on the ROE (that being the sum of the lagged coefficients) ranges between 0.46 and 1.94% and between 0.04 and 0.16% for the ROA.

Complementary investigations

Does the way in which banks increase their capital hold any significance?

Our results show that higher capitalisation generates greater accounting profit. However, some authors claim that capital represents a costlier source of financing, which leads to a decrease of banks' profits following an increase of capital requirements. Myers and Majluf (1984) go from the observation that managers have more information than investors on the value of the firm. Managers who act in the interest of the firm's existing shareholders can choose to not issue shares even if this would allow the financing of projects with a net positive present value. Actually, the issuing of shares creates dilution costs for the existing shareholders and imposes issuing costs. The new shares could then be sold at a low price if the issuing is interpreted as a bad signal for the bank's prospects. Miller (1995), who examines the application of Modigliani and Miller's propositions (1958) to banks, underlines the fundamental distinction between the cost of "raising new capital" and the cost of "holding capital". Therefore, the raising of new capital can turn out to be costly while the effects of holding capital might be beneficial.[7]

In order to test whether the cost of raising capital has a negative effect on profitability, we calculate a lagged dummy variable,[8] namely "share capital growth" equal to 1 when share capital growth is strictly positive, and equal to 0 otherwise. In fact, the variation of share capital reports only increases of capital made by an issuing of shares. We are interested in the interactions between share capital growth and our capital ratios. More precisely, we aim at assessing to what extent the effect of capitalisation on profitability is different when capital is raised. If the costs of raising capital reduce banks' profits, we should estimate a negative sign coefficient for the interaction term between share capital growth and each of our capitalisation measures. The estimated model is as follows:

Equation 2

$$
\begin{aligned}
Y_{i,t} = {} & \alpha_i + \theta_t + \beta_1 Capitalisation_{i,t-j} \\
& + \beta_2 Capitalisation_{i,t-j} \\
& \times Growth\ of\ social\ capital_{i,t-j} \\
& + \beta_3 Growth\ of\ social\ capital_{i,t-j} \\
& + X_{c,i,t}\beta_c + \varepsilon_{i,t}
\end{aligned}
$$

Table 4 reports the results of fixed effect regressions with the different capital ratios interacting with share capital growth. The dichotomous variable is introduced in the model with the same lag as the capital ratios. For the ROE, none of the interaction terms are significant. For the models that explain the ROA, the interaction terms are significantly negative with the exception of those associated with the regulatory capital ratios. We have also tested the same fixed effect models by including only the capital ratios, share capital growth and interaction terms. The results remain consistent. The issuing of shares therefore appears to be more costly and contributes to the reduction of the positive effect of capitalisation on the ROA.

Is this result valid for banks which have a smaller capital buffer in accordance with the minimum requirements of "pillar 2"?

We then assess to what extent the capital buffer built up by banks beyond the total requirements set by regulation can affect the relationship between capital and performance. We use confidential prudential data which focus on the extra

7. It should be noted that capital requirements are not imposed from one day to the next but are gradually implemented (box 1). This allows banks to pursue different strategies, like distributing less profit or reallocating assets, in order to reach the required capitalisation levels. In addition, the costs of raising capital can also be spread over the whole implementation period and over the period during which banks anticipate the entering into force of the new framework presented in the consultative documents published by the Basel Committee. Consequently, this gradual implementation eased bankers' worries with regards to the costs of raising capital, especially after taking into account the beneficial effects that holding more capital entails.

8. Since the cost of raising capital can have a short-term effect, we have also conducted tests using non-lagged variables of share capital growth. The results remain the same.

Table 2
Bank capital and profitability (estimations of variant A of Equation 1)

	Return on equity (ROE)					Return on assets (ROA)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital ratio $_{t-1}$	0.307									
	(0.498)									
Capital ratio $_{t-2}$						0.107***				
						(0.028)				
Tier 1 / tangible assets $_{t-1}$		0.611								
		(0.490)								
Tier 1 / tangible assets $_{t-2}$							0.116***			
							(0.039)			
Tier 1 / tangible and off-balance sheet assets $_{t-1}$			1.118*							
			(0.615)							
Tier 1 / tangible and off-balance sheet assets $_{t-2}$								0.179***		
								(0.040)		
Tier 1 regulatory ratio $_{t-1}$				0.553*						
				(0.320)						
Tier 1 regulatory ratio $_{t-2}$									0.071***	
									(0.019)	
Total regulatory capital ratio $_{t-1}$					0.413*					
					(0.231)					
Total regulatory capital ratio $_{t-2}$										0.039***
										(0.013)
Asset diversification	0.278*	0.265*	0.259*	0.278**	0.271**	0.003	0.004	0.002	0.009*	0.010*
	(0.148)	(0.141)	(0.138)	(0.135)	(0.136)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
Loan share	- 0.248*	- 0.253*	- 0.266**	- 0.288**	- 0.264**	- 0.005	- 0.009	- 0.011*	- 0.015**	- 0.012*
	(0.139)	(0.132)	(0.128)	(0.128)	(0.130)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
Safety net	0.174	0.195	0.191	0.178	0.174	- 0.001	0.001	- 0.002	- 0.001	0.001
	(0.149)	(0.139)	(0.140)	(0.139)	(0.140)	(0.007)	(0.006)	(0.006)	(0.007)	(0.007)
Portfolio risk	- 0.018	- 0.042	- 0.047	0.041	0.013	0.001	0.003	0.004	0.016**	0.011
	(0.119)	(0.128)	(0.125)	(0.133)	(0.133)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
Liquidity ratio	0.003	0.003	0.003	0.003	0.003	- 0.000	- 0.000	- 0.000	- 0.000	- 0.000
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	- 0.012	- 0.012	- 0.009	- 0.051	- 0.051	- 0.001	- 0.003	- 0.001	- 0.008**	- 0.008**
	(0.057)	(0.055)	(0.055)	(0.059)	(0.060)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Fixed year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	135	135	135	135	135	135	135	135	135	135
Number of banks	17	17	17	17	17	17	17	17	17	17
Adj. R^2 (%)	44.5	45	45.7	45.6	45.5	77.8	77.4	78.8	77.5	76
Adj. R^2 within (%)	31.6	32.1	33	32.9	32.8	27.7	26.6	31.1	26.8	22

Note: This table presents the estimations' results (variant A of equation 1) with fixed effects of return on equity (ROE) and assets (ROA) on a series of independent variables. Capital ratios are lagged respectively by one and two years for ROE and ROA estimations. The definitions of the variables figure in table 1. The estimations have been made with the Stata software using the Newey-West method which provides robust standard errors in the presence of heteroscedasticity and autocorrelation of the error term for the coefficients estimated by the ordinary least squares method. The standard errors are indicated in brackets. The ***, ** and * represent the levels of statistical significance of 1%, 5% and 10% respectively.
Reading note: In the (1) specification, an increase of 1 percentage point of the capital ratio at the *t*-1 date leads to an increase of 0.307 percentage points of the ROE at the *t* date, all else being equal.
Sources: Annual data drawn from the accounting and prudential database of the French Prudential Supervision and Resolution Authority; unbalanced panel of 17 French banking groups over the period 1993-2012.

Table 3
Bank capital with two year lag and profitability (estimations of variant B of Equation 1)

	Return on equity (ROE)					Return on assets (ROA)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital ratio $_{t-1}$	- 0.893									
	(0.891)									
Capital ratio $_{t-2}$	1.769*					0.081*				
	(0.932)					(0.041)				
Capital ratio $_{t-3}$						0.027				
						(0.057)				
Tier 1 / tangible assets $_{t-1}$		- 0.704								
		(0.867)								
Tier 1 / tangible assets $_{t-2}$		1.848**					0.061			
		(0.926)					(0.058)			
Tier 1 / tangible assets $_{t-3}$							0.053			
							(0.061)			
Tier 1 / tangible and off-balance sheet assets $_{t-1}$			- 0.578							
			(0.933)							
Tier 1 / tangible and off-balance sheet assets $_{t-2}$			2.522**					0.119*		
			(1.015)					(0.063)		
Tier 1 / tangible and off-balance sheet assets $_{t-3}$								0.043		
								(0.068)		
Tier 1 regulatory ratio $_{t-1}$				- 0.021						
				(0.486)						
Tier 1 regulatory ratio $_{t-2}$				0.790					0.034	
				(0.550)					(0.027)	
Tier 1 regulatory ratio $_{t-3}$									0.031	
									(0.025)	
Total regulatory ratio $_{t-1}$					0.223					
					(0.384)					
Total regulatory ratio $_{t-2}$					0.232					0.009
					(0.423)					(0.019)
Total regulatory ratio $_{t-3}$										0.026
										(0.019)
Sum of lag coefficients	0.877	1.144	1.944	0.769	0.456	0.108	0.113	0.162	0.065	0.035
	0.495*	0.547**	0.674***	0.378**	0.26*	0.04***	0.048**	0.049***	0.021***	0.014**
Test for all lags=0	2.51*	2.99*	5.05***	2.18	1.58	5.52***	2.88*	5.98***	4.63**	3.43**
p-value	0.087	0.0552	0.008	0.118	0.212	0.006	0.062	0.004	0.012	0.037
Asset diversification	0.195	0.192	0.163	0.262*	0.267*	0.003	0.003	0.002	0.008	0.009*
	(0.132)	(0.127)	(0.129)	(0.135)	(0.140)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
Loan share	- 0.207	- 0.245*	- 0.265**	- 0.312**	- 0.272**	0.000	- 0.003	- 0.005	- 0.009	- 0.007
	(0.131)	(0.128)	(0.125)	(0.135)	(0.131)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
Safety net	0.126	0.118	0.097	0.133	0.162	- 0.001	0.001	- 0.000	0.000	0.001
	(0.142)	(0.131)	(0.135)	(0.142)	(0.153)	(0.009)	(0.008)	(0.008)	(0.008)	(0.009)
Portfolio risk	- 0.065	- 0.038	- 0.045	0.072	0.019	0.001	0.004	0.004	0.015**	0.011
	(0.121)	(0.124)	(0.121)	(0.137)	(0.139)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
Liquidity ratio	0.002	0.002	0.000	0.002	0.002	- 0.000	- 0.000	- 0.000	- 0.000	0.000
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.031	0.021	0.039	- 0.045	- 0.048	- 0.002	- 0.004	- 0.003	- 0.008**	- 0.007**
	(0.056)	(0.055)	(0.057)	(0.062)	(0.062)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Fixed year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	135	135	135	135	135	118	118	118	118	118
Number of banks	17	17	17	17	17	17	17	17	17	17
Adj. R^2 (%)	46.2	46.4	47.8	46.2	45.1	85.4	84.7	85.4	84.2	83.5
Adj. R^2 within (%)	33.8	33.9	35.7	33.7	32.4	39.4	36.3	39.1	34.2	31.3

Note: This table presents the estimations' results (variant B of equation 1) with fixed effects of return on equity (ROE) and assets (ROA) on a series of independent variables. The capital ratios are lagged by one and two years in the specifications which explain the ROE, and two and three years in the specifications which explain the ROA. The definitions of the variables figure in table 1. The estimations have been made with the Stata software using the Newey-West method which provides robust standard errors in the presence of heteroscedasticity and autocorrelation of the error term for the coefficients estimated by the ordinary least squares method. The standard errors are indicated in brackets. The ***, ** and * represent the levels of statistical significance of 1%, 5% and 10% respectively.
Reading note: In the (1) specification, an increase of 1 percentage point of the capital ratio at the *t*-1 and *t*-2 dates leads to an increase of 0.877% percentage points of the ROE at the *t* date, all else being equal.
Sources: Annual data drawn from the accounting and prudential database of the French Prudential Supervision and Resolution Authority; unbalanced panel of 17 French banking groups over the period 1993-2012.

capital requirements from "pillar 2": the supervisor can in fact demand that a bank holds more capital than the regulatory minimum imposed on all banks.[9]

We calculate banks' capital buffer for each year as the difference between their effective level of regulatory capital and the level of capital required from pillars 1 and 2 (minimum requirements plus additional individual requirements). Banks always have to meet the minimum capital imposed by the pillar 1 or pillar 2 regulation. But the level of the buffer is explained by the bank's choice to hold a level of capital more or less close to the requirements imposed by regulation. We build a dummy variable equal to 1 when the bank's buffer level at a given date is less than the median value of the sample and equal to 0 in the other cases.[10] We interact it with the different variables of banks' capitalisation measures. This variable isolates the behaviour of banks which have a small capital buffer. The following model is estimated:

Equation 3

$$Y_{i,t} = \alpha_i + \theta_t + \beta_1 Capitalisation_{i,t-j} + \beta_2 Capitalisation_{i,t-j} \times Small\ capital\ buffer_{i,t-j} + \beta_3 Small\ capital\ buffer_{i,t-j} + X_{c,i,t}\beta_c + \varepsilon_{i,t}$$

Table 5 presents the results of the interaction between capitalisation and the dichotomous variable which discriminates between banks according to the level of their capital buffer. This dichotomous variable is introduced in the model with the same lag as the capitalisation measures. The coefficients of the capitalisation measures are positive and significant with the exception of models 1, 9 and 10. For the ROE, the coefficients of the interactions are not significant. For the ROA, we observe overall a stronger positive effect of the increase of capital on profitability for banks which have *ex ante* a smaller capital buffer. Capital increases seem to be managed as closely as possible and correspond more to the seizing of investment opportunities that are profitable than to the building of a simple safety buffer.

Robustness of the results

We amend all our models by replacing the variable of the ROE (resp. of ROA) by a variable of "return on risk-adjusted capital" (RORAC). RORAC focuses on the link between banks' profits and capital requirements associated with risk-taking instead of capital or assets. We highlight again the positive influence of the capitalisation measures on the RORAC variable (for more details see the online complement C3). Finally, we run various complementary tests: non-linearity of certain effects; impact of the differences of market power between banks on profitability. The existence of non-linear effects between two capital ratios and the ROA is highlighted and the size of market share does not contribute to the improvement of profitability.

* *
*

The article contributes to the debate on the relationship between capitalisation, capital requirements and banks' performance, for which, so far, no consensus has emerged in the literature. It brings new elements to this question by analysing the French banking system. We demonstrate that an increase of capital has a positive effect on banks' profitability, beyond the lower level observed with regards to the pre-crisis period. Our econometric estimations highlight a positive and significant effect of the increase of capital on profitability. However, capital increases through the issuing of new, more costly shares, entail a lower positive effect on profitability.

By drawing on confidential data relating to all the regulatory requirements (especially the pillar 2 requirements that are specific to each bank), we highlight that the positive impact of capital on the profitability of assets is stronger for banks which have a smaller capital buffer. For these banks, capital increases seem to be more dedicated to seizing investment opportunities than to building a simple safety buffer. The positive relationship between capital and performance might be explained in particular by a management monitoring the investment choices better, leading to improved efficiency. Finally, gradual capital increases through

9. As indicated above, since Basel II these requirements are called "Pillar 2" capital requirements. These requirements are not revealed to the market.
10. We also separate the sample according to the 25th percentile. Our results remain the same.

Table 4
Strengthening of bank capital, share capital growth and profitability (estimations of Equation 2)

	Return on equity (ROE)					Return on assets (ROA)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital ratio$_{t-1/t-2}$	0.271					0.107***				
	(0.499)					(0.030)				
Capital ratio$_{t-1/t-2}$ × share capital growth$_{t-1/t-2}$	- 0.367					- 0.048***				
	(0.325)					(0.018)				
Tier 1 / tangible assets$_{t-1/t-2}$		0.553					0.117***			
		(0.480)					(0.035)			
Tier 1 / tangible assets$_{t-1/t-2}$ × share capital growth$_{t-1/t-2}$		- 0.184					- 0.051***			
		(0.312)					(0.018)			
Tier 1 / tangible and off-balance sheet assets$_{t-1/t-2}$			0.989					0.151***		
			(0.624)					(0.040)		
Tier 1 / tangible and off-balance sheet assets$_{t-1/t-2}$ × share capital growth$_{t-1/t-2}$			- 0.097					- 0.040**		
			(0.316)					(0.017)		
Tier 1 regulatory ratio$_{t-1/t-2}$				0.325					0.061***	
				(0.309)					(0.022)	
Tier 1 regulatory ratio$_{t-1/t-2}$ × share capital growth$_{t-1/t-2}$				0.296					- 0.011	
				(0.259)					(0.016)	
Total regulatory ratio$_{t-1/t-2}$					0.333					0.036
					(0.334)					(0.024)
Total regulatory ratio$_{t-1/t-2}$ × share capital growth$_{t-1/t-2}$					0.049					- 0.007
					(0.383)					(0.024)
Dummy variable of share capital growth$_{t-1/t-2}$	0.034	0.023	0.018	- 0.012	0.009	0.002**	0.002**	0.002**	0.001	0.001
	(0.023)	(0.021)	(0.019)	(0.024)	(0.048)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
Asset diversification	0.271*	0.258*	0.254*	0.270**	0.264**	0.002	0.002	0.002	0.009*	0.009*
	(0.142)	(0.136)	(0.134)	(0.130)	(0.130)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Loan share	- 0.251*	- 0.255*	- 0.267**	- 0.305**	- 0.269*	0.000	- 0.002	- 0.004	- 0.007	- 0.005
	(0.138)	(0.132)	(0.128)	(0.138)	(0.137)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
Safety net	0.174	0.190	0.190	0.185	0.179	0.002	0.004	0.002	0.002	0.002
	(0.148)	(0.136)	(0.137)	(0.141)	(0.138)	(0.007)	(0.007)	(0.007)	(0.008)	(0.009)
Portfolio risk	- 0.006	- 0.037	- 0.045	0.045	0.009	0.001	0.002	0.003	0.013*	0.009
	(0.115)	(0.123)	(0.121)	(0.131)	(0.138)	(0.005)	(0.006)	(0.006)	(0.007)	(0.007)
Liquidity ratio	0.002	0.003	0.003	0.003	0.003	0.000	0.000	- 0.000	0.000	- 0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	- 0.030	- 0.019	- 0.015	- 0.037	- 0.049	- 0.004	- 0.005*	- 0.004	- 0.009**	- 0.008*
	(0.060)	(0.055)	(0.055)	(0.054)	(0.065)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Fixed year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	135	135	135	135	135	118	118	118	118	118
Number of banks	17	17	17	17	17	17	17	17	17	17
Adj. R^2 (%)	45.3	45.2	45.7	46	45.6	86.6	85.6	85.9	83.8	83
Adj. R^2 within (%)	32.7	32.6	33.2	33.5	33.1	44.3	40.3	41.4	32.6	29.4

Note: This table presents the estimations' result (equation 2) with fixed effects of the return on equity (ROE) and assets (ROA) on a series of independent variables by distinguishing the increases of share capital from other types of capital increases. Capital ratios are lagged by respectively one year and two years for ROE and ROA estimations. The definitions of the variables figure in table 1. The estimations have been made with the Stata software using the Newey-West method which provides robust standard errors in the presence of heteroscedasticity and autocorrelation of the error term for the coefficients estimated by the ordinary least squares method. The standard errors are indicated in brackets. The ***, ** and * represent the levels of statistical significance of 1%, 5% and 10% respectively.
Reading note: In the (1) specification, an increase of 1 percentage point of the capital ratio without issuing share capital at the *t*-1 date leads to an increase of 0.271 percentage points of the ROE, all else being equal. -0.367 indicates to what extent the relationship between capitalisation and profitability is different when the bank proceeds with an issuing of share capital. Capital ratio$_{t-1/t-2}$ refers to the one-year lag capital ratio in the specifications which explain the ROE, and to the two year lag capital ratio in the specifications which explain the ROA.
Sources: Annual data drawn from the accounting and prudential database of the French Prudential Supervision and Resolution Authority; unbalanced panel of 17 French banking groups over the period 1993-2012.

Table 5
Banks' capitalisation, capital buffer and profitability (estimations of Equation 3)

	Return on equity (ROE)					Return on assets (ROA)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital ratio$_{t-1/t-2}$	0.539					0.083***				
	(0.499)					(0.026)				
Capital ratio$_{t-1/t-2}$ × small capital buffer$_{t-1/t-2}$	- 0.374					0.065***				
	(0.421)					(0.024)				
Tier 1 / tangible assets$_{t-1/t-2}$		0.932*					0.085***			
		(0.531)					(0.026)			
Tier 1 / tangible assets$_{t-1/t-2}$ × small capital buffer$_{t-1/t-2}$		- 0.183					0.079***			
		(0.481)					(0.026)			
Tier 1/ tangible and off-balance sheet assets$_{t-1/t-2}$			1.522**					0.123***		
			(0.678)					(0.035)		
Tier 1/ tangible and off-balance sheet assets$_{t-1/t-2}$ × small capital buffer$_{t-1/t-2}$			- 0.158					0.073***		
			(0.449)					(0.024)		
Tier 1 regulatory ratio$_{t-1/t-2}$				0.767*					0.029	
				(0.419)					(0.027)	
Tier 1 regulatory ratio$_{t-1/t-2}$ × lower capital buffer$_{t-1/t-2}$				- 0.122					0.085**	
				(0.635)					(0.036)	
Total regulatory ratio$_{t-1/t-2}$					0.587**					0.032
					(0.287)					(0.020)
Total regulatory ratio$_{t-1/t-2}$ × lower capital buffer$_{t-1/t-2}$					- 0.092					0.011
					(0.660)					(0.034)
lower capital buffer$_{t-1/t-2}$	0.037	0.030	0.029	0.032	0.032	- 0.002	- 0.002*	- 0.002	- 0.006*	0.000
	(0.027)	(0.028)	(0.024)	(0.054)	(0.069)	(0.001)	(0.001)	(0.001)	(0.003)	(0.004)
Asset diversification	0.262*	0.258*	0.256*	0.292**	0.283**	0.006	0.007	0.007	0.007*	0.010**
	(0.149)	(0.143)	(0.144)	(0.138)	(0.139)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)
Loan share	- 0.259*	- 0.280**	- 0.301**	- 0.332**	- 0.300**	0.000	- 0.002	- 0.005	- 0.010	- 0.007
	(0.140)	(0.136)	(0.135)	(0.138)	(0.137)	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)
Safety net	0.139	0.190	0.185	0.181	0.180	0.008	0.012*	0.011	0.002	0.003
	(0.142)	(0.138)	(0.142)	(0.137)	(0.144)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Portfolio risk	- 0.008	- 0.047	- 0.049	0.065	0.026	- 0.003	- 0.002	- 0.000	0.015**	0.011
	(0.112)	(0.120)	(0.117)	(0.125)	(0.124)	(0.005)	(0.006)	(0.005)	(0.007)	(0.007)
Liquidity ratio	0.003	0.002	0.002	0.002	0.002	- 0.000	- 0.000	- 0.000	- 0.000	- 0.000
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	- 0.027	- 0.026	- 0.025	- 0.087	- 0.087	- 0.003	- 0.006**	- 0.006**	- 0.006	- 0.009**
	(0.056)	(0.053)	(0.052)	(0.069)	(0.073)	(0.003)	(0.002)	(0.003)	(0.004)	(0.004)
Fixed year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	135	135	135	135	135	118	118	118	118	118
Number of banks	17	17	17	17	17	17	17	17	17	17
Adj. R^2 (%)	44.8	45.2	46.1	45.8	45.8	87.3	86.9	87.3	85.6	83.6
Adj. R^2 within (%)	32.1	32.6	33.7	33.4	33.3	47.2	45.5	47.1	40.1	32.1

Note: This table presents the estimations' results (equation 3) with fixed effects of the return on equity (ROE) and assets (ROA) on a series of independent variables by distinguishing the banks which have a lower capital buffer from the others. Capital ratios are lagged by respectively one year and two years for ROE and ROA estimations. The definitions of the variables figure in table 1. The estimations have been made with the Stata software using the Newey-West method which provides robust standard errors in the presence of heteroscedasticity and autocorrelation of the error term for the coefficients estimated by the ordinary least squares method. The standard errors are indicated in brackets. The ***, ** and * represent the levels of statistical significance of 1%, 5% and 10% respectively.
Reading note: In the (1) specification, an increase of 1 percentage point of the capital ratio of the banks which have a larger capital buffer at the *t*-1 date leads to an increase of 0.539 percentage points of the ROE, all else being equal. -0.374 indicates to what extent the relationship between capitalisation and profitability is different when the bank has a small capital buffer. Capital ratio$_{t-1/t-2}$ refers to the one-year lag capital ratio in the specifications which explain the ROE, and to the two-year lag capital ratio in the specifications which explain the ROA.
Sources: Annual data drawn from the accounting and prudential database of the French Prudential Supervision and Resolution Authority; unbalanced panel of 17 French banking groups over the period 1993-2012.

retained earnings do not appear to be detrimental to banks' performance. This conclusion, which confirms for France some of those formulated by Berger and Bouwman (2013) and complements them in terms of analysis of capital buffers, comes to mitigate the frequent criticisms with regards to the potentially negative effects of prudential regulation on the banking system. Other than the need to integrate the following stages of the Basel III agenda which runs until 2019, future works could study the interaction with credit distribution and investigate in more detail the channels through which profitability is affected. □

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Monetary policies and financial crisis: Towards a new central banking

Comment *on "An evaluation of the effects of unconventional monetary policies on the cost of credit to companies in the eurozone" by Désiré Kanga and Grégory Levieuge, "Monetary policy, illiquid collateral and credit in the economy during the European sovereign debt crisis" by Jean Barthélémy, Vincent Bignon and Benoît Nguyen, and "Can better capitalised banks be more profitable? An analysis of large French banking groups before and after the financial crisis" by Olivier De Bandt, Boubacar Camara, Pierre Pessarossi and Martin Rose.*

André Cartapanis*

Abstract – Three articles of this special issue evaluate the effects of unconventional monetary policies and the relationships between new capital requirements and bank profitability. These articles present several similarities: two of them draw on individual bank data and not on aggregated data; they highlight the combined consequences of several shocks, by introducing an interaction term between several variables; they conclude to a strong heterogeneity or a heightened magnitude of the effects brought on credit or bank profitability. That comment will underline that if policies of liquidity injections at a time of stress are especially efficient as they draw on widened collaterals, then it is important to keep certain unconventional instruments in the central banks' toolbox, including outside times of crisis. And if the transmission channels from these policies to lending rates demand close coordination with the fixing of short term interest rates and turn out to have heterogeneous effects due to each banking intermediary's specific situation, then rates policy must be closely correlated to both microprudential and macroprudential policies.

JEL Classification: E52, E58, G01, G21, G28
Keywords: monetary policy, central bank, credit, financial crisis, bank capital, prudential regulation

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The financial crisis has led to extensive changes to central banking. By leading central banks to urgently manage, firstly, the liquidity crisis coming from the American banking system, then the banking crisis and the sovereign debt crisis in the eurozone, this crisis brought about a reconfiguration of both monetary policies and prudential regulations. Of course, this was in the form of short term interest rates near to zero. But also by conducting unconventional policies that, at the outset, amounted to a leap into the unknown (Rajan, 2013). Finally, the deepening of microprudential and macroprudential rules, within the framework of Basel III, brings out the new role granted to the preservation of financial stability, as well as monetary stability, among the objectives assigned to the central banks and supervisors, notably by raising capital requirements for banks.

While the normalisation of monetary policies is now topical (BIS, 2017), this experience of unconventional policies and the first steps taken in the reconfiguration of prudential policies are far from having led to a new consensus about the transmission channels taken by these new instruments or about their real and financial effects. The three contributions covered in this issue dedicated to "The crisis, 10 years after" bring original responses to several of these interrogations: with regards to the effects of unconventional monetary policies on the cost of credit in the eurozone; regarding the efficiency of the unconventional provision of liquidity against collaterals to banks in the eurozone; and, finally, regarding the relationships between capital requirements imposed on banks and their profitability.

After a few comments on the specific lessons to be learned from these three contributions, we will widen this analysis to the outlines, still uncertain, of the new post-crisis central banking.

The question of the effects of unconventional monetary policies in the eurozone

Unconventional monetary policies target several objectives and involve different types of instruments face to face the risk of ineffectiveness of the conventional action on short term interest rates in times of crisis. The objectives are: to support banks facing a liquidity run; the better transmission of the interest rates policy towards the cost of credit and its volume; the direct influence on long term interest rates because of increased risk premiums. The instruments are: massive liquidity injections to banks, coupled with the redefinition of eligible collaterals or the extension of maturities; the practice of zero rates and of negative base rates; forward guidance of rates expectations... The purpose is therefore, in times of crisis, to both ensure the solvency of banking establishments in difficulty and to oppose a large-scale credit crunch which would be of such a nature as to provoke a strong contraction of economic activity. For the eurozone, notably between 2011 and 2014, it was more specifically a matter of controlling the contagion of illiquidity to which the European banks were subjected with the sovereign debt crisis and, also, to stem the rise of risk premiums and the climb of long term rates despite short term interest rates being close to zero.

With this backdrop, the article by Désiré Kanga and Grégory Levieuge examines the repercussions of the ECB's unconventional policies on the cost of credit for non-financial companies, between 2003 and 2014, with particular attention to the years 2008-2014. Their contribution, which draws on aggregated individual bank data over monthly periods for 11 eurozone countries, presents several original ideas in methodological terms: the splitting up of different forms of liquidity injections (fixed-rate full allocations, widening of the range of eligible collaterals, extension of the maximum maturity of refinancing operations...) and the consideration of different asset purchase programmes; for each measure, a distinction is made between the direct effects and indirect effects by way of an interaction term with the interbank market interest rate; and for the period September 2008-December 2014, they use a panel conditionally homogeneous VAR (PCHVAR) model to explain the heterogeneity of the impact of unconventional policies depending on the macroeconomic, financial or banking particularities of the economies concerned. Without going into the details of the results, two major phenomena are highlighted: on the one hand, the indirect effects on the lowering of base rates, that being the effects conditional to rates policy, are much more significant than the direct effects, with a more pronounced influence of the widening of guarantee conditions on collaterals; on the other hand, we observe a strong heterogeneity of this impact on the cost of credit depending on the unconventional instruments mobilised (with a dominant factor for fixed-rate liquidity allocations and long term refinancing operations, LTRO and TLTRO), depending on the country (a higher impact in Austria, Germany, Spain and

Italy, and a negligible or insignificant impact in France, Greece and Ireland) and according to the macroeconomic or macro-financial characteristics of each country. The impact of the lowering of rates on the cost of credit is especially weak given that growth is declining, that systemic risk is high, that bank ratios have declined and that the public debt to GDP ratio is strongly increasing. To sum up, unconventional monetary policies led by the ECB are moderately efficient in terms of lowering the cost of credit, and they operate mainly through indirect effects backed with the traditional transmission channels of rates policy. But the impact is highly heterogeneous and it is not the countries which needed them the most, faced with the extent of the credit crunch risk, who benefited from them the most. We will soon come back to the lessons that can be learned in terms of new central banking.

Again for the eurozone, Jean Barthélémy, Vincent Bignon and Benoît Nguyen study another aspect of unconventional policies, this time the impact, not on rates but on credit volume, of the emergency rescue operations led by the ECB among banks during the sovereign debt crisis between January 2011 and December 2014. At that time, with growing interbank market illiquidity, the European authorities not only considerably increased their liquidity injections, but also widened the range of collaterals accepted for this purpose, notably for non-negotiable assets on interbank markets, labelled as illiquid, like the debts arising from non-securitised credit granted, all the while presenting a risk of default lower than 0.4%, and even ranging temporarily from 0.4% to 1.5%. Available since 2007, it is from 2009 and at the time of the sovereign debt crisis that the central banks members of the ESCB (European System of Central Banks) widely accepted these collaterals in return for liquidity injections to eurozone banks. By using monthly individual data on the largest 177 banks in the eurozone (refinancing volumes granted, composition of the pool of collaterals provided, balance sheets), the authors first build, in a highly original way, an individual indicator of bank run (identified when interbank financings decline by at least 10% from one month to the next, and measured in volume and duration) that is, an indicator of rationing of the refinancing obtained in euros on the European interbank market or in dollars on the American Money Market Mutual Funds market, in order to match this indicator on the one hand with the amount of illiquid collaterals having enabled each bank concerned access to the unconventional liquidity injections, and on the other hand to the evolution of credit granted to non-financial companies and households. In other words, it is a matter of examining the last resort lending role of the ECB to banks suffering a run on the interbank market, not from the point of view of rescuing banks, but in light of the effects on credit granted to the real economy. Panel regression, with a fixed effect by bank and by country, provides very clear results: it is the banks which provided the most, proportionately, of their illiquid collaterals to the ECB which reduced the least, or increased the most, their credit to companies and households a month later, all throughout the eurozone crisis. This is a mark of success for the ECB, with the increase of last resort loans and the widening of eligible collaterals having limited the extent of the credit crunch connected to the sovereign debt crisis, while more than 40% of the sample of banks considered were faced with a run over the summer of 2011. Again, we will come back to the lessons that can be learned with regard to the normalisation of policies conferred to the central banks.

Ratios of capital and bank profitability

The contribution from Olivier de Bandt, Boubacar Camara, Pierre Pessarossi and Martin Rose does not directly address questions of unconventional monetary policy but rather the challenges brought on by the new prudential regulations since the crisis. We know the Basel III objectives, whose implementation is incomplete: improve the volume and quality of capital in order for banks to be better able to resist an unanticipated drop in the value of their assets; prevent situations of illiquidity by limiting maturity transformation and recourse to short term interbank financings, through the creation of two new liquidity ratios; take better account of exposures to counterparty default risks on derivatives, reverse repurchase agreements, securities loans and the development of off-balance sheet securitisation structures; complement risk weighted capital requirements, like in Pillar I of Basel II, by another device, the leverage ratio; and implement countercyclical capital buffers at the discretion of the supervisors. Yet the quantitative raising of capital requirements, but also their enhanced quality, with a higher proportion of ordinary shares, have worried banks, invoking a threat to their profitability, on the cost and volume of credit, indeed on economic growth. Hence the question raised in this article: beyond the positive effects on banks' resilience to illiquidity shocks or major defaults, does capitalisation negatively affect bank profitability?

The analysis, mainly econometric, is conducted over the period 1993-2012 based on a sample of 17 French banking groups among the largest. Whatever the measures of capitalisation, including on the basis of the Basel III ratios, the leverage ratio in particular, the panel model estimated, with fixed effects, confirms what some BIS analyses (Borio, 2016b) had already highlighted without offering an empirical demonstration: beyond the tendential downward evolution of bank profitability over the course of this period, the banks whose capital ratios increase more than the average register a relative rise in their profitability, of course after having taking into account a whole series of control variables. Reference is made to the article for the details of the results, but two observations must be formulated: on the one hand, the positive effect is much higher on the return on assets (ROA) than on the return on equity (ROE); on the other hand, the range of influence is very wide since in response to an increase of 100 basis points of one of the capitalisation ratios, the positive effect on profitability varies from 3 to 10% for ROE and 7 to 30% for ROA. The originality and robustness of the method of measuring bank capitalisation should be noted. Firstly, this is because Olivier de Bandt, Boubacar Camara, Pierre Pessarossi and Martin Rose use confidential data provided by the French Prudential Supervision and Resolution Authority; these data include not only regulatory capital but also data on the extra capital requirements in accordance with Pillar II imposed on each bank at the initiative of the supervisor, without this being made public, ensuring a measure which is much closer to the reality of each bank's capitalisation. Then, it is because the sample includes very contrasting business models (on average, loan share represents 28% of the balance sheet for the first decile and 88% for the last decile), and the tests do not allow to differentiate the results according to the traditional opposition between retail banks and investment banks. It is also due to the estimations explaining this positive relationship between capitalisation and profitability: a positive link between capitalisation on the one hand and the weight of loans to households and companies or the improvement to banks' efficiency (measured using the net operating surplus ratio over administrative expenses) on the other hand. Finally, it is because the estimation period is long enough to include several business cycles, with successive regimes of more or less high interest rates, between 1993 and 2012. In other words, the reinforcement of capital that French banks, to different extents, have been held to honour or that they have decided to implement, seems in no way to negatively affect their profitability and therefore would not call into question the new Basel III options.

Normalisation or reconfiguration of central banking?

Beyond the results treating specifically each of the research targets chosen (the cost and volume of credit in the eurozone, bank profitability in France) in response to regulatory or policy changes linked to the financial crisis, these articles present several particularities: two of them draw on individual data (bank or financial data by country) and not on aggregated data to analyse banking behaviour; by introducing an interaction term between several explanatory variables, they highlight the combined effects of several shocks; beyond the parameters estimated, they conclude with a strong heterogeneity or a high magnitude of induced effects on credit supply or banks' profitability. Yet there are lessons to be learned here from the point of view of post-crisis central banking.

The discussions are numerous about the normalisation of monetary policies. Despite the slight increase of rates in the US, it is not certain that we have already entered a conventional monetary regime that significantly distances us from zero rates. For Summers (2015), the increase in inequalities, and population ageing, would push desired savings rates up and lead to a decline of the natural interest rate, that is the rate ensuring a full-employment macroeconomic equilibrium. If we add the deceleration of the productivity gains and the slowdown of potential supply growth (Gordon, 2015), we find here the issue of secular stagnation whose prominent symptom is the weakness, even negative level, of the post-crisis natural interest rate. With a backdrop of short term interest rates nearing zero and inflation much lower than the central banks' targets, around 2%, it is not certain that the rise in rates will be confirmed. Unconventional monetary policies could therefore remain necessary, despite the fact that financial tensions seem to be reappearing on stock markets and real estate prices.

From the point of view of post-crisis central banking, the paradigm associating monetary targeting only with the adjustment of short term interest rates, while retaining the principle of separation between the objectives of monetary stability and financial stability, and validating the dominant microprudential factor of bank

regulation... all this seems to be behind us, without a new model having been imposed yet. This is especially so since the recourse to unconventional monetary policies has accentuated this difficulty by raising new questions, firstly of an operational nature. Must we go back to the only rates policy by adjudication on a pro rata basis of the liquidity requests or must we keep using the fixed-rate full allocation method? Must we keep making direct interventions on medium or long term rates (as with LTRO and TLTRO) in the eurozone? Must accepting illiquid collaterals be reserved for last resort loans? How far must the quantification of forward guidance go? Beyond these technical questions, the interrogations on the new central banking also show a more fundamental nature. How must the policy of price stability and the banking system's objective of financial stability now be articulated? Two models are worth consideration (Betbèze et al, 2011): A strict separation of the two objectives by assigning to them dedicated instruments which two distinct institutions would have, the central bank and the supervisor, while respecting the Tinbergen rule? Or a more integrated model in the hands of a central bank equipped with multiple functions, for example by adding a module of bank crisis risk into the central bank's reaction function via short term rates, drawing on the consideration of the financial cycle (Borio, 2016a)? Or yet still by placing multiple instruments under its sole responsibility, from rates policy to macroprudential policy, last resort interventions on microprudential policies, from quantitative easing in times of crisis to forward guidance, as has already been rolled out since 2014 with the implementation of the ECB's sole banking supervision within the framework of the European Banking Union? Beyond governance, it is the outlines of the mandate given to the monetary authorities which are at stake, and also indirectly the question of the central bank's independence, especially in times of crisis.

Answering these questions is not the point of this comment. This must not prevent us from noting that the debates relating to the new central banking are addressed, in the literature but also among the central bankers, from a specifically macroeconomic perspective, in reference to the optimality of the decisions of one or several public institutions, the central bank and/or the supervisor, faced with a representative agent presumed to be homogeneous, the banks or the banking system, ensuring the transmission of monetary shocks or regulatory innovations towards the real economy or financial markets. These analyses of central banking rarely come from a microeconomic perspective which integrates the heterogeneity of banking intermediaries or the combined effects and the interactions of changes to several instruments, in a macro-financial climate which greatly restricts each bank's reactions. Yet, the results presented in the three articles to which this comment is dedicated may also provide valuable contributions to the debates on the new central banking.

If the policies of liquidity injections in times of stress are especially effective in avoiding a credit crunch since they draw on widened collaterals, then it is important to maintain certain unconventional instruments in the central banks' toolbox, and also to mobilise them outside of crises. It is therefore important to avoid that normalisation lead to give them up. If the transmission channels of these policies towards lending rates demand close coordination with the fixing of base rates and turn out to be heterogeneous due to the specific situation of each bank (weight of non-performing loans, capital ratios, liquidity ratios, bank profitability) then, to be effective, the rates policy must be closely correlated to both microprudential policies (extra capital in accordance with Pillar II) and macroprudential policies (changes to the countercyclical capital buffer). This is especially so when the concentration of the banking sector multiplies interdependencies between the microprudential and macroprudential, which is the case in the eurozone (Panetta, 2016; Alessandri & Panetta, 2015).

We believe that the new central banking must operate via an enhanced granularity of monetary and financial regulations managed by one sole institution leading discretionary policies aiming at objectives of both monetary and financial stability, without any obligation to satisfy a defined ex ante decision-making rule (Santor & Suchanek, 2016). It must also operate by mobilising the full range of monetary and regulatory measures used during the financial crisis. In a way, by making the unconventional policies conferred to central banks durable in the post-crisis period. □

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Why does household demand for shares decline during the crisis? The French case

Luc Arrondel* and André Masson**

Abstract – The economic crisis has impacted French savers, now less willing to take risks in their financial decisions. What is the explanation behind these changes? According to "standard" theory, savers' investments rest on three fundamental determinants: present resources; expected risk and returns on assets, as well as expectations on earned income; and lastly, individual preferences, especially risk preferences. We use French data from the *Pater* panel, a survey collected in 2007 and again in 2009, 2011 and 2014. We show that it is the downward adjustment in the expected return from shares and negative impacts on current resources that help explain why the French are investing less and less in risky assets. Risk preferences, however, have remained stable. In contrast, the resurgence in optimism shown by savers in 2014 did not play out in reality, as the number of shareholders has continued to decrease. A new puzzle to be solved?

JEL Classification: J12, D63, D31, D12
Keywords: saver preferences, risk aversion, time preference, wealth, demand for stocks

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Great Recession savers underwent multiple "depressions": a financial and economic crisis making the environment more uncertain; concerns for the future of the social protection system (pensions, health insurance, etc.), rising unemployment risks, the vagueness of fiscal and institutional reform, enthusiasm for "activation" policies aimed at making individuals responsible for their futures, etc. Probably as a result of all the aforementioned uncertainties, French savers favour safe investments and short-term assets now even more than in the past, in particular passbook savings, insurance savings and real estate, at the expense of risky, long-term financial investments. For instance, according to the French Wealth survey (Insee's survey *Patrimoine*) the proportion of shares holders fell from approximately one in 4 French households in 2004 to one in 6 in 2014 (and one in 5 in 2010).

These figures reveal a significant drop in the number of shareholding households during the financial crisis, as well as, more generally speaking, the structurally-low participation rate in the stock market. This lack of interest on the part of savers for the securities market gives rise to two puzzles: the stock participation puzzle and the equity premium puzzle, despite better long-term returns to equities. These puzzles, beyond the case of France, reflect a widespread phenomenon, in particular in the euro zone. Indeed, according to the *HFCS* (*Household Finance and Consumption Survey*), approximately one in five households own risky financial assets in major countries and the overall euro zone (Arrondel et al., 2016). Risky assets ownership is higher, but still far from 100%, among the wealthiest households: for instance, in the wealthiest 5%, nearly three out of four households in Belgium hold such assets, as compared to just under two out of three in France, and around one out of two in Spain, Italy and Germany (Arrondel & Masson, 2015).

Faced with these two empirical puzzles, economists offer a variety of explanations in the framework of standard theory enlarged to a more realistic environment that acknowledges, in particular, that the markets are imperfect, as well as in the framework of behavioural economics, which fundamentally calls the standard model into question, in particular the rationality of the saver. Both behavioural finance and the standard framework make savers' behaviours and portfolio decisions dependent on only three sets of individual determinants: preferences (risk aversion, time preference, etc.); current resources, which can show varying levels of risk or availability; and expectations on future resources or tastes, in particular on equity return and risk and earned income. The question then becomes identifying "what has changed" since the collapse of Lehman Brothers in 2008, and the sovereign debt crisis in 2011: more specifically, has the "psyche" of savers changed (has their risk aversion risen), or is it rather that their expectations on asset return have significantly adjusted downward, in an environment generating high anxiety? In contrast, behaviourist models acknowledge non-standard forms of rationality and bring in other determinants of savings behaviour than mere risk aversion, in particular aversion to loss and to ambiguity.

Today's crisis provides valuable insights into households' financial behaviours in situations of high uncertainty. It entails to profoundly rethink assumptions regarding household finance in general and the formation of beliefs or expectations in particular. The first section will offer an overview of the current debate on the basic premises of stable preferences and rational expectations, which are assumed to respond only to "innovation": standard theory commonly recognises both these premises, while psychological economics, to the contrary, posits that changes in individuals' tastes can result from emotions and that expectations can fluctuate wildly. Today's financial and economic crisis also offers an ideal observatory, a kind of "natural" experiment of sorts, which sheds light on and magnifies the obstacles to household demand for shares, as long as fine-grained micro-economic data are available and make it possible to track the (same) savers prior to and during this troubled period. The longitudinal data from *Pater* surveys, unique in France, offer us the means to study the responses of savers during the Great Recession, and identify the changes that could explain their heightened cautiousness, by observing the concurrent development of their resources, preferences and increasingly pessimistic expectations. This analysis is developed in the second part of the article.

Why do households hold so few shares and how can changes in their behaviour be explained?

The risk premium puzzle was born of the inability of standard savings theory, a model that combines the life cycle hypothesis with the

theory of optimal portfolio choices (Merton, 1971), to explain households' low investment in shares. In attempting to solve this puzzle, economists have fallen into one of two categories: on one side, they expand the base model to a more realistic environment, allowing in particular for the existence of transaction costs, market imperfections and market incompleteness; on the other, in the framework of behavioural economics, they fundamentally challenge the assumed rationality of the standard theory's saver, both in terms of choices and expectation. After a brief review of the theory (see a more extensive presentation in online Complement C1), we will look at how the crisis also offers a valuable contribution to the critical discussion between "standard" economy advocates and those of psychological economy to explain the behaviours of households in the face of financial risk-taking.

From the "standard" investor to the non-standard investor: a brief theoretical review

The standard approach to saving behaviour primarily combines Arrow's theory on optimal portfolios (1965) with Modigliani's life cycle model (1986). In the simplest version, where the investor has the choice between a risky asset (which can match up with the market portfolio risk) with expected return α and standard deviation σ, r a risk-free asset; p the proportion of risky assets in the total assets depends on the "risk premium" $(\alpha - r)$, the volatility of the risky asset (σ) and the individual's relative risk aversion (γ), such that (for an isoelastic utility):

$$p = (\alpha - r)/\sigma^2\gamma \qquad (1)$$

The characteristics of assets (α, r, σ) depend on the saver's financial expectations, which are in turn a function of the degree to which they are informed. As soon as the expectations are uniform, this model thus predicts that it is always optimal for the individual to hold risky assets, if only as a minimal fraction of their total wealth. This baseline model can be enhanced by taking into account market imperfections or incompleteness: transaction and information costs, exposure to other risks (income, human capital, housing, health, etc.) and liquidity constraints. However, even in this extended version, the standard model offers only limited predictive power. It generates portfolios that are much more diversified than those seen in reality. Transaction costs, other risks, liquidity or credit constraints and ban on equity short-selling limit investments made all the more, but do not prevent a minimum amount of shares held from being profitable, as a result of their long-term high return (over 20 years or more).

The limited attractiveness of the stock market is then analysed, in general, as resulting from the existence of fixed entry costs of all kinds, including informational. These (fixed) costs of transaction, ownership and management, and threshold and indivisibility effects are assumed to explain the massive effect of total wealth on its degree of diversification (King & Leape, 1998); however, if the portfolios composed only of liquidities and quasi-liquidities are the province of the smallest fortunes, while well-diversified portfolios that of the highest, the explanatory power of the wealth level on the number of assets held or their composition is more limited to intermediate-level wealth (see Arrondel & Masson, 2015, for France). Thus, other factors need to be brought into the picture if we are to understand the low proportion of risky assets in household portfolios: liquidity constraints and other lending impossibilities (Gollier, 2001), risks faced outside financial markets (affecting income, health, family), but also taxation regimes, which can be more attractive with specific types of investments, in particular real estate. In addition to the limits of basic portfolio choice theory, even when extended (Guiso & Sodini, 2012), a variety of biases affect the way households manage their securities portfolio, calling more largely into question the standard model: a "home" bias in favour of national-level shares, "naive" (uniform) diversification, a "disposition" effect that causes individuals to part too early with winning assets and too late from losing assets, status quo bias, inertia, excessive transactions (Vissing-Jorgensen, 2003), etc.

On the other hand, "non-standard" models call into question the founding assumption of saver's rationality, and introduce preference parameters other than mere risk aversion, in particular aversion to loss and to ambiguity.

In the model developed by Kahneman and Tversky (1979), individuals value gains and losses differently: for those averse to loss, the disutility derived from a loss is greater than the utility derived from an equivalent gain. Barberis et al. (2006) also show that the combination of loss aversion and a focused "narrow framing" of stocks may help to understand non-participation in a stock market, even

without transaction costs. Aversion to ambiguity, meaning the fact that share return probabilities are not known (uncertain, as defined by Knight), can also explain failure to participate in the stock market (Ellsberg, 1961; Bossaerts et al., 2010; Epstein & Schneider, 2010) or under-investment in risky assets (Peijnenburg, 2014).[1] Individuals could also suffer from inadequate financial literacy and limited cognitive abilities (Lusardi, 2009; Guiso & Sodini, 2012) or could be victim to their emotions (Guiso et al., 2014). They are then said to make "errors" in calculation or strategy, or in expectation, when gathering and processing information –including overconfidence in their own judgements– and thus have trouble planning over the long term.

Despite some progress, both in extended models of the standard approach or those of behavioural economics, the two puzzles formed by stock market participation and equity risk premium have not yet been fully elucidated to date, and none of the above approaches effectively explain why the rate of share ownership has never exceeded one quarter of households these past few years, even in the most favourable periods of economic growth or stock market: neither unfavourable taxation conditions nor off-putting transaction costs can be invoked here, as ownership remains limited in households with large (financial) assets and education level.

One final avenue to explore is that of investors' information: the basic portfolio choice model assumes that financial information is free and available to all investors. Yet a series of stylised facts shows that portfolio diversification and share ownership increase with age (until retirement), as necessary financial information is gained, as well as with the level of general education (Arrondel & Masson, 2015). This role of education is backed up by a broader *habitus* effect and, above all, the ownership of transferable securities (as well as life insurance) appears to be inherited, increasing sharply with the presence of the same assets in the parents' wealth. A large body of recent literature looks into the factors relating to information, which appear to play a major part in determining participation in the stock market: cognitive abilities (Christelis et al., 2010 ; Grinblatt et al., 2011), confidence (Guiso et al., 2008), "sensitivity" to financial matters (Guiso & Jappelli, 2005), time spent collecting information (Guiso & Jappelli, 2007), social interactions (Hong et al., 2004), optimism (Jouini et al., 2006), financial education (van Rooij et al., 2011; Lusardi & Mitchell, 2014). However, the exact mechanism by which these factors influence households' financial decision-making (*via* the stock of information available, expectations, etc.) has yet to be formally established (Grinblatt et al., 2011). However, there too, these factors even all combined do not adequately explain why direct shareholding is now chosen by no more than one in seven French households.

The crisis has made savers more cautious in their behaviour, pushing them to prefer safe assets, at the expense of risky assets. Analysis of the factors explaining change in behaviours during the crisis is a valuable "test" of the two cornerstones to the standard approach: temporal stability in preferences and the rational expectations hypothesis.

Possible sources of change in behaviour: preferences, resources and expectations

In the standard approach, portfolio choice theory shows that demand for risky assets (see Equation 1) decreases with the (relative) risk aversion, decreases with exposure to risk on earned income and is an increasing function of the household's expected risk premium, but a decreasing one of the expected risk portfolio. More generally speaking, investment behaviours depend on the interaction between three components:

(i) risk (and time) preferences, inherited from the past;

(ii) disposable resources and present endowments (assets and income, liquidity constraints, current unemployment risk; health and human capital, etc.; financial literacy and cognitive capacities that determine the individual's information level);

(iii) expectations and beliefs with respect to the future: earned income, unemployment probabilities, pension rights, expected return and risk on financial or real estate assets, inflation, credit constraints, etc.

1. More specifically, ambiguity could also explain the two puzzles connected with portfolio management, home-bias (French & Poterba, 1991) and own-equity stock *(Benartzi, 2001):* home bias *translates as low demand for foreign shares, the probabilities of which are little known to investors; in contrast, an investor adverse to ambiguity will be likely to give preference to shares issued by the company for which they work, favouring "familiarity" over risk diversification.*

These three components can be summed up in the following empirical equation:

$$\text{Behaviours} = F\left(\text{Preferences, current Resources, Expectations}\right) \quad (2)$$

To study the increased behavioural cautiousness of French savers on the stock market since the start of the crisis, the relationship (2) needs to be rewritten in differences:

$$\Delta\text{Behaviours} = F\left(\Delta\text{Preferences}, \Delta\text{current Resources}, \Delta\text{Expectations}\right) \quad (3)$$

Consequently, to explain the changes in financial behaviour during the crisis, the following factors can be suggested: an increase in risk aversion –or aversion to loss and ambiguity, etc. (Δ Preferences); reduced and/or riskier resources (Δ current Resources); gloomier expectations on the assets' technical characteristics (return, volatility) (Δ Expectations).

Empirical analysis of relationship (3) will enable us to test, during the crisis and on French data, two foundations of standard savings theory: the assumption of temporal stability in preferences and the rational expectations hypothesis. Let us first go back over the theoretical challenges raised with this latter hypothesis before coming to the conclusions of foreign studies that offer empirical measurements of risk preferences.

Challenging the rational expectations hypothesis

The 2008 financial crisis unsettled the macro-economy's traditional foundations to a certain extent (Hall, 2010; Stiglitz, 2011). Debate today revolves around the role of expectations in the standard macro-economic models, in particular on the financial markets. These models are based on the paradigm of rational expectations in which (omniscient) individuals draw on all available information, past and present, to form their expectations, which are consistent with the economic model connecting the expected variable with the other variables. According to these assumptions, individuals, on average, are not mistaken about the future, revise their predictions only in accordance with innovations observed (and not their emotions) and, in fact, share a single, identical prediction. The paradigm of rational expectations leaves but little room for lasting heterogeneity in beliefs.

Challenging the rational expectations hypothesis, in particular belief homogeneity, appears a promising avenue for research. Behavioural finance puts forward, in this sense, different cognitive biases in the formation of expectations;[2] according to Gollier (2013, p. 3), "*it gives people license to dream of impossible returns, reject the information that does not suit them [though relevant], or agree to disagree with one another*", these psychological biases being likely to contribute to explaining "*bubbles, cycles and crashes*", especially if they are reinforced by biased media coverage; it is also concerned by the "*extreme pessimism of economic agents during the phases of [acute] crisis*" caused by a strong aversion to ambiguity combined with increasingly gloomy expectations on stock market prices. While considering the applications of behavioural economics to finance relatively disappointing to date, Guesnerie (2010, p. 1) develops another avenue for research in order to understand expectations: "*What is at stake here is the ability of agents to coordinate their depictions of the future. The optimism of many a financial market model –for instance, those which point to forms of informational market efficiency– relies largely on the optimism of the assumption of coordinated expectations. Whereby the said optimism should be explained and not only assumed.*"

To assess the heterogeneity of expectations, the best method remains to measure them in surveys as Dominitz and Manski (2011) suggest, and evaluate their impact on financial behaviours (Arrondel et al., 2016). The impact of the 2008 crisis on stock market expectations has been analysed by Hudomiet et al. (2011) for the United States, based on data from the *Health and Retirement Survey* (*HRS*, 2008-2009). They show that, on average, the crisis had a (temporary) positive effect on expected return and variance, as well as on expectation heterogeneity (in the longer term) within the American population. More specifically, shareholders form more optimistic, less uncertain and more uniform expectations than do non-shareholders. However, shareholders' expectation heterogeneity has increased relatively after the crisis. The same can be observed even looking at groups of informed persons compared to non-informed persons, or even based on level of cognitive ability (high versus low). The authors

2. *"Representativeness" bias in particular causes a (positive) combination of circumstances to be seen too positively even when it may be the result of chance, or cause initial expectations to be inadequately adjusted in light of realities (Kahnemann, 2011). "Availability" bias, which causes individuals to place too much value on personal events or events connected to their own experience, and "anchoring" basis, were concepts ushered in by Tversky and Kahneman (1974), etc.*

conclude that different categories of population do not receive the same signals or do not respond to them in the same manner, thus lending credence to the heterogeneity hypothesis as regards households' financial expectations.

Time stability of preferences with regard to the risk in question

The time stability of preferences hypothesis is implicitly at the heart of standard saver theory. In most models, preferences are assumed to be exogenous and constant over time. As Stigler and Becker (1977) wrote in a hallmark article, individuals' preferences do not change and changing behaviours can come only from changes in the economic environment.

This taste invariance hypothesis has been challenged by abundant empirical literature based on survey data or experimental protocols. This research is aimed at testing whether individuals' preferences evolve over time, or whether they are modified for the long term by life events (health problems, death of loved ones, unemployment, financial losses, etc.) and structural shocks (natural disasters, wars, economic crises, etc.) which individuals have to face.[3] Many articles address in particular the connection between the economic environment and attitudes towards risk, in particular during times of crisis. Sahm (2012) for instance, studies change in risk aversion based on responses to a lottery regarding professional choices over the 1992-2002 period in the United States (resulting from different waves of the HRS panel). Her analysis on individual panel data shows that nearly three-fourths of the variation in risk aversion can be explained by permanent individual heterogeneity, age and macroeconomic environment explaining the remainder. This study thus tends to assert preferences stability, but over a relatively quiet pre-crisis period. Other recent work following the same savers during the crisis show more contrasting results. Guiso et al. (2014) use data on investments made by an Italian bank's customers before and after the 2008 financial crisis. They measure individuals' risk aversion using a qualitative question on the propensity to invest in risky assets, first, (*cf. infra,* Figure II) and based on a series of lotteries, as in experimental economics, secondly. They show that risk aversion increased after the financial crisis, even for those who did not undergo any financial losses. According to the authors, an emotion, the "fear" triggered by the crisis, is the reason for this outcome.[4]

Cohn et al. (2015), similarly, demonstrate the counter-cyclical nature of risk aversion (individuals are more risk tolerant when markets are booming and vice versa) on the basis of a lab experiment carried out with traders. Drawing upon methods derived from psychometrics, the subjects are "conditioned" to behave either during "boom" or during "bust" periods. Their experience shows that traders conditioned during "bust" periods are less inclined to take financial risks than are their counterparts conditioned during "boom" periods. Like Guiso et al. (2014), they show that fear could be the reason behind this outcome.

Dohmen et al. (2016) use data from Germany's *Socio-Economic Panel* and the Ukrainian *Longitudinal Monitoring Survey* to analyse time stability in risk aversion measured by a Likert scale (0 to 10) over the 2007-2012 period. They also observe that in both countries, individuals appear less risk tolerant after 2008 than before the crisis. The change is said to be due primarily to the macro-economic shocks triggered by the crisis, while the actual experience of the individuals and their labour market status is said to play only a minor role. Using other data from Germany (*SAVE*), Necket and Ziegelmeyer (2016) show that households that ascribe their loss of wealth to the crisis are also less risk tolerant (as measured on the Likert scale).

The results from Weber et al. (2012) go against the conclusions of these previous studies. Drawing upon data on customers of a British bank, they show that demand for risky assets significantly declined between September 2008 and June 2009. This change is not, however, due to a variation in the customers' risk aversion (still measured with the same scale), which remained stable over the same period, but to changes in their individual expectations regarding return and risk on equities. Malmendier and Nagel (2011) adopt a longer-term vision of the

3. Chuang and Schechter (2015) survey the studies considering the impact of natural disasters and wars on individual preferences (aversion to risk, preference for the present). The result is a contrasting picture, whether in terms of tolerance for risk or time preference: some studies show an increase in risk aversion and impatience due to shocks, while others point up a decrease! Chanel et al. (2014) show for instance that Danish soldiers on mission in Afghanistan in Spring 2011 had, on average, become less risk-averse and more impatient after combat.

*4. To test this hypothesis, they doubled up their study with: a "randomised" laboratory experiment on two samples, one involving individuals who had been shown a horror film (*The Hostel*) before answering the lottery, the other individuals who had not watched any film. The authors concluded, controlling individuals by their taste in films, that those who were still under the impact of the horror film proved less tolerant with respect to risk.*

impact of macro-economic shocks on attitudes toward risk in the financial arena. Using data from the US *Survey of Consumer Finances* over the 1960-2007 period, they show that people who have, in particular in early childhood, experienced periods of low-return securities (particularly during the "Great Depression" in the aftermath of the 1929 crisis) take less risk in their subsequent investment decisions (see question in Figure II). Their expectations on future returns are also more pessimistic than those of individuals who have experienced periods of high return; it is also likely that they are less tolerant with regard to risk. These effects taper off, however, with time.

Although no final conclusions can be drawn, empirical results appear to lean, by and large, toward an increase of risk aversion on the part of savers during the crisis or periods of recession, the said increase perhaps explaining in part the drop in their risky investments. Two criticisms can be voiced nonetheless with respect to the studies in question – regardless of whether they confirm preference stability. The first reservation is methodological in nature and pertains to risk aversion measures (Arrondel & Masson, 2014), some of which relate more to risk-taking behaviours (a propensity to take risks) than to intrinsic preferences (as with the question in Figure II). But above all, the most common measures derived from lotteries on professional choices or Likert scales show significant flaws, to which we will return later. The second criticism, in particular against Dohmen et al., 2016, is econometric: conclusions based on panel data (fixed effects models) need to be taken with care, as they do not always make it possible to separate age effects (risk aversion increasing over the life cycle) from period effects.

The French savers during the Great Recession

We will now study changes in individual preferences, revisions to subjective expectations on return and equity risk and the impact of the crisis on available resources, then connect those potential changes up with those observed on investment behaviours, in particular demand for shares. In other words, we seek to empirically estimate a type (3) relationship. To do so, we will turn to the *Pater* surveys (French surveys on Household Wealth, Time and Risk Preferences –see Box 1), which offers the probably unique advantage of combining all the information needed for such an estimation over a representative sample of the French population. Thanks to its longitudinal dimension and the subjective information gathered, this survey makes it possible to study the consequences of the crisis on French savers' financial behaviours, their preferences when it comes to saving, their resources, and their expectations about the labour market and assets.

Compared to the studies presented earlier on risk preferences time stability, the originality of our empirical approach lies in the variety of measures of preference used: beside the usual risk aversion measures used in these studies, we will adopt, to avoid the flaws of these measures, a new approach based on a "scoring" procedure. It results in more satisfying measures of preference and thus enables a more robust test of the time stability of risk tolerance. In addition, the dates of each wave of the *Pater* panel study were particularly well-chosen: May 2007 coincides with high CAC 40 indices, while the two following waves (June 2009 and November 2011) come shortly after major crashes of this same market (see figure in Box 1); these historical breaks will help us separate age effects from period effects in the explanation of changes in preferences.

Financial behaviours became less and less risky during the crisis…

The data from the Insee's Wealth surveys (surveys *Patrimoine*) show that the percentage of shareholders (excluding mutual funds) fell by seven points in France, from 19% of households in 2004 to 12% in 2014 (15% in 2010). According to the quarterly survey *SoFia* carried out by Tns-Sofres with 12,000 panel members (including those of our *Pater* surveys), the number of "direct" individual shareholders decreased by 55% following the collapse of Lehman Brothers, between December 2008 and March 2016 (13.8% to 6.2%). These data show an increase of around 30% in the amounts placed on "Livret A" savings passbooks over the same period. This decrease in the number of shareholding households (direct or indirect) also emerges from the *Pater* surveys (Figure I). Over the period from 2007-2014, the percentage of households holding shares in all households decreased from 31.1% to 16.8% (–46%). The decrease can also be seen in the balanced panel, which includes 807 households across

Box 1 – **The French survey on Household Wealth, Time and Risk Preferences (*Pater*) 2007-2009-2011-2014**

The *Pater* survey was initiated in 2002, in order to supplement Insee's Household Wealth surveys on more subjective aspects (preferences, expectations, attitudes). The panel waves were structured on our initiative and conducted by the TNS-Sofres Institute (see Arrondel & Masson, 2014). The surveys' history is summarised below.

The strong panel-based dimension and the timing of the waves (May 2007, June 2009, November 2011 and December 2014) made it possible to cover a period of significant stock market variations, before and after the Lehman Brothers collapse in 2008, and after the August 2011 sovereign debt crisis (see Figure).

In addition to the information usually collected in Insee's Wealth surveys, *Pater* surveys include a range of qualitative and subjective questions aimed at measuring individuals' preferences as regards savings, as well as their expectations with regards to their future resources (Table B).

Table A
***Pater* survey waves**

	Sofres 2002	TNS-Sofres			
		2007	2009	2011	2014
Number of observations	2 460	3 825	3 782	3 616	3 670
Panels		2002-07 (798 panellists)	2002-07-09 (600 panelled) 2007-09 (2 234 panelled)	2007-09-11 (1 087 panelled) 2009-2011 (1 970 panelled)	2007-09-11-14 (807 panelled) 2011-2014 (2 204 panelled)
Special features	2 generations (440 parent-child couples)	Both spouses are surveyed (905 couples)	-	-	-
Number of questions for scores	50	115	90	90	90
Barsky et al. lottery	Yes	Yes	Yes	Yes	Yes
Scales	No	Yes	Yes	Yes	Yes
Experimental measures	No	Yes	No	No	No

Figure
***Pater* survey waves and change in CAC40**

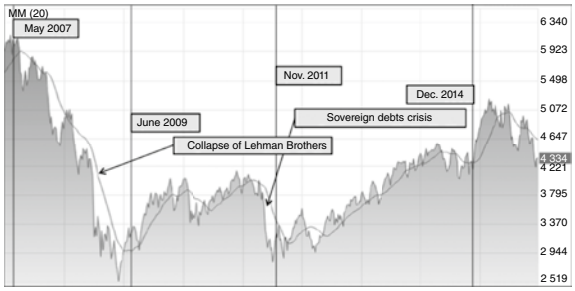


Table B
Questions from *Pater* survey on expectations about the labour and stock markets

C33 **In 5 years' time, do you think that <u>your household's income (salary, pension)...</u>** *For each item, rate the likelihood, from 1 to 100, that the event described will occur.* **<u>The total sum of the responses in the column must be equal to 100.</u>**

	C33	C34
• Will have increased by over 25 %	%	%
• Will have increased by 10 to 25 %	%	%
• Will have increased by less than 10 %	%	%
• Will be at its current level	%	%
• Will have decreased by more than 10 %...	%	%
• Will have decreased by 10 to 25 %	%	%
• Will have decreased by more than 10 to 25%.	%	%

C34 **In 5 years' time, again, do you think that the Stock Market.** *For each item, rate the likelihood in plain text, from 1 to 100, that the event described will occur.* **<u>The total sum of the responses in the column must be equal to 100.</u>**

C35 **In your opinion, in 5 years' time, <u>in the event of an increase, what will be the maximum decrease (in percentage terms) in...</u>**
Write down the percentage in plain text

	C35	C36
• Your household's income	%	%
• The Stock Market	%	%

C36 **In your opinion, in 5 years' time, <u>in the event of a decrease, what will be the maximum decrease (in percentage terms) in...</u>**

four waves: 27.8% in 2007, vs. only 14.8% in 2014 (– 47%).

Moreover, when these 807 households studied from 2007 to 2014 are interviewed regarding their overall financial investment strategies, it emerges that a growing percentage of them believe that "all savings should be placed into safe investments", even though a slight decrease can be seen in the last wave: 59% in 2007, 66% in 2009, 72% in 2011, and 67% in 2014 (Figure II). The same can be seen across broader samples: even though, in terms of behaviours, no recent increase can be seen in demand for risky assets (see Figure I), the French are said to now appear more inclined toward turning to the stock market than at the peak of the crisis. It should be noted that this type of question is used by some authors to measure individuals' risk aversion (Guiso et al., 2014, Malmendier & Nagel, 2011), probably wrongly, as it mixes up preference and behaviour.

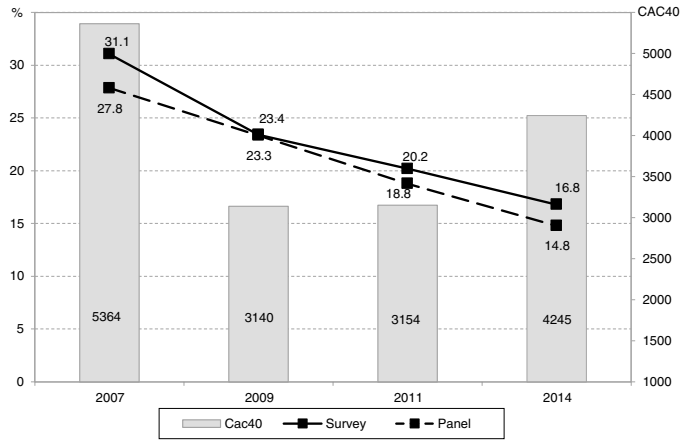
Through these two statistics, our data thus show that, while the French may have deserted the stock market since the 2008 crisis, they are however now not hostile to returning to it. If they are not, actually, returning, the challenge lies in understanding the reasons. A tendency toward caution can also be seen in the respondents' answers to a more evasive question: "Would you say that, since the financial crisis, you have become more careful, less careful, or have not changed?" In 2009, while half of households reported that their behaviour had not changed, the other half (48%), made up primarily of the most underprivileged, also most exposed to the crisis classes (low level of education, low income), reported being more cautious. In 2011 and in 2014, the cautious group grew into the majority.

Beyond these broad changes, it is important to see that households did not respond in a uniform manner to the context of crisis, in particular along the distribution of income or wealth. Nonetheless, one observation remains indisputable: in the face of the crisis, the French became more cautious in their financial behaviour, looking to place their savings in safer investments and concurrently limit their risky investments; and this change appears to have been even starker after the sovereign debt crisis of Summer 2011 than following the macro-economic shock created by the collapse of Lehman Brothers in September 2008.

... but expectations during the crisis showing growing pessimism only up to 2011

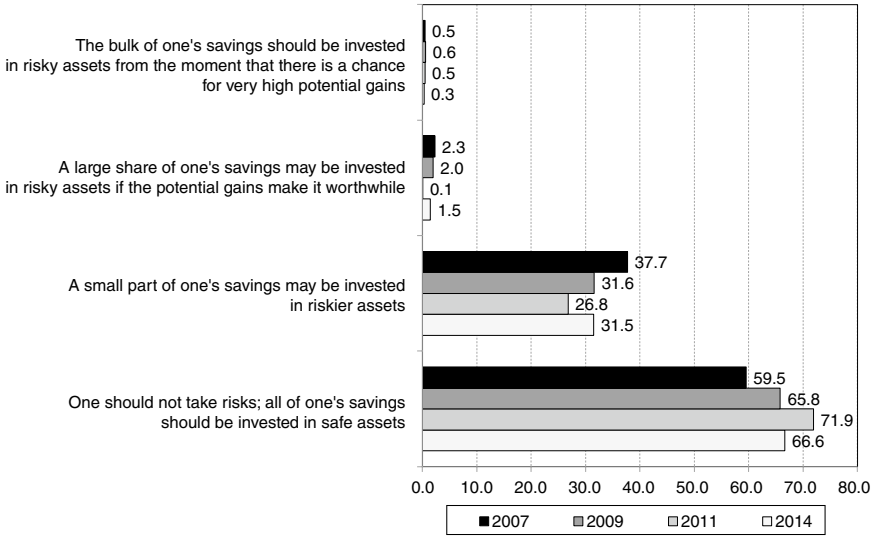
In addition to estimating preferences, the 2007 to 2014 waves of the *Pater* survey aimed to measure household expectations on the return and risk connected with financial assets, as well as those on their future earned income. One method for measuring expectations on earned income or pensions involves offering the respondent the chance to assign probability to different possible levels of variation over the

Figure I
Percentage of shareholders (direct or indirect) in 2007, 2009, 2011 and 2014



Reading note: In 2011, 20.2% of households in the survey owned shares directly or via mutual funds. This percentage amounted to 18.8% in the panel sample. As at the survey date, the CAC 40 was at 3,154 points.
Coverage: Total sample representative of the French population and panelled population having responded to all 4 waves of the survey (807 individuals).
Source: *Pater* surveys 2007, 2009, 2011 and 2014.

Figure II
When it comes to financial investments, what is your preference? (%)



Reading note: In 2007, 59.5% of those having responded to all three successive waves of the *Pater* Survey gave preference to "putting all their savings in safe investments". The percentages amounted respectively to 65.8% in 2009, 71.9% in 2011, and 66.6% in 2014.
Coverage: Panelled population responding to all 4 survey waves.
Source: *Pater* surveys 2007, 2009, 2011 and 2014.

next five years, upward (from 0 to 10%, from 10 to 25%, above 25%), downward (same brackets), or unchanged (see Box 1, Table 1). This makes it possible to reconstruct the breakdown in anticipated changes in income and thus deduce the related mean and variance.[5] The same method has also been used to measure stock market expectations.[6] Asked in the same manner in 2007, 2009, 2011 and 2014, these questions make it possible to approach the impact of the crisis on the same savers over two, three, or even all four waves. As these questions are relatively complex, they are also subject to an unusually high non-response rate: in each wave, as for the individuals in the panel, only slightly more than half of those surveyed responded adequately. Descriptive analysis, however, shows that the characteristics of respondents and non-respondents are not markedly different (although the respondents appear to have more time available to answer the questionnaire).

Figure III shows the resulting values for an expected average 5-year return on the stock market, on four dates, for the total population and various sub-populations. One of the first conclusions matches up with those of studies on other countries, whether American or other, already cited: low expected return, even in 2007, is not entirely compatible with rational expectations.[7] Secondly, it can be observed that, in the overall population, the average expected return sharply declines over the period: from 5.5% in 2007 to 1.4% in 2014, after a drop of 2 points in 2009 (3.5%) and 3.5 points in 2011 (0%). The same trend can be seen in the expectations of the respondents to the four waves: approximately 5.0% in 2007, 4.5% in 2009, 0% in 2001 and 1% in 2014.

In summary, even though a slight return to "optimism" can be noted in 2014, the French were, at the height of the crisis, very pessimistic on the stock market prospects, and this

5. Placing, for instance, 50 points in the upper segment (an increase of over 25%) and 50 points in the lower segment (a decrease in excess of 25%) results in an average expectation of zero, but renders maximal risk (variance)... To calculate the expected return, the centre of the segment is used for the restricted intervals, and the maximum upper and lower limits provided by the respondent, for the non-restricted intervals.
6. Other techniques are nonetheless more common, including one-off surveys on expectations or measurements of cumulative distribution (for example, Dominitz & Manski, 2011).

7. When surveyed about past *changes in the CAC 40,* Pater *respondents (2007) underestimated on average the performance of the market index over the previous five years, placing it at 12% compared to the actual 20% observed (see Arrondel et al., 2016). It can be noted nonetheless that the modal value (over one-fourth of the sample) matches reality, thus attesting to a certain level of information in the population surveyed.*

could explain the fact that they have moved (even farther) away from it.[8]

Lower income expectancy, fainter return prospects on equities and an expected increase in risks impacting the labour market (see footnote 8): this increased pessimism on the part of households since the crisis, though it does seem to have faded in 2014, appears to have stirred them, consistently with the portfolio choice theory, to turn away from risky investments, either as a result of the supposed smaller attractiveness of these investments, or to mitigate the overall risks which they faced (risk substitution). The downward adjustment in professional and equity expectations could thus in large part explain the more cautious behaviour of households since the crisis, even more pronounced after 2009. What about preferences, though?

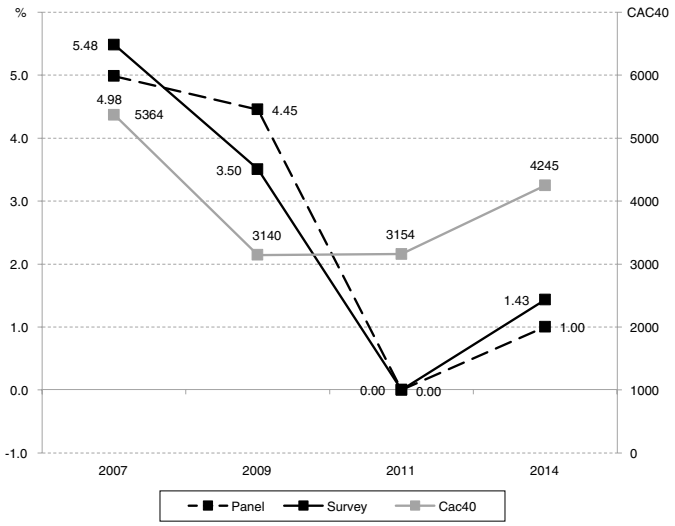
The traditional measures find risk aversion on the increase from 2007 to 2011

Three measures of risk preference will be analysed now. The first is based on hypothetical lottery choices regarding individual permanent income (Barsky et al., 1997). The individual is offered a variety of work contracts in place of the existent one, generating life cycle income R: for instance, a contract under which the individual has a likelihood of 1/2 to earn 2 times more income R and likelihood of 1/2 to earn only 2/3 of R. This method makes it possible to classify individuals into four categories, from the least to the most risk-tolerant (Sahm, 2008). The second measure is based on self-reported levels of aversion/appetite on a scale of 0 to 10 (Likert scale, see Dohmen et al., 2011). The third and final measure, which is more original, consists of "profiling" individuals using our scoring method.

Table 1 shows the population breakdown (balanced panel) by response to the lottery question. According to this measure, the same individuals became, on average, more risk averse after the crisis, at least up to the end of 2011: 51.8% rejected the two contracts in 2007, as compared to over 60% in 2009 and 2011, and still 59% in 2014; conversely, 7.9% were ready to accept both contracts in 2007 compared to 5.4% in 2009, 3.5% in 2011 and 6.0% in 2014. This lottery thus shows that individuals possibly became more risk averse at the time of the 2008 and 2011 market shocks, but would have become slightly more tolerant since then (at least back to the 2009 levels).

8. Likewise, household expectations regarding future changes in labor income have been adjusted downward: overall, the French anticipated that their income would increase on average by more than 3% in 2007, and by 2% in 2009, but foresaw stagnation in 2011 and 2014.

Figure III
Average expected return (over the next 5 years) on the stock market in 2007, 2009, 2011 and 2014



Reading note: In 2009, households expected average return of 4.45% on the financial market (3.50% amongst households having responded to all 4 waves of the survey). As at the survey date, the CAC 40 was at 3,140 points.
Coverage: Total sample representative of the French population and panelled population having responded to all 4 waves of the survey.
Source: *Pater* surveys 2007, 2009, 2011 and 2014.

Figure IV illustrates individuals' average self-reported positioning on the Likert scales, as regards risk preference ("+" indicating greater risk tolerance). As to global risk, it can be seen that the 2008 and 2011 shocks had a negative effect on risk tolerance (4.6 in 2007 compared to 4.3 in 2009 and 4.0 in 2011) as was the case with the lottery. There too, however, a slight turnaround can be seen in 2014 (4.1), though relatively smaller than with the lottery (still below the 2009 levels).

If these preferences are measured as in the Barsky et al. lottery (1997) or using a Likert scale, it can be assumed that individuals became more tolerant to risk during the crisis, at least up to 2011, but then regained, in 2014– to varying extents– some of their lost appetite for risk.

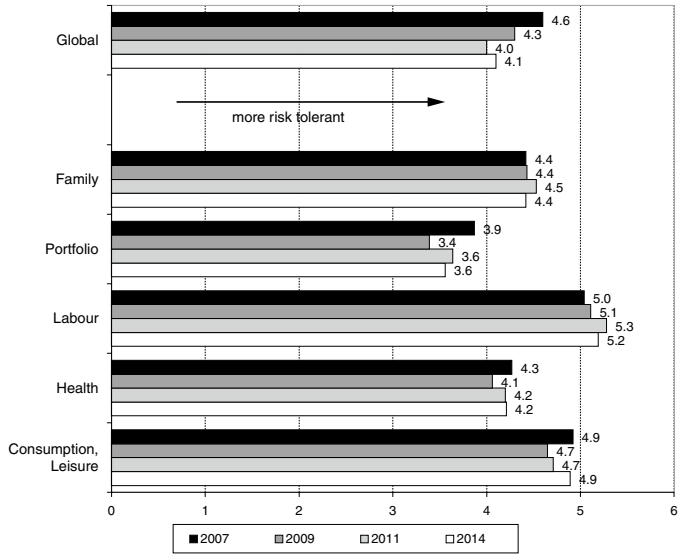
These measures present some major flaws, however, as has been pointed out in the literature (Arrondel and Masson, 2014). Lotteries on professional decision-making, for instance, lack constancy over time, and the responses provided by a single individual can vary significantly and inconsistently from one survey to the next (as can be seen in American data as well as in our own data); they depend on

Table 1
Distribution according to Barsky et al. lottery (1997) in 2007, 2009, 2011 and 2014

	Contract A rejected		Contract A accepted	
	Contract C rejected	Contract C accepted	Contract B rejected	Contract B accepted
Relative risk aversion: γ	3.76=<γ	2=<γ<3.76	1=<γ<2	γ<1
2007	51.8	22.3	18.0	7.9
2009	60.2	20.0	14.4	5.4
2011	63.4	21.2	11.9	3.5
2014	59.0	21.7	13.3	6.0

Reading note: 63.4% of individuals rejected both contracts in 2011 (and thus showed high aversion to risk γ) while only 6% accepted both contracts (respectively low risk aversion).
Coverage: Panelled population responding to all 4 survey waves.
Source: *Pater* surveys 2007, 2009, 2011 and 2014.

Figure IV
Likert scale distributions in 2007, 2009, 2011 and 2014



Reading note: In 2007, the average response on overall risk scale (between 0 and 10) amounted to 4.6. The average was 4.0 in 2011: Respondents thus became more risk-averse.
Coverage: Balanced panel (807 individuals).
Source: *Pater* surveys 2007, 2009, 2011 and 2014.

the respondent's exposure to risk, in particular with regard to their personal wealth; they furthermore lead to biased results, insofar as they are more accessible to individuals with greater financial literacy. The Likert scales, meanwhile, show well-known anchoring biases (around the central value, 5); they too are unstable from survey to survey, but to a lesser degree than lottery choices.

Two inter-related questions thus arise: do measures as sensitive to the economic environment as these truly reflect an intrinsic risk preference? Is their evolution over time not merely reflect households' greater exposure (to unemployment risk, for instance), or does it echo too closely changes in job- or equity-related expectations, expectations that were increasingly pessimistic up to 2011? More specifically, two interpretation hypotheses can be offered for the above results:

Hypothesis H1: despite their limitations, the usual measures attest to an overall increase in risk aversion after the 2008 and 2011 shocks, the magnitude of which cannot however be assessed with precision; savers fell victim to "trauma" after each shock, and even more so after the second. The preference stability assumption of the standard theory is thus rejected, and the influence of "emotions" on tastes must be taken into account, at least where major macro-economic shocks are concerned.

Hypothesis H2: the obvious biases hampering the usual measures are such that their results are not robust, as they can be the result of parasite variations in exposure to risks or in expectations. They do not make it possible to discard the hypothesis of globally stable preferences after each shock.

Unless available measures at close intervals before and after each shock, making it possible to eliminate "noise", it is hardly possible to opt in favour of one or the other of these hypotheses. A more satisfying, but also more costly measure of risk preferences will enable us to do so.

The scoring method finds attitudes to risk insentitive to the crisis

Our original approach to measuring savings' preferences, in particular with regard to risk, is based on a scoring procedure devised and improved for the past fifteen years, with each wave of the *Pater* survey (Arrondel and Masson, 2014). Using an extensive questionnaire that spans multiple areas of life, the idea is to build, for each respondent, summary and consistent ordinal measurements –qualitative "scores"– that assess their general attitude toward risk and uncertainty, as well as their time preference in a life-cycle perspective, their degree of impatience in the short term and their degree of altruism toward their children (a more detailed presentation is provided in Box 2). Where risk is concerned in particular, the score based on sixty identical questions in each wave, does not present the flaws of the usual measures (lottery choice or self-reported Likert scale) and offers statistical properties that are far superior and much more robust from one wave to the next (see Box 2).

Age and period effects

What does the risk aversion score tell us about changes in preferences during the crisis? The score histograms sketched out two by two, first for the sub-population of households interviewed before and after the collapse of Lehman Brothers (in 2007 and 2009), and secondly for those surveyed before and after the sovereign debt crises in 2009 and 2011, and lastly for respondents to waves in 2011 and 2014, overlap almost perfectly, with nearly the same average on two successive dates, and they are actually not statistically different (figure V-A): the Kolmogorov-Smirnov test shows 0.0299 in 2007-2009 (significance threshold: 0.269), 0.0163 for 2009-2011 (threshold: 0.956) and 0.0372 for 2011-2014 (threshold: 0.102). The first two graphs in Figure V-A are particularly enlightening and tend to plead in favour of Hypothesis H2: the score proves broadly insensitive to both crisis-related shocks, suggesting an absence of period effects on risk preferences; the change recorded with the usual risk aversion measures would then be an artefact due to parasite phenomena.

As concerns the 2007 and 2014 histograms regarding the respondents to the four waves (figure V-B), the Kolmogorov-Smirnov test (0.0720 with a significance threshold at 0.033) shows, however, a significant shift to the right, i.e., growing risk aversion over the period: taking into account the previous results, it is likely that this change reflects nothing more than an age effect, the individuals being 7 years older. All of the surveys, French (including *Pater*) or foreign, show that risk aversion, regardless of the measure adopted, is increasingly a function

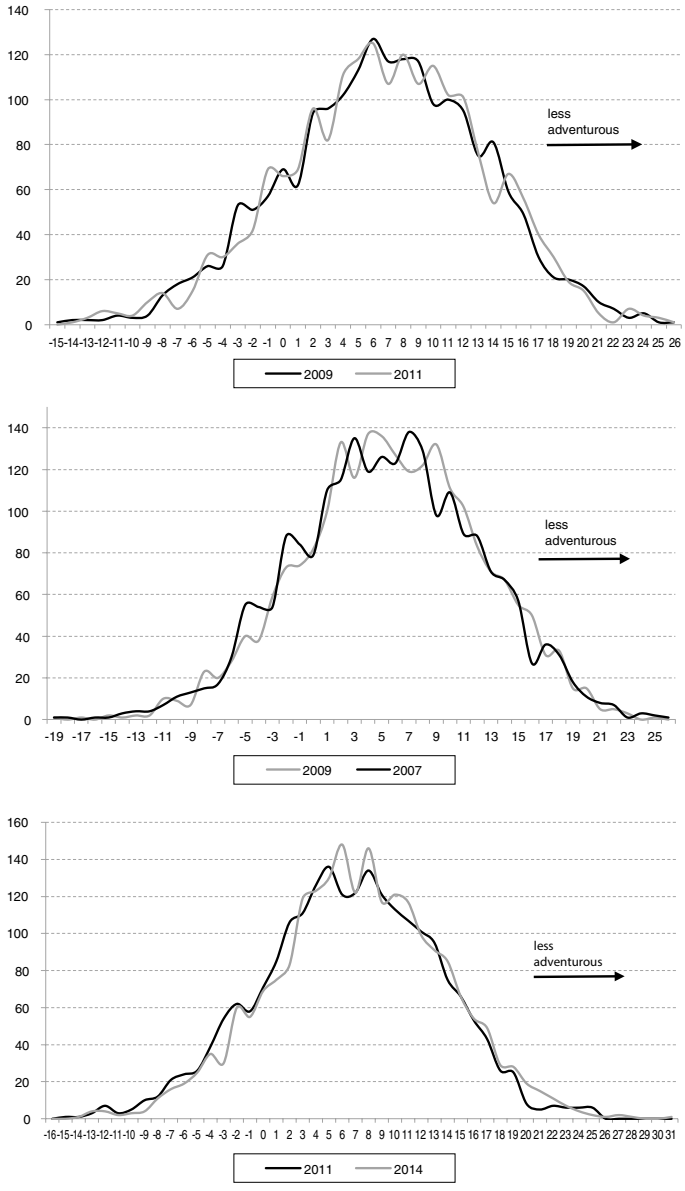
of age with cross-section data; and this consensus on a negative age effect on risk tolerance extends to the smaller number of longitudinal studies (see Sahm, 2012, for instance).[9]

The results of the statistical analysis are supported by econometric analysis. Table 2-A shows a regression (linear model) of the determinants of the risk aversion score. This model is the same as a cross-sectional regression, but in which the four waves are stacked (and variances are "clusterized").[10] We obtain again the effects highlighted in each of the survey's waves

9. The identification of an age effect in connection with risk aversion on an interval limited to 7 years does not give rise to any particular problems. The same cannot be said over a longer period, including with our risk aversion score, as an anonymous commenter pointed out: some questions necessarily refer to "situations that are quite different", depending on whether the respondent is young or old: "Involvement [current or past] in extreme sports, opinion on marriage, the virtues of social monogamy, the desire to live a longer life, etc." *We check that removing the most contentious questions did not change the substance of the most conclusions that emerged (except for limiting score quality).*

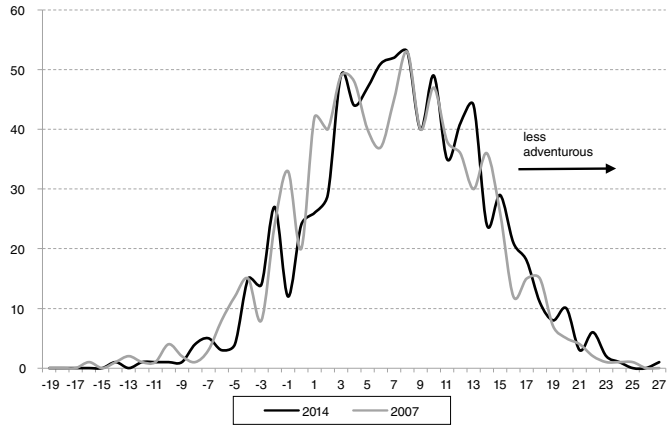
10. As to the variables that do not change over time, the estimation is probably robust. In contrast, for those that change over time, the estimation shows a bias that can be corrected using panel data econometrics techniques.

Figure V-A
Risk score histograms in 2007, 2009, 2011 and 2014



Reading note: Over 140 respondents posted a risk score of 6 in 2014. There were 120 of them in 2011.
Coverage: Panelled population responding to two successive survey waves.
Source: *Pater* surveys 2007, 2009, 2011 and 2014.

Figure V-B
Risk score histograms between 2007 and 2014



Analysis: Less than 40 respondents posted a risk score of 6 in 2007. There were 50 of them in 2014.
Coverage: Panelled population responding to all 4 survey waves.
Source: *Pater* surveys in 2007 and 2014.

Box 2 – **The *scoring* method**

Our method for measuring individual preferences involves devising scores to "profile" individuals, based on their taste for risk, the way they approach the future, and their degree of parental altruism, that is, the three components of savings and wealth accumulation models (see Arrondel & Masson, 2014, for a detailed presentation). Tested and developed with data from the Insee's Household Wealth survey 1998, then the 2002 TNS-Sofres survey, this method was repeated for the last four waves *Pater* in 2007, 2009, 2011 and 2014.

These summary and ordinal scores are computed on the basis of over one hundred questions covering a wide range of economic and social areas, such as consumption, leisure, investments, work, family, health, retirement, etc. These questions are often concrete or related to everyday life or plans, and are relatively easy to answer; others are more abstract, and pertain to responses to fictional scenarios or lottery choices. On the basis of these questions, the aim was to build, for each respondent, consistent relative indicators or "scores" on preferences or attitudes in the four fields identified in the theoretical literature: risk or uncertainty; preference for the present in the long term; preference for the present in the short-term, or "impatience"; and family altruism. The scores are meant as aggregate measures, qualitative and ordinal metrics, assumed representative of the responses provided by the respondent to a range of questions. Some examples of these questions have been listed below:

- attitude with regard to risk: *"Do you take an umbrella with you when the weather looks iffy?" or "Do you park your vehicle illegally?";*

- lottery choices, consumer practices: *"Do you ever go to live performances randomly, even if it might mean setting yourself up for disappointment?"*:

- opinions: *"Do you agree with the assertion that 'marriage is an insurance policy'?" or: "Are you sensitive to the debate over current issues in health (AIDS, contaminated blood, etc.)?"*

- reference question to identify future depreciation rate: *"Due to an unexpected increase in workload, your employer asks you to postpone your week on holiday by one year, offering in exchange to grant you X additional days of leave. Do you agree?"*

The scores used in this article are based on 58 questions to measure attitudes toward risk and 30 on preference for the present.

This raises the issue of how many different scores should be placed within a given area of preference, in particular that of uncertainty. (Non-standard) theory refers to several parameters of risk preference: risk aversion, ambiguity and loss; "temperance" (in managing multiple risks); "pessimism" or "optimism" (in assessing subjective change in probabilities), etc. Experimental data, meanwhile, would rather show that subjects do not respond in the same way to small and large risks and that the responses given to questions on anecdotal choices or on vital decisions cannot be considered on the same plane. Lastly, attitudes with regard to risk are likely to vary from one domain of life to another: after all, paragliding and tax evasion are both risky activities but have little in common.

Computation of the scores

The first stage consists of assigning *a priori* the questions asked to one of the four areas of preference listed earlier. Some overlapping is difficult to avoid, for instance, as regards the distinction between the short-term and the long-term, and even more so regarding the fact that the future is both uncertain and remote from the present. Consequently, items such as *"Would you find it worth the effort, if it enabled you to live a few years longer, to forego what you deem are the pleasures in life?",* and *"In order to avoid health problems, do you watch your weight or your diet, do you engage in sports, etc.?"*, were assigned to both risk preference and time preference.

Box 2 (suite)

No question isolated from the others is adequate for measuring a given preference parameter. If a question is focused on theory (a lottery, for instance), it can appear too abstract and generate a lot of "noise" (in particular from one wave to the next). In contrast, the way in which responses to lifestyle questions is interpreted inevitably raises issues, due to context effects and irrelevant factors: a risk-tolerant individual might consequently, as a civic act, never *"park in no-parking zone"*. The underlying idea is thus that only the "average" of all responses would have meaning, provided that the aggregation makes it possible to generally do away with parasite dimensions (bias, context effect, endogeneity, etc.).

The statistical method thus consists, as a second stage, of encoding responses, in general into three modalities; for instance, for attitudes toward risk: risk-loving = −1; neutral = 0; risk-averse = +1; then adding up the resulting "ratings" for each individual. The score is the sum of all the ratings, limited to only those items which, ex post, turn out to have formed a statistically consistent set.

As regards the number of scores to be incorporated into each area of preferences, data have the last say. Yet statistical analysis gives rise to a remarkable outcome: out of the four waves of *Pater*, we were able to test that a single score is always enough to characterise, ordinally, the respondent's attitudes toward risk and uncertainty: it then has to be interpreted as a mix between the individual's degree of risk aversion or prudence, as well as his/her aversion to loss or ambiguity. We were also able to see that time preference, impatience in the short term and altruism toward one's children can each be characterised by a single, representative, score in each *Pater* sample. This constancy in results attests the robustness of the scoring method we chose.

The fact that this method was able to be fully-reproduced in different *Pater* survey waves made it possible to test its robustness on other crucial points: the number of questions needed to build scores, the factors explaining the scores, time auto-correlations of scores; the explanatory power of financial behaviours. The results of these tests are detailed in online complement C2.

In addition, the scores are far better correlated from one survey to the next than the standard indicators. Lastly, in all waves of the *Pater* survey, it can be seen that:

- The characteristics of households have greater explanatory power: over the stacked sample, for instance, the pseudo R2 of the qualitative regression is 7.0% using the score method, (see Table 2-A), vs. 1.4% with the lottery and 0.9% with the scale.

- The explanatory power of the scores on various risky behaviours (demand for risky assets, entrepreneurship, etc.) is always higher with the risk scoring method than for scales of the same kind, lottery nonetheless sometimes doing just as well, though it subsequently requires to be corrected for endogenity biases (Sahm, 2012).

- The scores' specific effects on financial behaviours and portfolio choices are far greater, quantitatively, but also highly comparable from one wave to the next. To take only one example: an increase in the score's standard deviation (less risk tolerance) decreases the probability of share ownership by a comparable percentage, around 3%.

Scores prove excellent instruments for other preference measurement. In a wealth regression estimated using the instrumental variables method, the score of risk aversion used as an instrument for other measures is shown to have very high predictive power and that it is statistically exogenous. This tends to support the idea that scores are a collection of "natural" instruments in the approach to individual preferences.

(Arrondel & Masson, 2014): risk tolerance is highest amongst young singles, men, children of self-employed (except sons or daughters of farmers, who are more risk-averse), and when the children no longer live at home. This regression also shows risk aversion to be increasing in the most recent waves: overall, the population appears to be less tolerant to risk. If we operate from the assumption that the risk score depends only on age, this overall change results solely from composition effects: population ageing, new young households more risk-averse than the previous generations, etc. However, to verify such a hypothesis, age and period effects would have to be separated, when the two variables are perfectly correlated.

In attempting to respond to this question, we will compare the characteristics of the risk score, risk scale and lottery distributions as a function of the observation period and the individuals' age (Table 2-B). These regressions are based only on those individuals having responded to all four surveys (balanced panel) and simply pile up the observations. This selection makes it possible for us to econometrically test whether the crisis has had an effect on any of these three preference indicators. The first specification distinguishes between the observations only by the date of observation: a significant increase can be seen in risk aversion during the crisis until 2011 for each measure. In the second specification age is introduced as an additional variable:

here, it can be noted that, where the score is concerned, the onset of the crisis does not appear to have any influence on preferences once taken into account the ageing of the panelled individuals, whereas for other measures (scale or lottery), the impact of the shock remains, growing until 2011, then receding in 2014.

Did savers become more risk-averse during the crisis? The answer to this question depends on preference measurement. While the scale and lottery methods appear to show growing risk aversion of individuals (up to 2011), risk scores, in contrast, indicate that savers have not "changed" overall: adjusting for age effects, they are on average just as risk-tolerant as they were prior to the crisis, no more, no less; this holds true as much after the September 2008 shock as in the longer term, after that of Summer 2011 or in 2014. Considering the score-method's superior reliability, this conclusion appears the most relevant to us.

Why is financial behaviour more cautious since the crisis?

Since the crisis, households have displayed behaviours testifying to lesser appetite for risky assets, generally stable risk preferences,

Tableau 2-A
Risk score determinants (linear model)

	OLS	
Variables	*Coef.*	*Robust-t*
Wave (ref : 2007)		
2009	0.4317	3.96
2011	0.8321	6.43
2014	0.7951	4.51
Age	0.1334	30.81
Income (ref : Q1)		
Q2	1.0122	4.47
Q3	1.0270	4.47
Q4	1.1237	4.52
No response	1.7273	6.33
Sex: female	2.5938	18.69
Married	1.6539	10.75
Social background (ref.: Employee)		
Farmer	0.7909	3.81
Self-employed	- 0.5226	- 2.55
Liberal profession	- 0.1893	- 0.49
Education (ref.: < Baccalaureate)		
Baccalaureate	- 0.0270	- 0.16
> Baccalaureate	- 0.1378	- 0.84
Number of children		
Living in the family home	- 0.0788	- 1.24
Independent (living on their own)	- 0.2199	- 3.47
Constant	- 7.6059	- 20.02
N (observations)	14,895	
n (individuals)	8,435	
R2	0.195	

Note: Stacked samples (14,895 observations and 8,435 individuals).
Reading note: Age has a statistically significant positive effect (Robust t> 1.96) on the risk score: the older one is, the more risk-averse. Robust t: clustered variances.
Coverage: Population without missing data in regressions.
Source: *Pater* surveys, 2007, 2009, 2011 and 2014 waves.

available resources relatively unaffected by the crisis in the majority of cases –but also increasingly gloomy expectations on earned income and risky financial assets. *A priori*, the source of behavioural change thus presumably lies in individuals' perception of the economic environment rather than in their *psyche*. The estimation of equation (3) allows to test this hypothesis. The choice of the dependent variable proves a delicate one. The amounts invested in shares, for instance, are impaired by serious measurement errors (all the more troublesome when used in differences) and can reflect capital gains or losses. The focus here will thus be only on changes in share ownership, whether direct or indirect. Demand (Equation 2) is estimated using simple probit models ("clusterizing" variances) on the stacked sample, and probit models with random effects on the sample restricted to individuals having responded prior to the crisis and at least once afterwards, and on the balanced panel (the estimation results are shown in Table C3-1 of online Complement C3). Changes in stock ownership are estimated by linear models in difference.

Another variable, possibly better suited and available in the four waves from 2007 to 2014, pertains to the financial investment strategy depicted in Figure II, in four modalities (only one response possible), from "put all your savings into safe investments" up to "put most of your savings into risky investments, but which can result in high returns". With respect to shareholding, this variable further offers the benefit of identifying household intentions on risky investments, these intentions sometimes differing from actual behaviours for reasons which remain to be highlighted. The responses to this question are first analysed based with an ordered probit model over the stacked samples and with a linear random effects model over samples restricted to those responding to at least two waves (including that of 2007) and over the balanced sample (Table C3-2 of online Complement C3). Table 4 shows the determinants of behavioural change based on a linear model in difference.

We check (equation (2)) that the risk and time preference scores have the expected significant effects: the less risk tolerant an individual is, the less that individual will be attracted to risky assets, whether in terms of share owning or intention to hold shares (see tables in online Complement C2); the more far-sighted a person, the more she turns to this type of asset. The total wealth level also has a significant positive effect, while the amount of earned income impacts only share ownership, and expected future risk on that income has no effect on shares owned, but is thought to play out in a relatively positive way on the propensity to take portfolio risks (in contrast to a "temperance" strategy). Age and level of education are also major positive factors, linked with the level of financial information, in explaining risk taking; likewise, having or having had shareholding parents positively influences individuals' likelihood to own shares or intent to purchase shares themselves. As for the expectation variables, the expected shares return has

Table 2-B
Risk score determinants (linear models) OLS

	Score				Scale				Lottery			
Variables	Coef.	t (*)	Coef.	t (*)	Coef.	t (*)	Coef.	t (*)	Coef.	t (*)	Coef.	t (*)
2009 wave	0.199	1.24	- 0.101	- 0.61	- 0.407	- 4.23	- 0.452	- 4.67	0.165	4.05	0.165	3.98
2011 wave	0.405	2.35	- 0.131	- 0.70	- 0.674	- 7.15	- 0.757	- 7.84	0.253	6.17	0.252	5.99
2014 wave	0.808	4.37	- 0.148	- 0.68	- 0.559	- 5.69	- 0.706	- 6.76	0.146	3.39	0.144	3.20
Age			0.118	8.12			0.0184	4.17			0.001	0.11
Constant	6.228	26.76	- 0.127	- 0.15	5.661	65.72	4.669	18.49	3.186	85.87	3.175	32.28
N (Obs.)	3,168		3,168		3,084		3,084		2,884		2,884	
n (Indiv.)	792		792		771		771		721		721	
R2	0.002		0.063		0.014		0.026		0.010		0.010	

Notes: Stacked samples (balanced). *: Robust t, clustered variances.
Reading notes: Risk score regressions show that the significance of dummies relative to each wave disappears when age is taken into account, in contrast to what happens with scale and lottery.
Coverage: Panelled population responding to all 4 survey waves.
Source: *Pater* survey, 2007, 2009, 2011 and 2014 waves.

a (significant) positive effect, the significance of which is often comparable to that of the risk score (while volatility has no effect).[11] Lastly, it is ensured that portfolio risk taking decrease significantly with the observation period.

The analysis of behavioural change (Equation 3) is based on a linear model in difference (Tables 3 and 4). The estimates show that variations in the risk score do not have any effect. As for variations in financial expectations, only those regarding the expected share return have a significant and positive effect (Table 4). It should also be noted that those individuals who reported to have been affected by the crisis more (or as much as) the average have, in some cases, sold their shares (see Table 3).

In summary, the trend in French savers' financial behaviours during the crisis, reflected in a lesser propensity for risk-taking, cannot be explained by an overall change in preferences as measured by the scores. The differences affecting available resources (or the expected earned income) do not have any greater explanatory power. Only those households considering that they had been "more affected by the crisis than on average" sold their shares more than the others. In contrast, individual variations in the anticipations on expected stock returns do have a significant effect: the greater pessimism shown by the French population on the whole in this area would then be the main cause (on the demand side) behind the lesser overall appetite for risky assets since the crisis.

11. This outcome is consistent with those observed in demand for equities: Arrondel, Calvo and Tas (2016) show, for instance, on the Pater *2007 data, that the latter depends statistically on expected stock market returns: the decision to own or not own shares correlates positively with the expected risk premium, thus eliminating in effect those who estimate it to be negative.*

Table 3
Determinants of share ownership (in difference)

Variables	Coef.	Robust t	Coef.	Robust t
Risk-aversion score (in difference)	- 0.002	- 1.12	- 0.0022	- 1.05
Time preference score for present (in difference)	- 0.002	- 0.73	- 0.0020	- 0.72
Expected stock market return (in difference)	0.092	1.67	0.0886	1.66
Expected variance in future income (in difference)	- 0.193	- 0.41	- 0.2232	- 0.47
Wave (ref : 2014)				
2009	- 0.021	- 1.06	- 0.0321	- 1.44
2011	0.023	0.94	0.0152	0.57
Age	- 0.001	- 2.99	- 0.0019	- 3.28
Affected by the crisis (ref.: more than the average)				
Less than the average			0.0780	2.39
As much as the average			0.0776	2.38
No response			- 0.0927	- 0.69
Education (ref.: < Baccalaureate)				
Baccalaureate			- 0.0063	- 0.36
> Baccalaureate			0.0064	0.4
Married			0.0255	1.69
Number of children				
living with parents			0.0018	0.25
Independent (living on their own)			- 0.0094	- 1.11
Constant	0.037	1.11	- 0.0184	- 0.40
Number of observations	2,023		2,023	
Number of individuals	1,231		1,231	

Note: Robust t: clustered variances.
Reading note: The expected stock market return has a statistically significant positive effect of 10% (t=1.67 in the first model) on demand for shares.
Coverage: Sample of individuals having responded in 2007 and at least one time thereafter.
Source: *Pater* surveys 2007, 2009, 2011 and 2014

Table 4
Propensity for risk-taking (in difference)

Variables	Coef.	t	Coef.	t
Risk-aversion score (in difference)	- 0.006	- 1.55	- 0.006	- 1.53
Time preference score for present (in difference)	- 0.001	- 0.24	0.000	- 0.07
Expected stock market return (in difference)	0.293	2.88	0.295	2.92
Expected variance in future income (in difference)	0.457	0.48	0.444	0.47
Wave (ref : 2014)				
2009	- 0.080	- 4.53	- 0.107	- 1.41
2011	- 0.019	- 0.79	- 0.041	- 0.51
2014	0.028	1.13	0.001	0.01
Age			0.000	- 0.17
Affected by the crisis (ref.: more than the average)				
Less than the average			0.049	0.76
As much as the average			0.049	0.75
No response			0.112	1.57
Education (ref.: < Baccalaureate)				
Baccalaureate			- 0.012	- 0.42
> Baccalaureate			0.033	1.39
Married			- 0.007	- 0.32
Number of children				
living with parents			- 0.010	- 0.95
Independent (living on their own)			- 0.006	- 0.44
Number of observations	1,892		1,892	
Number of individuals	1,164		1,164	

Note: Robust t: clustered variances.
Reading note: The expected stock market return has a statistically significant positive effect of 10% (t=2.88 in the first model) propensity for risk-taking in portfolio choices.
Coverage: Sample of individuals having responded in 2007 and at least one time thereafter.
Source: *Pater* survey, 2007, 2009, 2011 and 2014 waves.

* *
*

With four waves from 2007 to 2014 and a strong panel-based dimension, the *Pater* data now offer the possibility to analyse numerous questions regarding savings, wealth and inequalities, providing a useful supplement, with more subjective and qualitative aspects of financial behaviours, to the information from the Insee's Wealth surveys. Like other sources, the *Pater* data highlight the lesser appetite of the French to take risks in their savings or their portfolio decisions during the crisis. Our article shows that this change in behaviours is not due to a change in the preferences of the savers we followed during the crisis: these preferences are thought to have remained –age effect aside– statistically stable since June 2007. The lesser willingness to take risks is thought to be the result, above all, of increasingly gloomy expectations regarding the (expected) return from financial assets.

The stability of risk preferences over time, observed on the basis of our scores goes against the conclusions of other empirical studies measuring preferences using other methods (Likert scale, lottery, qualitative questions). By refuting the psychological impact of the current crisis on investor tastes, this result should be credited to standard saver theory rather than to behavioural economics, which establishes a parallel between emotions –sometimes even "fear"– and preferences. These results, however, call for further investigations in a variety of directions.

A new wave of the *Pater* panel would likely round out our study on multiple points. First of all, it would enable us to determine whether

the French are gradually returning to the stock market (demand for equities decreased at least up to March 2016) as certain indicators appeared to show in 2014, as well as why this delay might occur. It would secondly enable more robust statistical checks, over a less limited sample. As regards preferences, the aim will be to analyse changes in the distribution of risk aversion within an ageing population, the new generations of which will be those of the "Great Recession". Secondly, we have highlighted one last puzzle, as regards individual shareholders' demand for equities: if, in actuality, if French savers have indeed deserted the Stock Market since 2008, the curve of their investment intentions on the stock market turned around in 2014. What remains to be understood then is why households' financial intentions and behaviours are now diverging and for how long. □

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The individual dynamics of wage income in France during the crisis

Pierre Pora*, Lionel Wilner**

Abstract – The uncertain nature of future income limits the ability of agents to smooth their consumption over time. Variation in this uncertainty can thus bring about variation in well-being. We study the evolutions of the uncertainty on wage income in France before and over the course of the crisis of 2008 drawing on longitudinal administrative data. Using a non-parametric method, we estimate the magnitude and form of this uncertainty and show that they depend on past wage income. This uncertainty is broken down into wage and working time, and according to the mobility of the wage earners. During the crisis, the magnitude of this uncertainty on future wage income increases slightly, and its downward asymmetry is stronger at both ends of the wage income scale: with this uncertainty, unfavourable evolutions have a bigger impact during the crisis than in the preceding period. This is explained by a heightened probability of unfavourable individual evolutions in terms of working time for the lowest-paid workers, and in terms of wage for the highest-paid. Mobility is more frequent during the crisis but the uncertainty associated with it is lower than over the preceding years.

JEL Classification: E24, J24, J31.
Keywords: wage income, non-Gaussian shocks, non-parametric estimation, skewness, kurtosis

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The magnitude and evolution of income inequalities today takes up a central place in the public debate (Piketty, 2013). These inequalities can be sensitive to the business cycle. Thus, in France, for wage income, that is the sum of all wages received by an individual over the course of one year, the financial crisis of 2008 (the "Great Recession") brings a halt to the downward trend of inequalities (Coudin et al., 2014): wage income inequalities in the lower half of the distribution are greater between 2009 and 2011 than between 2007 and 2008. The concentration of the mass of wages in the 1% of the highest wage earners shows a reverse trend: it decreases from 2007 to 2008. However, the measurement of inequalities based on cross-section data alone may turn out to be insufficient: increasing inequalities might indicate that the incomes of different individuals diverge permanently but it is also possible that the individuals are confronted with temporary income variations that are more difficult to foresee, in other words that the uncertainty on their future incomes grows.

These two possibilities have different repercussions on the inequalities in terms of consumption (Blundell & Preston, 1998; Pistolesi, 2014). Great uncertainty on future incomes thus limits the ability of agents to smooth their consumption over time, and can incite them to save more. It can also affect their behaviour on the labour market, for example by leading them to increase their labour supply (Flodén, 2006). This uncertainty is not necessarily the same for all individuals and disparities between individuals can themselves bring about inequalities in terms of well-being. The uncertainty may vary, in terms of magnitude or asymmetry, not only from one individual to the next but also over the course of the business cycle (Mankiw, 1986; Constantinides & Duffie, 1996), even if empirical studies do not always converge on the direction of this variation.

This article examines the dynamics of wage income around the crisis of 2008. During this crisis, wage income slows down: average wage income (in real terms) for all wage earners progresses by 0.2% per year on average between 2007 and 2012, against 0.6% per year from 2002 to 2007 (Coudin et al., 2014). However, these variations in average wage income do not necessarily reflect the individual evolutions of wage income over the period, since they also incorporate the effect of workers entering and leaving paid employment. We compare the individual dynamics of wage income between the period 2005-2006 – that being the individual evolutions of wage income over 2005-2006 and 2006-2007 – and the period 2008-2011 – that being the individual evolutions of wage income 2008-2009 to 2011-2012. Between these two periods, the individual dynamics may differ in two respects. On the one hand, over the course of the crisis, wage earners may see wage income increases that are faster or slower than over the course of the years which precede it. This variation is not necessarily the same with respect to differences in individuals' past wage income and their observable characteristics. This has an impact on inequalities, and may reflect a relatively permanent and foreseeable divergence of their wage incomes. On the other hand, the individual dynamics of wage income may also be more or less uncertain, and therefore more or less difficult to anticipate for the wage earners. This uncertainty might too evolve over the course of the crisis, and in a variable way in accordance with the wage earners.

After a review of the international literature on the variations of uncertainty on future wage income with the business cycle, we describe the difficulties in the estimation of the uncertainty on future wage income, then we analyse the individual dynamics of wage income in France. For this, we apply the non-parametric method proposed by Guvenen et al. (2014) on a French panel data set, based on the panel of annual declarations of social data (*Déclarations anuelles de données sociales – DADS*) called the "all wage earners" panel which is paired with the permanent demographic sample (*Échantillon démographique permanent – EDP*) produced by Insee (Box 1). This approach relies on a precise division, and focuses on the shape parameters of the distribution of wage income evolutions. It would therefore be difficult to implement over survey data. Conversely, the considerable size of the sample of the "all wage earners" *DADS* panel (about two million wage earners aged from 20 to 60 for each year in the period studied) and the good quality of data allow for the use of this method. We then compare the dynamics of wage income over the course of the crisis to the dynamics of wages in previous years, then the evolutions within a same firm in relation to those which are associated with mobility between two firms.

Box 1 – **Data, coverage and definitions**

***The "all wage earners"* DADS *panel and its pairing with the* EDP**

The "all wage earners" panel of annual declarations of social data [*déclarations annuelles de données sociales* (*DADS*)] is a longitudinal file extracted from several administrative sources. These administrative sources are the annual declarations of social data (*DADS*), the pay files of government agents, and the information system of public servants (Système d'information des agents des services publics – SIASP). Existing since 1967 in the private sector, the all wage earners panel covers the whole scope of paid employment since 1988, namely the private sector and public services (state public service, regional public service and public hospital service). It follows periods of employment, the characteristics of the employers and employees in a sample of 1/12th of the population of wage earners since 2002.

For each position occupied in the sample by an employee in a given company over the course of one year, the all wage earners panel gives information on net remuneration paid by the employer, the number of days of remuneration in the year, as well as the gender, year of birth and employment status of the wage earner. The number of hours remunerated is available for the wage earners in the private sector, in regional public service and public hospital service over the whole period studied. It gives an overview for wage earners in state public service from 2009 onwards only. We do have, however, for these wage earners, a duration of pay converted into full-time equivalent up until 2008.

The biographical file taken from the permanent demographic sample (*Échantillon démographique permanent* (*EDP*), paired with the *DADS* panel, also gives an overview on the degree level of a part of the wage earners present in the sample, taken from data from annual population censuses and annual census surveys.

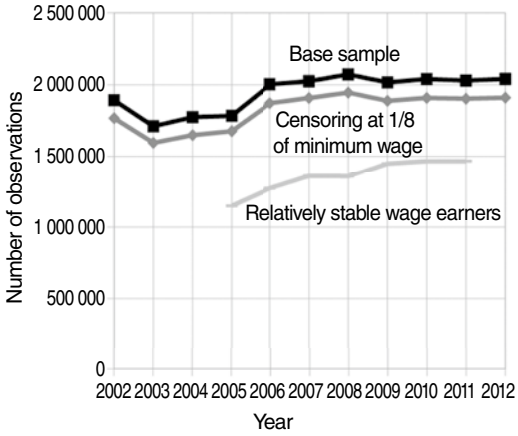
Coverage

The results presented in this article concern wage earners aged from 20 to 60 years, working in metropolitan France between 2002 and 2012. Agricultural wage earners, apprentices and trainees, and wages directly paid by households are not taken into account.

In order to limit the study to wage earners who are relatively well established on the labour market, the coverage is restricted to the wage earners who earn more than an eighth of the yearly minimum wage. The main stylised facts highlighted in this article are robust with regards to the choice of threshold (a sixteenth, an eighth or a quarter of the yearly minimum wage). We make the choice to keep the data relating to extremely highly wage incomes unmodified. Our main results are also robust thanks to a winsorizing for each quantile in the way of 0.9999 of yearly wage income, that being when the wage income of the 0.01% highest-paid wage earners is put at the same level of this quantile.

The method employed requires restricting the data to a portion of relatively stable wage earners who have been in employment for several consecutive years. More specifically, a wage earner goes into the field of relatively stable wage earners for the year t if they receive a wage higher than an eighth of the minimum wage in *t*, *t+1*, *t-1*, and two years at least between *t-5* and *t-2*. Due to the left censoring in 2002, this condition is slightly more demanding at the start of period – 2005 and 2006 – than from 2007 onwards: the share of relatively stable wage earners in the starting sample increases automatically (see Figure). We show, however, that in terms of increased female participation, age distribution, sector, socioprofessional category and degree, and in terms of wages and wage income, this selection differs little between 2005-2006 and 2008-2011 (see annex, Tables A1 and A2).

Figure
Number of observations per year and selection of the sample of relatively stable wage earners



Coverage: Metropolitan France from 2002 to 2012, all wage earners except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Sources: Insee, "all wage earners" *DADS* Panel

Wage income

The variable of interest is real yearly wage income. It incorporates net remunerations (that being after social security contributions, CSG [general welfare contributions] and CRDS [social debt repayment contributions]) taken from paid work undertaken by a same individual over the course of a given year. These remunerations may be paid by different employers. Wage income is therefore defined only for individuals who have been in paid employment over the course of a year. It does not take into account unemployment benefits.

It integrates two factors: hourly wage, the price of one unit of paid work, and the volume of paid work undertaken over the course of a year. This volume reflects the wage earner's quota of working time (full-time, part-time) and the number of days they have worked over the course of the year (periods of employment). It therefore integrates a part of the risk linked to non-employment, notably for the wage earners in the private sector. ➔

Box 1 (suite)

Work volume

We use the data of the duration of wage-earning convertible into full-time equivalent, available for wage earners in state public service up until 2008, and of the number of hours remunerated, available for the rest of the wage earners over the period studied, and for wage earners in state public service from 2009 onwards in order to build a yearly full-time equivalent working time *l* of between 0 and 1. The use of the variable *l* supposes that the duration of wage-earning convertible into full-time equivalent and the number of hours can be manipulated to make them comparable and relatively homogeneous over time. It therefore brings one to disregard the break in the series that arose in 2009 in state public service. Each year of the period studied, the calculation of an FTE work volume is possible for 99.9% of the relatively stable wage earners. The construction of this full-time equivalent working time is detailed in the online complement C3.

The business cycle and uncertainty on future wage income in the literature

An increased uncertainty during recessions?

Many studies on the United States agree on the counter-cyclical nature of the magnitude of uncertainty on future wage income. Gottschalk et al. (1994) show that the variance of the temporary evolutions of wage income increases notably between 1974 and 1975 with the 1st petrol shock, and between 1980 and 1983 during the two episodes of recession which came at the start of the 1980s. In addition to these fluctuations with the business cycle, this variance shows a long-term upward trend over the 1970s and 1980s. Moffitt and Gottshalk (2002), drawing on another modelling of the individual dynamics of wage income, obtain the same result for the period 1980-1983. Over the period 1967-1991, Haider (2001) also documents an increase of the extent of uncertainty during recessions, which is essentially linked to instability in terms of working time, with hourly wage volatility hardly varying at all over the course of the period studied. Finally, studying the period 1968-1993, Storesletten et al. (2004) also highlight an uncertainty whose magnitude, increasing by 75% between periods of growth and periods of recession, is very counter-cyclical.

Most of these works relates to measures of moments of order 2 of the evolutions of wage income. Some use very simple methods which do not take into account wage earners' heterogeneity; others call upon more sophisticated specifications, which assume conditional log-normality of the variations of wage income, and therefore neglect their asymmetry. Contrastingly, Guvenen et al. (2014) use a method which does not presuppose the log-normality of wage income evolutions. This leads them to reject the hypothesis of a counter-cyclical variance of the evolutions of wage income in the US, in particular between 2007 and 2010. They show that the hypothesis of counter-cyclical variance, that is a conditional variance of the evolutions of wage income that increases during recessions, may result in part from an underestimation of how heterogeneous variations with the business cycle of these individual wage income evolutions are across the distribution of past wage income. In other words, it is not that the evolutions of wage income are more dissimilar within very similar groups of wage earners over the course of recessions, but rather that over the course of recessions the evolutions of wage income are more dissimilar between groups of wage earners which are already dissimilar, and, notably, between wage earners located at the extremes of the distribution of past wage income and those not. The authors show that over the period 2007-2010, the loss of wage income is concentrated on average over the lowest-paid wage earners in the past, and over the very high wage incomes. Moreover, over the course of the recessions that they study, and for all levels of past wage income the individual evolutions of wage income are more downwardly asymmetrical: the share of less favourable evolutions in the dispersion increases whereas that of the most favourable evolutions decreases.

For a more recent period, Dynan et al. (2012), still over American data, by using an aggregated measurement of the variance of the evolutions of wage income, show an increase in the magnitude of uncertainty on future wage income over the years which precede the 2008 crisis, without however explicitly linking it to the business cycle.

Variations over a long period of uncertainty on future wage income in Europe

A few studies treat the evolutions of the volatility of wage income in European countries, using methods that assume conditional log-normality of the individual evolutions of wage income. For the United Kingdom, Ramos (2003) highlights a possible increase of the volatility of the transitory evolutions of wage income between 1991 and 1999. For Italy, Cappellari (2003) rather links the rise of inequalities between the 1970s and 1980s to a long-term component; however, the youngest cohorts could be characterised by a greater uncertainty of the transitory evolutions of wage income. In France, Ceci-Renaud et al. (2014) highlight the evolutions of wage income volatility over a long period: it is approximately constant from the end of the 1960s to the early 1980s. It then increases before decreasing throughout the 1990s. Before the crisis, it decreases to reach its local minimum in 2008. It then increases in 2009, at the start of the crisis.

Wage income uncertainty can be heterogeneous between wage earners

The temporal variations of the uncertainty on future wage income do not affect wage earners in a uniform manner. So, by using a method which allows them to distinguish, when making choices of education, between an uncertain component and a component which is foreseeable by the agents, mixing observed and unobserved heterogeneity, Cunha and Heckman (2007) link the rise in income inequalities at the end of the 20th century in the US to an increase in the uncertainty and the heterogeneity of wage earners over the period. The rise of uncertainty explains a large part of the increase in inequalities among the least-skilled wage earners, while its weight is much lower among the most-skilled wage earners.

Britton et al. (2015) focus on the disparities of the evolutions of wage income according to the education level during the crisis of 2008. To do this they draw on survey data and administrative data, and highlight large losses of wage income when cohort effects are controlled for. These losses are much greater for non-graduates than for graduates, while the average differences in terms of wage income level are not very large, which would reflect a protective effect of degrees.

Finally, Ayllón and Ramos (2015) conduct a comparative work on the evolution of wage income instability among young people (17 to 29 years old) in the European Union during the 2008 crisis. Despite differences between countries, their results, obtained with relatively simple methods applied to the EU-SILC survey data, show for these young people an increase in wage income volatility, that breaks the downward trend of the years preceding the crisis. This increase is not uniform depending on age, sex and degree level, and its magnitude is not the same across all countries.

Measuring uncertainty on future wage income

From the point of view of individuals, uncertainty on future wage income depends on the information available to each of them. A large part of this information is however not observed directly in the data. Representing this uncertainty as the distribution of probability of future incomes (conditional to the observable and unobservable characteristics of individuals) shall be therefore based on a modeling. The most current ones distinguish between transitory evolutions and long-term evolutions on the one hand, and heterogeneity between individuals (observed and unobserved) and uncertainty on the other hand. This modelling of wage income dynamics relies in general on an assumption of conditional log-normality of the evolutions of wage income (Moffitt & Gottschalk, 2002, 2011; Baker & Solon, 2003; Low et al., 2010; Altonji et al., 2013; Magnac et al., 2017; Ceci-Renaud et al., 2014).

The log-normality assumption leads to focus the analysis on the dispersion of wage income evolutions, measured notably by the variance, and to neglect the role of the shape parameters of the distribution, in particular the asymmetry and weight of extreme shocks, measured for example by the moments of order 3 and 4 (consistent with the log-normality hypothesis). On the contrary, the asymmetry and weight of the tails of distribution in the evolutions of wage income make up a central point for Guvenen et al. (2016). By offering an original non-parametric approach and by exploiting very rich administrative data, they highlight the highly asymmetrical downward shape of wage income evolutions, the significance of extreme individual wage income variations, which leads them to reject the assumption of log-normality

of the distribution of wage income evolutions. They also document a strong non-linearity of the dependence of future evolutions on past wage income levels. They finally show that the hypothesis of log-normality can lead to a significant underestimation of the cost of income shocks in terms of well-being. There are few other approaches relaxing the log-normality hypothesis (Bonhomme & Robin, 2009; Arellano et al., 2017).

The first step in estimating the uncertainty on future wage income consists of setting the temporal scale of this uncertainty. Here we make the choice to focus only on wage income uncertainty in the year immediately following, that is the uncertainty on wage income of year $t+1$ for a wage earner observed in year t. We also consider that the wage income of year t is known with certainty; the uncertainty therefore comes from the variation of wage income between t and $t+1$. Finally, we equate this uncertainty on future wage income with the distribution of probability of the yearly variations of the wage income logarithm: $\delta\tilde{y}_{i,t} = \tilde{y}_{i,t+1} - \tilde{y}_{it}$, where $\tilde{y}_{it}$ represents the logarithm of wage income individual i in year t, for each year of the period studied.

Following on from Guvenen et al. (2014), we focus on four different properties of this distribution. The first is the level of these variations, typically measured by the average or quantiles. The second relates to the dispersion of these variations: it can be measured by the variance or the D9-D1 interdecile range. We consider that it estimates the magnitude of the uncertainty on future wage income.[1]

The two other properties relate to the shape of this distribution. Firstly, its asymmetry, that is the relative weight of high and low evolutions in the dispersion; it is measured by the skewness, or by a measure based on quantiles, Kelley's Measure of Skewness (Kelley, 1947) (see Box 2). A decline in skewness or in Kelley's Measure of Skewness during recessions, that is, in this case, a significant downward asymmetry, means that the uncertainty on less favourable evolutions increases more than the uncertainty on more favourable evolutions. In other words, very negative shocks become relatively more probable than very positive shocks, which the measurements of level and dispersion do not account for. These disastrous evolutions may have very different consequences from those of negative evolutions of a smaller scale, notably in terms of well-being. It is therefore important to detect a potential variation of their frequency. A rise in the probability of very negative shocks seems to be a fairly general characteristic of recessions, not only from the point of view of wage earners, but also for firms or macroeconomic aggregates (Salgado et al., 2016).

Then, the weight of the tails of distribution, that being the relative importance of rare events in the dispersion, estimated by the kurtosis, or a measure based on quantiles, Crow-Siddiqui Kurtosis (Crow & Siddiqui, 1967). The measures of the level and dispersion of individual evolutions of wage income do not distinguish between relatively current evolutions of weak magnitude, and between rarer and extreme evolutions. It is, however, plausible that the long-term consequences of these extreme shocks, whether they are positive or negative, differ from those of less significant shocks. So, a given dispersion of individual evolutions of wage income, can have different effects on the behaviour of individuals, depending on whether it is associated or not with a heightened weight of rare events, for example in terms of consumption and saving (Guvenen et al., 2016). Under the (log)normality hypothesis, the shape parameters – asymmetry or the weight of distribution tails – are presumed to be constant.

Described as the distribution of probability of the individual variations of wage income between two successive years, uncertainty on future wage income depends largely on the information available: the uncertainty must be perceived as a conditional distribution of probability. All of the information to which a given individual has access in t is of course not available: it is therefore necessary to model it in order to approach it. In the preceding case, we consider that all the information available is brought by the wage income of recent years. We then divide up the heterogeneity of the yearly evolutions of wage income considered over all of the individuals according to two factors. On the one hand, the individual yearly evolutions of wage income depend on the individuals' past level of wage income. This form of heterogeneity is taken into account by grouping together the wage earners who have had a comparable wage income in recent years. On the other hand, in each of these groups of wage earners with comparable past wage income, the evolutions of wage income are variable, which is measured by focusing on the distribution of evolutions of wage income for each of them. It is this

1. This conditional distribution may also incorporate chosen and anticipated evolutions which are not interpreted as an uncertainty.

conditional distribution that we interpret as a reflection of this uncertainty.

A significant part of the yearly evolution of an individual's wage income is linked to their age. To build the groups of wage earners with recent-past wage income, the average effect of age must be neutralised in order to make the wage income of wage earners of different ages comparable. We normalise the wage income by negating this

Box 2 – **Method**

Breakdown of the yearly evolutions of wage income

We use the method developed by Guvenen et al. (2014), by applying it to the yearly evolutions, and not to the five-yearly evolutions, of wage income.

For each wage earner *i*, let's consider $\tilde{y}_{i,t}$ the logarithm of their wage income of the year *t*, and $Y_{i,t}$ their wage income. We focus particularly on the yearly evolutions of wage income $\delta\tilde{y}_{i,t}=\tilde{y}_{i,t+1}-\tilde{y}_{i,t}$, whose distribution we wish to estimate conditional to the characteristics of *i*, and notably to their past wage income.

We wish to highlight a potential variation of this distribution over time, notably by distinguishing between the period which precedes the crisis and the one that succeeds it. On average over the course of professional life, wage income increases with age, but its progression is less and less quick. So, if age is not monitored, and if for example the crisis led young people to delay their entry into paid employment, such that the average age of the population studied increases between the period which precedes the crisis and the one which succeeds it, we would be brought to the conclusion that the evolutions of wage income became less favourable with the crisis, without the dynamics of wage income being affected as such. To avoid this, we normalise wage income by eliminating the average effect of age. This does not however take into account potential composition effects linked to age over the dispersion or the form of the distribution of the individual evolutions of wage income.

More specifically, we define the average effect of age β_a that we wish to take away from wage income by:

$$\begin{cases} \tilde{y}_{it} = \sum_a \beta_a \mathbf{1}\left[age_{it}=a\right] + \sum_T \gamma_T \mathbf{1}\left[birth_i=T\right] + \varepsilon_{it} \\ \mathbf{E}\left[\varepsilon_{it} \,|\, age_{it}, birth_i\right] = 0 \end{cases}$$

We estimate the coefficient β_a by conducting a regression analysis on all the wage earners of metropolitan France aged from 20 to 60 years between 2002 and 2012 who receive more than an eighth of the yearly minimum wage.

The results of the estimation of β_a fulfil the expectations regarding the average effect of the life cycle on wage income: rapid progression at the start which corresponds to entry onto the labour market, then a slower increase under the effect of the gradual accumulation of experience, a slight decrease at the end of the career which reflects departures from paid employment which occur over the course of the year (see Figure).

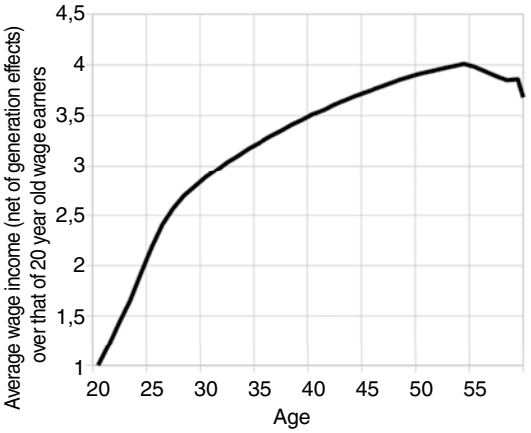
The estimation of β_a allows for the introduction of normalised wage income $\delta y_{i,t}=\tilde{y}_{i,t}-\hat{\beta}_a$. We are particularly interested in the individual evolutions of normalised wage income: $\delta\tilde{y}_{i,t}=\tilde{y}_{i,t+1}-\tilde{y}_{i,t}$ or $\delta y_{i,t}=\hat{\varepsilon}_{i,t+1}-\hat{\varepsilon}_{i,t}$. We introduce again the past normalised wage income of the relatively stable wage earners.

$$Y_{it}^{ant} = \frac{1}{\sum_{\tau=t-5}^{\tau=t-1}\sum_a exp\left(\hat{\beta}_a\right)\,\mathbf{1}\left[\hat{age}_{i\tau}=a\right]} \sum_{\tau=t-5}^{\tau=t-1} \tilde{y}_{i\tau}$$

By using the results from the estimation of $\hat{\beta}_a$, we consider $y_{i,t}$ et Y_{it}^{ant} as representing on the one hand the logarithm of wage income in the year *t*, from which the average progression of wage income over the course of a life cycle has been taken away, and on the other hand average wage income over the 3 to 5 preceding years, neutralised by the average effect of age.

We then order all the relatively stable wage earners in paid employment according to their past normalised wage income Y_{it}^{ant} to build a scale of past wage income net of the average effects of age. More specifically, we associate with the wage earner *i* in the year *t* a rank α_{it} of between 0 and 99 such as Y_{it}^{ant} being between the percentile of rank α_{it} and the percentile of rank $\alpha_{it}+1$ of the distribution of Y^{ant}.

Figure
Average effect of age on the life cycle calculated using the coefficient β_a



Reading note: average wage income net of the generation effects valued at 30 years old is 2.9 times what it should be at 20 years old.
Coverage: Metropolitan France from 2002 to 2012, all wage earners having earned 1/8 of yearly minimum wage, except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Source: Insee, "all wage earners" *DADS* Panel ➔

Box 2 (suite)

Measures of dispersion, of asymmetry and of weight of tails of distribution

We measure the dispersion of the evolutions of wage income $\delta y_{i,t}$ conditional to the rank, alternatively by the standard deviation and the D9-D1 interdecile spread.

Skewness is a measure of asymmetry which corresponds to the moment of order 3 of the reduced centred variable. We use an unbiased estimator:

$$Skewness = \frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} \left(\frac{x_i - \bar{x}}{\hat{\sigma}} \right)^3$$

Kelley's Measure of Skewness is a measure of the asymmetry of distribution alternative to skewness (Kelley, 1947). It measures the parts relating to the D9-D1 interdecile spread explained by interdecile spreads D5-D1 and D9-D5:

$$Kelley's\ Skewness = \frac{D9 + D1 - D5}{D9 - D1}$$

Kurtosis measures the weight of the tails of distribution from the moment of order 4 of the reduced centred variable. We use an unbiased estimator which is equal to 0 for a Gaussian distribution:

$$Kurtosis = \frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum_{i=1}^{n} \left(\frac{x_i - \bar{x}}{\hat{\sigma}} \right)^4 - \frac{3(n-1)^2}{(n-2)(n-3)}$$

The Crow-Siddiqui Kurtosis is a measure of the weight of the tails of distribution alternative to kurtosis (Crow & Siddiqui, 1967). It is defined by:

$$Crow - Siddiqui\ Kurtosis = \frac{P97.5 - P2.5}{P75 - P25}$$

where Px represents the quantile of order $x/100$ of the distribution. It is consistent at 2.91 in the case of a Gaussian distribution. The usefulness of the measures based on quantiles stands to their robustness with regards to extreme values.

Bootstrap

In order to ensure that our results are significant, we estimate a confidence interval at 95% by bootstrap. In order to limit the calculation time, we conduct this estimation point by point along the wage scale, and not over the whole procedure. This comes to the consideration that the attribution of rank α is made without error, and therefore the term of variance linked to the attribution of ranks is neglected. This term is even greater since the density of the percentiles of the distribution of normalised wage income is small – for example for the highest wage incomes – and since the statistic of interest varies greatly with the rank. We limit ourselves in the end to 100 replications.

In the case of the average, the confidence interval thus estimated is comparable to that which is estimated using the variance, under the same hypothesis of perfect attribution of ranks.

Normalisation of wages and working time

By using the data of (the logarithm of) wage income Y and of full-time equivalent work time L, we construct a full-time equivalent wage $W_{it} = Y_{it} / L_{it}$. Then, we use the logarithm of these quantities (written in lower case).

To focus on the yearly evolutions of full-time equivalent work time and wages, we then treat w and l independently of each other, in the same way as y:

$$\tilde{w}_{it} = \sum_a \lambda_a 1\left[age_{it} = a\right] + \sum_T \mu_T 1\left[birth_i = T\right] + \nu_{it}$$

$$\tilde{l}_{it} = \sum_a \theta_a 1\left[age_{it} = a\right] + \sum_T \kappa_T 1\left[birth_i = T\right] + \eta_{it}$$

We conduct the estimation of each of these regressions separately. The normalised full-time equivalent wage is defined as $w_{it} = \tilde{w}_{it} - \hat{\lambda}_a$ and the normalised work volume as $l_{it} = \tilde{l}_{it} - \hat{\theta}_a$. We introduce the yearly evolutions of full-time equivalent wages and work volume δ_w and δ_l, whose distribution we study conditional to α.

This approach therefore supposes the treatment of wages and working time as two factors that are independent of each other, and therefore that the possible correlation between the yearly evolutions of work volume and the yearly evolutions of wages is neglected.

Inter-company mobility

We define more specifically the wage earners who do not undergo inter-company mobility as those who in t and $t+1$ occupy a position of paid employment in one same company identified by its SIREN [Système d'identification du répertoire des entreprises – French company number]. Conversely, we consider that a wage earner has undergone an inter-company move when, between t and $t+1$, the main company changed (in terms of its SIREN number), with the main company for a year being defined as the one in which the duration of wage-earning is the longest. So, while the wage earners who do not undergo inter-company moves may not be multi-assets (wage earners), this may be the case for those who do not undergo moves.

Division of periods

We focus on the evolutions of the distribution of δy conditional to α with time. More specifically, we seek to know whether this conditional distribution varied over the course of the crisis, and whether these variations may be characterised in terms of changes of the uncertainty on future wage income. To do this, it is necessary to distinguish between the evolutions that occur over the course of the crisis and those which succeed it.

The data available also play on this choice. In fact, the past normalised wage income Y^{ant} which is necessary to the definition of α, is only defined for the relatively stable wage earners, that being those in paid employment for three years before the year t. In other words, by using a sample which starts in 2002, the distribution of δy conditional to α can only be estimated from 2005 onwards.

The status of the year 2008, and from that, the evolutions of wage income between 2007 and 2008, is uncertain. This is why we choose not to study it. This leads to the comparison of two periods: 2005-2006 (that being the individual evolutions of wage income 2005-2006 and 2006-2007) and 2008-2011 (that being the individual evolutions of wage income 2008-2009 to 2011-2012).

effect. We write $\delta y_{i,t} = y_{i,t+1} - y_{it}$ as the evolution between t and $t+1$ of the wage income of wage earner i net of the average age effect (box 2).

The evolutions of normalised wage income indicate whether a wage earner progresses faster or slower than the average of wage earners of their age. The groups of wage earners whose wage income is comparable are defined by ordering the wage earners according to the average normalised wage income over the five preceding years. The wage earners are thus put into 100 groups of equal size, each one corresponding to a rank α variant of 0 (for the lowest-paid) to 99 (for the highest-paid), on the scale of past wage incomes. This approach requires restricting the study population to wage earners present in paid employment for seven years: the five years over which past normalised wage income is calculated, and the two years between which the evolution of normalised wage income is observed. Our results therefore do not concern the uncertainty on the future wage income of wage earners who have a very fragmented employment path, or who are confronted with long periods of unemployment. They do not take into account uncertainty at the very start of professional life either. Finally, we compare the distribution of $\delta y_{i,t}$ conditional to α between the period 2005-2006 – therefore the individual evolutions of wage income 2005-2006 and 2006-2007 – and the period 2008-2011 – that is the evolutions 2008-2009 to 2011-2012.

Wage income evolutions: on average more favourable at both ends of the distribution of past wage income, but more dispersed

Over the whole period 2005-2011, and for a large part of the past wage income scale, the average yearly progression decreases as wage income net of the age effect increases (Figure I). In other words, the lowest-paid wage earners in the past face evolutions of wage income that are more favourable than those of their better-paid counterparts (Figure I-A). This can result in part from mean reversion, if there are wage earners who have seen an unfavourable evolution in the past among the lowest-paid wage earners.[2] This catch-up effect tends to reduce the inequalities within the cohorts. Over the period studied, this is so for 89% of wage earners whose wage income was lower in the past, particularly for the 20% of the lowest-paid wage earners. The same remains observed when focusing on the conditional median of the wage income evolutions (Figure I-B).

The magnitude of uncertainty on future wage income, measured by the standard deviation (Figure I-C) and the D9-D1 interdecile range (Figure I-D) conditional of $\delta y_{i,t}$ present a U shape. In other words, the yearly evolutions of wage income are more dispersed for the lowest-paid wage earners, and to a lesser extent for the very high wage incomes, than for the wage earners whose past wage income takes up an intermediary position in the distribution. By admitting that this dispersion approximates the extent of the uncertainty on future wage income, this uncertainty is greater for the 25% of wage earners at the lower end of the wage income scale, and the 2% of the highest-paid wage earners, than for the rest of the wage earners.

For the 5% to 8% – according to the measurement considered, third moment (Figure I-E) or Kelley's Measure of Skewness (Figure I-F) – of the lowest-paid wage earners, the yearly evolutions of wage income present a slight upward asymmetry. This means that the most significant part of the dispersion of these evolutions is driven by the most favourable evolutions. However, for the rest of the wage earners, this asymmetry is significant and negative, except perhaps for the 1% highest-paid wage earners (according to the measure chosen). In other words, with the exception of the wage earners at the lower end of the past wage income scale, the considerable yearly variations of wage income are rather downward evolutions.

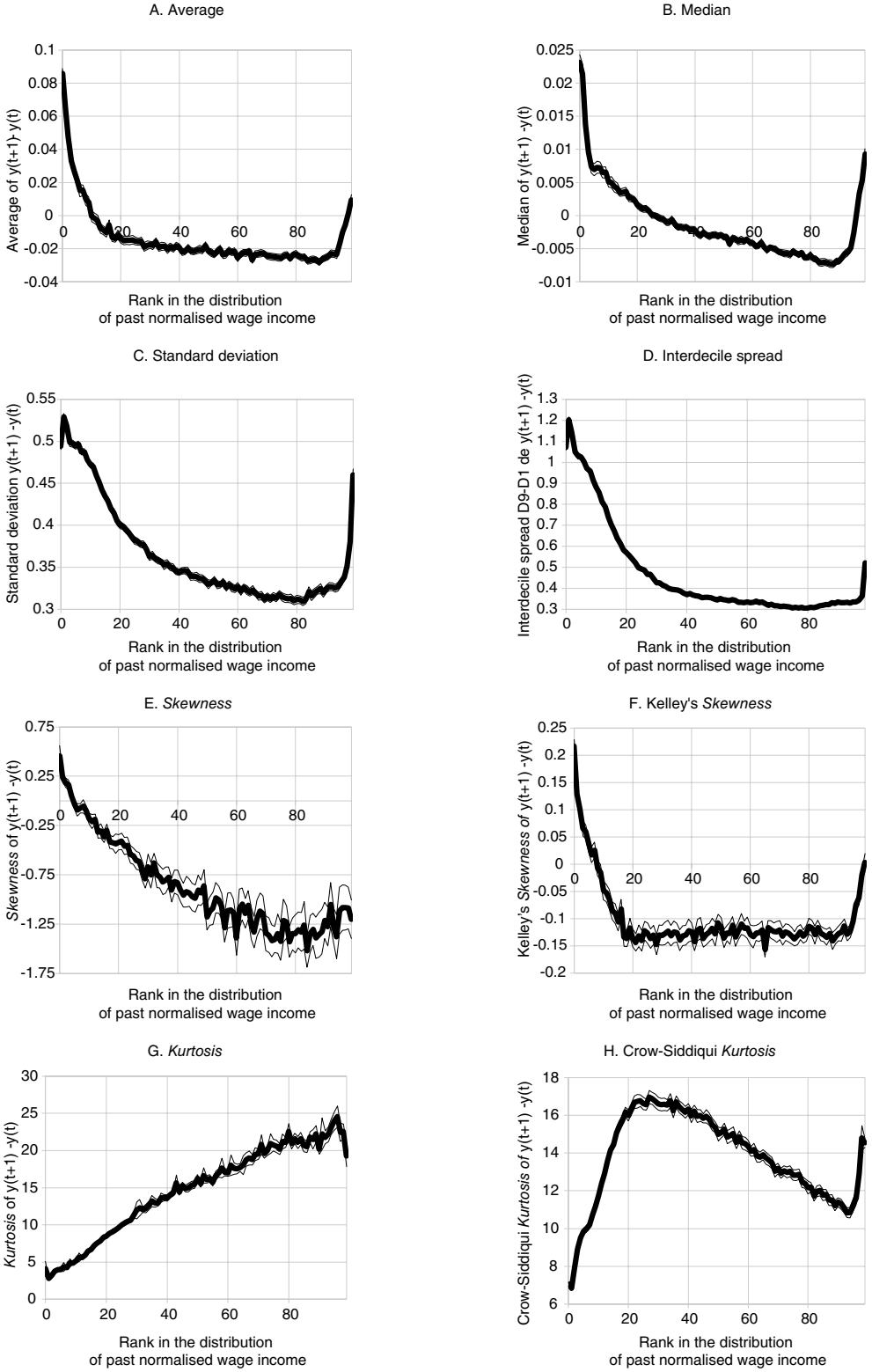
Extreme yearly variations, finally, have a large impact on the dispersion of wage income evolutions, and this is especially so since at the top end of the past wage income scale. This considerable weight of the tails of distribution in the uncertainty on future wage income, as well as its asymmetry, contradicts the usual log-normality hypothesis. In fact, under the log-normality hypothesis of wage income shocks, the kurtosis is null[3] and the Crow-Siddiqui Kurtosis is constant and equal to 2.91. Whereas the kurtosis of the yearly variations of wage income increases up until the 96th percentile of the distribution of past normalised wage income (Figure I-G), the

2. To the extent that the years over which on the one hand past normalised wage income (t-5 to t-1) and on the other hand the evolution of normalised wage income (t to t+1) are estimated are disjointed, and this return towards the norm does not, however, concern very temporary shocks (one sole year with small wage income).

3. Here we estimate the normalised kurtosis.

Figure I

Individual yearly evolutions of normalised wage income according to the rank in the distribution of past normalised wage income



Note: The lower and upper bounds of the confidence intervals at 95% are represented by thin lines. The confidence intervals are obtained by bootstrap (100 replications) (see box 2).

Reading note: at the 5th rank of the past wage scale, wage earners are confronted with yearly evolutions of wage income higher by 2.1 percentage points on average than the variation of average wage income at their age (graph A). Among them, 50% see more favourable evolutions of more than 0.6 percentage points than this variation of average wage income (graph B).

Coverage: Metropolitan France between 2005 and 2011, all relatively stable wage earners in paid employment, that being having received 1/8 of minimum wage in *t*-1, *t* and *t*+1 and at least two years between t-5 and t-2, except agricultural wage earners and apprentices and trainees, except wages directly paid by households.

Sources: Insee, "all wage earners" *DADS* Panel.

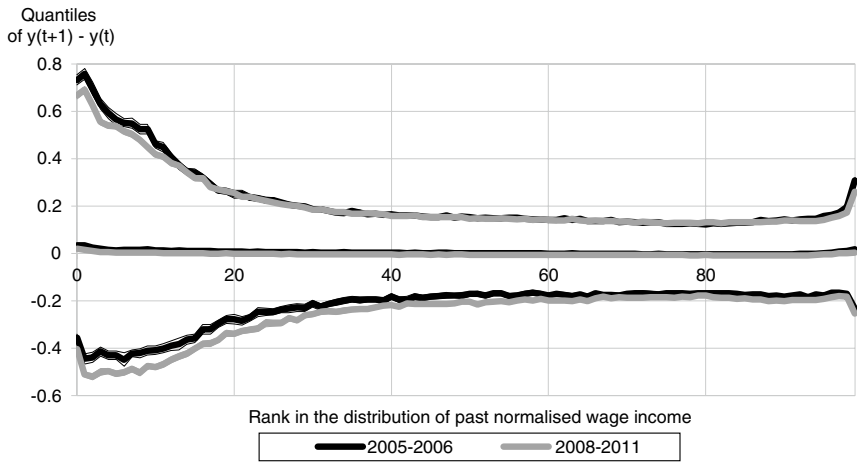
Crow-Siddiqui Kurtosis (Figure I-H) presents a non-monotone profile, which differs from the results obtained for the US (Guvenen et al., 2016). In other words, in France, the weight of rare events in the dispersion of the evolutions of wage income seems to be greater for individuals with very high past wage incomes, or with intermediary levels of past wage income, than for individuals with very low past wage income or, to a lesser extent, to the relatively high levels of the distribution. Contrastingly, in the US, this weight increases with the level of past wage income, with the exception of very high wage incomes. It is possible that this difference stems from differences in the grouping of wage earners between the results of Guvenen et al., (2016) and those which we present. Later on in this article, we privilege measures based on quantiles (median, inter-decile range, Kelley's Measure of Skewness and Crow-Siddiqui Kurtosis) which are more robust to extreme variations than measures based on moments (average, standard deviation, skewness and kurtosis).

The most unfavourable individual evolutions are amplified over the course of the crisis

Examining the conditional deciles of the individual yearly variations of normalised wage income shows that over the course of the crisis, these individual evolutions became less favourable than they were in the preceding years (Figure II). So, throughout the past income scale, the first decile (D1) and the median (D5) of the individual evolutions of normalised wage income are significantly lower between 2008 and 2011 (and thus for the yearly evolutions from 2008-2009 to 2011-2012) than between 2005 and 2006 (and thus for the yearly evolutions 2005-2006 and 2006-2007). The drop is greatest at the bottom of the wage income scale for the first decile, at the bottom and at the top for the median (Figure III-A). The magnitude of the drop is higher for the first decile than for the median. However, the last conditional decile (D9) only decreases significantly at the extremities of the distribution of past normalised wage income, for the 10% of lowest-paid wage earners and the 6% of highest-paid wage earners in the past; it does not vary significantly over the rest of the scale. For these extremities of the wage income scale, the decline of the last conditional decile is greater than that of the median.

This analysis of the conditional deciles already brings valuable information on the evolution of the distribution of individual evolutions of wage income over the course of the crisis. It shows firstly that the dispersion of these individual variations, that we interpret as being characteristic of the extent of the uncertainty on future

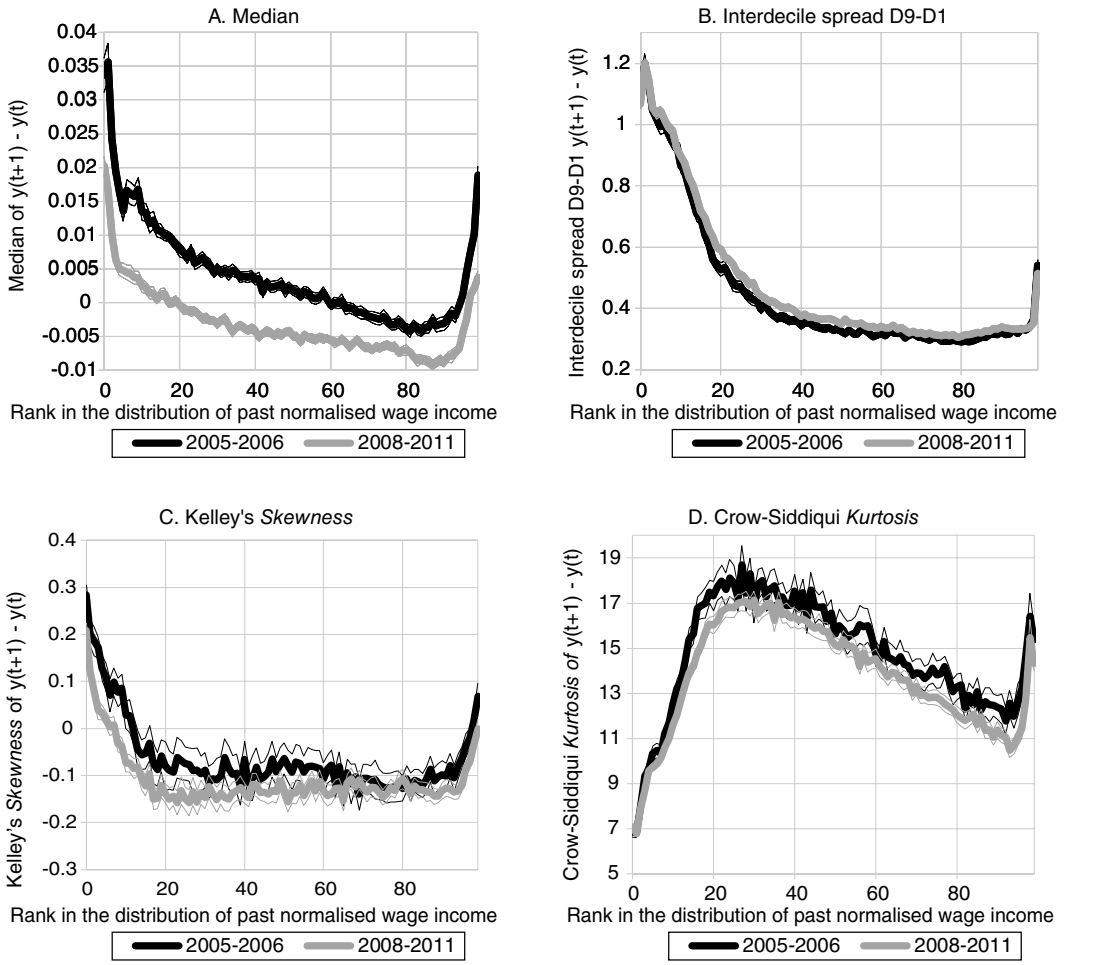
Figure II
Deciles of the individual evolutions of normalised wage income before and during the crisis



Note: The lower and upper bounds of the confidence intervals at 95% are represented by thin lines. The confidence intervals are obtained by bootstrap (100 replications) (see box 2).
Reading note: At the 10th rank of the past wage scale, for the years 2005 and 2006, 10% of the wage earners are confronted with yearly evolutions of normalised wage income lower than -0.41 in the logarithm. For the years 2008 to 2011, at the same level of the scale, 10% of the wage earners are confronted with evolutions lower than -0.48 in the logarithm.
Coverage: Metropolitan France between 2005 and 2011, all wage earners except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Sources: Insee, "all wage earners" *DADS* Panel.

wage income, increases slightly over the course of the crisis, in particular for the intermediary positions on the past wage income scale. It then indicates that at the lower end of the distribution of past normalised wage income, and to a lesser extent at the higher end, it is the dispersion of the less favourable evolutions which increases, whereas that of the most favourable evolutions decreases. These results are consistent with those obtained on the dispersion, measured by the D9-D1 interdecile range, and on the asymmetry, measured by Kelley's Measure of Skewness which estimates the relative parts of the dispersion in the upper half (D9-D1) and the lower half (D5-D1) in this interdecile range. In fact, over the course of the crisis, the measure of the D9-D1 interdecile range (Figure III-B) shows a slight increase in the part of the distribution from the 16th to the 95th percentile of the past wage income. Additionally, for wage earners located at the extremities of the past wage income scale, Kelley's Measure of Skewness decreases significantly between 2005-2006 and 2008-2011 (Figure III-C), indicating that the weight of the negative evolutions of normalised wage income in the dispersion has become more pronounced over the course of the crisis than in the years before. So, for the wage earners at the bottom and top ends of the past wage income scale, the unfavourable individual variations of wage income play a more important role in the dynamics of wage income over the course

Figure III
Individual yearly evolutions of normalised wage income before and during the crisis



Note: The lower and upper bounds of the confidence intervals at 95% are represented by thin lines. The confidence intervals are obtained by bootstrap (100 replications) (see box 2).
Reading note: At the 10th rank of the past wage scale, for the years 2005 and 2006, 50% of the wage earners are confronted with yearly evolutions of normalised wage income lower than 1.3%. For the years 2008 to 2011, at the same level of the scale, 10% of the wage earners are confronted with evolutions lower than 0.2%.
Coverage: Metropolitan France between 2005 and 2011, all wage earners except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Sources: Insee, "all wage earners" *DADS* Panel.

of the crisis than over the preceding years. This is, however, not the case for the wage earners located at more intermediary positions.

The Crow-Siddiqui Kurtosis of the yearly variations of wage income decreases significantly over the crisis for a fraction of the wage earners, among the relatively low past wage incomes on the one hand, and for a fraction of the highest past wage incomes on the other hand (Figure III-D). For the wage earners located over other positions in the scale of past wage incomes, the data do not allow to conclude that there was a significant variation in the weight of the distribution tails over the course of the crisis. This shows that the slight increase in the magnitude of the uncertainty on future wage income over the crisis does not result chiefly from rare events.

These results highlight a slight increase of the dispersion of individual yearly evolutions of wage income over the course of the crisis, to the same extent in France as that estimated by Guvenen et al. (2014) for the US, and inconsistent with the very large increase documented by Storesletten et al. (2004). At the bottom and top ends of the past wage income scale, the downward asymmetry of the distribution of the yearly evolutions of wage income is accentuated over the course of the crisis: the very unfavourable evolutions are more frequent, and play a greater role in the individual dynamics of wage income than over the years before. It is, however, not the case at the intermediary ranks of the scale, in contrast with the American case for which this phenomenon concerns all wage earners (Guvenen et al., 2014). What is more, the magnitude of this phenomenon is also greater in the US than in France. Additionally, this variation of the dynamics of wage income over the crisis is not observed identically for all wage earners, and may depend on their human capital. Indeed, holding a higher education degree seems to have a protective effect on wage earners, especially for the highest-paid. However, the youngest wage earners seem to be less affected by the crisis than their elders (see the online complement C1).

More unfavourable dynamics of working time for the lowest-paid wage earners, less advantageous wage evolutions for the highest-paid

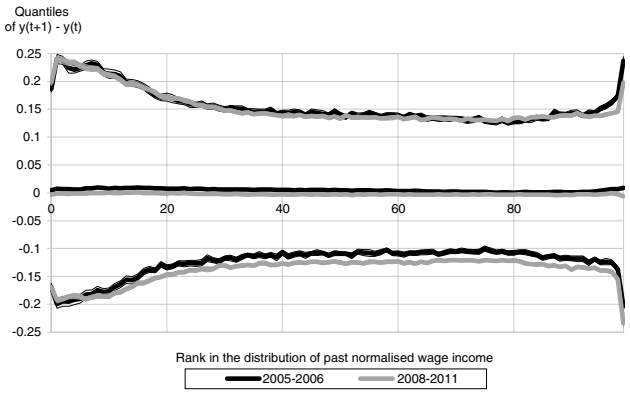
The yearly variations of wage income combine shocks regarding full-time equivalent wages (wage increase or reduction) and shocks regarding working time (job loss and unemployment).[4] Over the course of the business cycle, the same shocks might not be predictive of the evolutions of wage income: in a good economic period, positive shocks on wages (rises and upwards mobility) and, in times of crisis, the volatility of working time – reflecting the risk of non-employment – can weigh differently on the dynamics of wage income. By overlooking the possible correlation between these shocks, we split wage income into full-time equivalent (FTE) wages and into working time, and we examine changes in the conditional distributions of the evolutions of full-time equivalent wages (cf. Box 2).

The evolutions of normalised wages are less favourable over the course of the crisis than during the years preceding it. This, however, does not concern in the same way the strongest and the weakest evolutions, nor the lowest-paid and highest-paid wage earners. With the notable exception of the lowest-paid wage earners, the first decile of the evolutions of normalised wages decreases significantly between 2005-2006 and 2008-2011 (Figure IV): the least favourable evolutions of wages worsened during the crisis. However, for the lowest-paid wage earners, these least favourable evolutions did not vary. This may attest to rigidities in the adjustment of wages at the lower end of the wage scale, linked to minimum wage and wage grids. These rigidities are less pronounced at the top end of the scale, where the variable part of pay, which can be very significant, is a source of flexibility. The median of the wage evolutions decreases over the whole wage income scale (Figure V-A). The drop is the most significant at both ends of the scale, and the smallest around the 80th percentile of past normalised wage income. Finally, the last decile of the evolutions of wages, which corresponds to the most favourable evolutions, did not vary over the course of the crisis except for the highest-paid wage earners for whom it decreases significantly.

Consequently, except at the extremities of the scale, the dispersion of the evolutions of wages

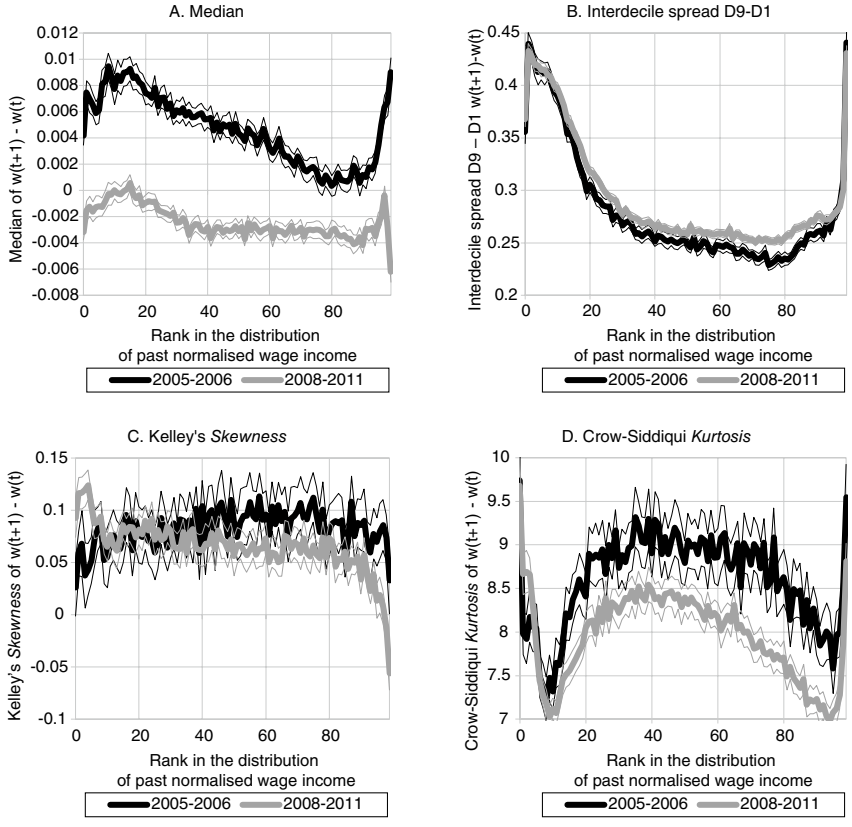
4. The "all wage earners" DADS panel does not allow for the observation of individuals for as long as they have been in paid employment. Morevover, we focus on individuals who have received a wage income greater than 1/8 of minimum wage between t-5 *and* t+1. *However, it does allow for the observation of interruptions to paid employment which arise for example during year* t+1, *since we do not impose any restriction with regards to the number of days remunerated. Thus, we do not directly observe unemployment and inactivity, but a decline in working time between* t *and* t+1, *especially if the number of days remunerated decreases, may be interpreted as a passing period of unemployment or inactivity. However, our method does not allow for the observation of long-lasting interruptions to paid employment, for example interruptions which might last the whole of year* t+1.

Figure IV
Deciles of the individual evolutions of normalised FTE wages before and during the crisis



Note: The lower and upper bounds of the confidence intervals at 95% are represented by thin lines. The confidence intervals are obtained by bootstrap (100 replications) (see box 2). Only wage earners for whom a full-time equivalent work volume can be calculated are taken into account in this figure.
Reading note:At the 10th rank of the past wage scale, for the years 2005 and 2006, 10% of the wage earners are confronted with yearly evolutions of normalised wage income lower than -0.11 in the logarithm. Reading note: at the 50th rank of the past wage scale, for the years 2005 and 2006, 10% of wage earners are confronted with yearly evolutions of normalised wage income lower than -0.11 in the logarithm.
Coverage: Metropolitan France between 2005 and 2011, all wage earners except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Sources: Insee, "all wage earners" *DADS* Panel.

Figure V
Individual yearly evolutions of normalised FTE wages before and during the crisis



Note: The lower and upper bounds of the confidence intervals at 95% are represented by thin lines. The confidence intervals are obtained by bootstrap (100 replications) (see box 2). Only wage earners for whom a full-time equivalent work volume can be calculated are taken into account in this figure.
At the 10th rank of the past wage scale, for the years 2005 and 2006, 50% of the wage earners are confronted with yearly evolutions of normalised wage income lower than 0.8%. For the years 2008 to 2011, at the same level of the scale, 50% of the wage earners are confronted with negative yearly evolutions (graph A).
Coverage: Metropolitan France between 2005 and 2011, all wage earners except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Sources: Insee, "all wage earners" *DADS* Panel.

increases over the course of the crisis, because the most unfavourable evolutions get worse whereas the most favourable do not vary: the D9-D1 interdecile range increases significantly over a large part of the scale, from the 20th to the 96th percentile of past normalised wage income (Figure V-B) and remains constant for the wage earners located at the extremity of the scale. The drop in median evolutions over the crisis limits the increase in the weight of the least favourable evolutions in this dispersion. The asymmetry of this uncertainty, measured with Kelley's skewness, does not vary significantly over the course of the crisis for the largest part of wage earners (Figure V-C). For the lowest-paid wage earners, the drop in the median evolutions comes to constrict the lower end of the distribution of individual wage evolutions and extend the upper end. The weight of the favourable evolutions in the dispersion increases: Kelley's Measure of Skewness increases below the 8th percentile of normalised wage income (Figure V-C). Finally, for the highest-paid wage earners, the drop in the most favourable evolutions and the least favourable evolutions is of a similar magnitude, and is larger than the drop in median evolutions: the dispersion does not increase, but the weight of the most favourable evolutions decreases whereas that of the least favourable evolutions increases. The downward asymmetry is accentuated: Kelley's Measure of Skewness decreases significantly between 2005-2006 and 2008-2011.

The weight of the distribution tails in the uncertainty on future wages, measured by Crow-Siddiqui Kurtosis, decreases over the course of the crisis for a large majority of wage earners, above the 14th percentile of past normalised wage income (Figure V-D): at these levels of the wage income scale, the increase of the dispersion of the evolutions of wages over the course of the crisis reflects more an increase of the uncertainty perceptible to all the wage earners than an amplification of the relatively rare evolutions. However, even over the period 2008-2011, this weight remains much higher than that of the Gaussian reference. For the lowest-paid wage earners, it does not vary or it increases slightly. For the highest-paid wage earners, the variation of the individual dynamics of wage income therefore arise from a deformation of the distribution of the individual evolutions of FTE wage over the course of the crisis. However, for the lowest-paid wage earners, this variation is not found in the evolutions of wages and therefore corresponds to a change in the individual dynamics of working time. This can be confirmed by focusing specifically on the shocks of FTE working time (see the online complement C2). So, for the lowest-paid wage earners, the asymmetry towards the bottom end of the individual evolutions of FTE working time is accentuated during the crisis: the increased significance of the unfavourable evolutions in the individual dynamics of wage income results from an increased frequency of very negative evolutions of working time.

Inter-firm mobility is more frequent but less uncertain over the course of the crisis, and the evolutions in a same company rarer and more dispersed

The individual evolutions of wage income may differ significantly according to whether they are associated or not with a change of employer: payment practices may in fact be dissimilar from one employer to the next (Abowd et al., 1999). Furthermore, by participating in the improvement of matching employee with employer, the transitions from one employer to another explain a large part of wage progression over the course of the professional life cycle (Topel & Ward, 1992). In the US, the evolutions of earned income associated with mobility are much more dispersed than those faced wage earners who do not change employer (Guvenen et al., 2016). The slight increase in the dispersion of individual evolutions of wage income measured over the course of the crisis could therefore result from more frequents changes of employers. We distinguish between the evolutions of wage income, of wages and of working time according to wage earners behaviour on the labour market, namely the evolutions seen by the wage earners who stay in the same firm between t and $t+1$ from those of the wage earners who change companies (see Box 2).

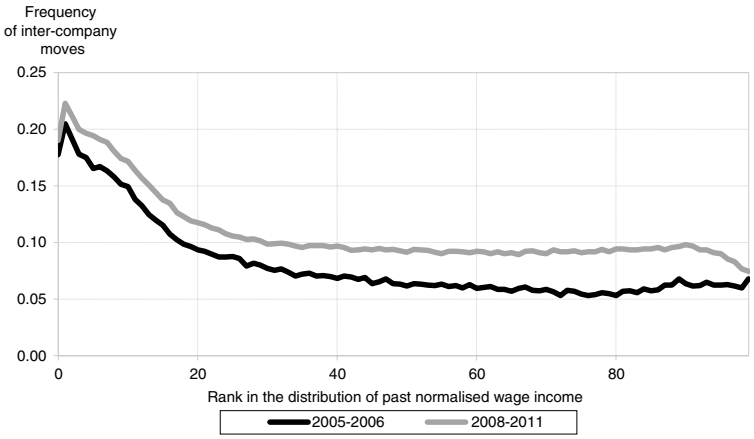
Inter-company moves are more frequent for the lowest-paid workers (Figure VI): the frequency of inter-firm moves is higher than 15% among the 10% lowest-paid wage earners, and lower than 10% for the 70% highest-paid. At all levels of past wage income, they are more common during the crisis, particularly in the upper half of the distribution of past wage income.

These results must however be taken with precaution: changes of employer may occur for different reasons – for example in the case of liquidation of a company – and the data do not distinguish between forced moves and chosen

moves. Furthermore, the choice to change company and the position occupied after this change depend on the wage earner's expected future wage income, and therefore the uncertainty that we seek to evaluate.

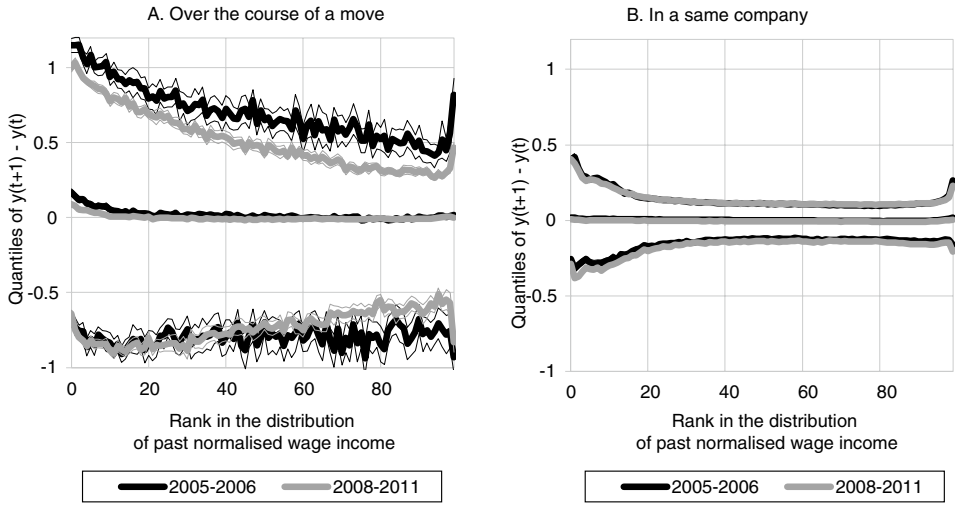
The crisis weighs above all on the most favourable moves, and to a lesser extent on the least favourable evolutions in a same company (Figure VII). So, however considerable its size, the increase of the first decile of the evolutions

Figure VI
Frequency of inter-company moves before and during the crisis



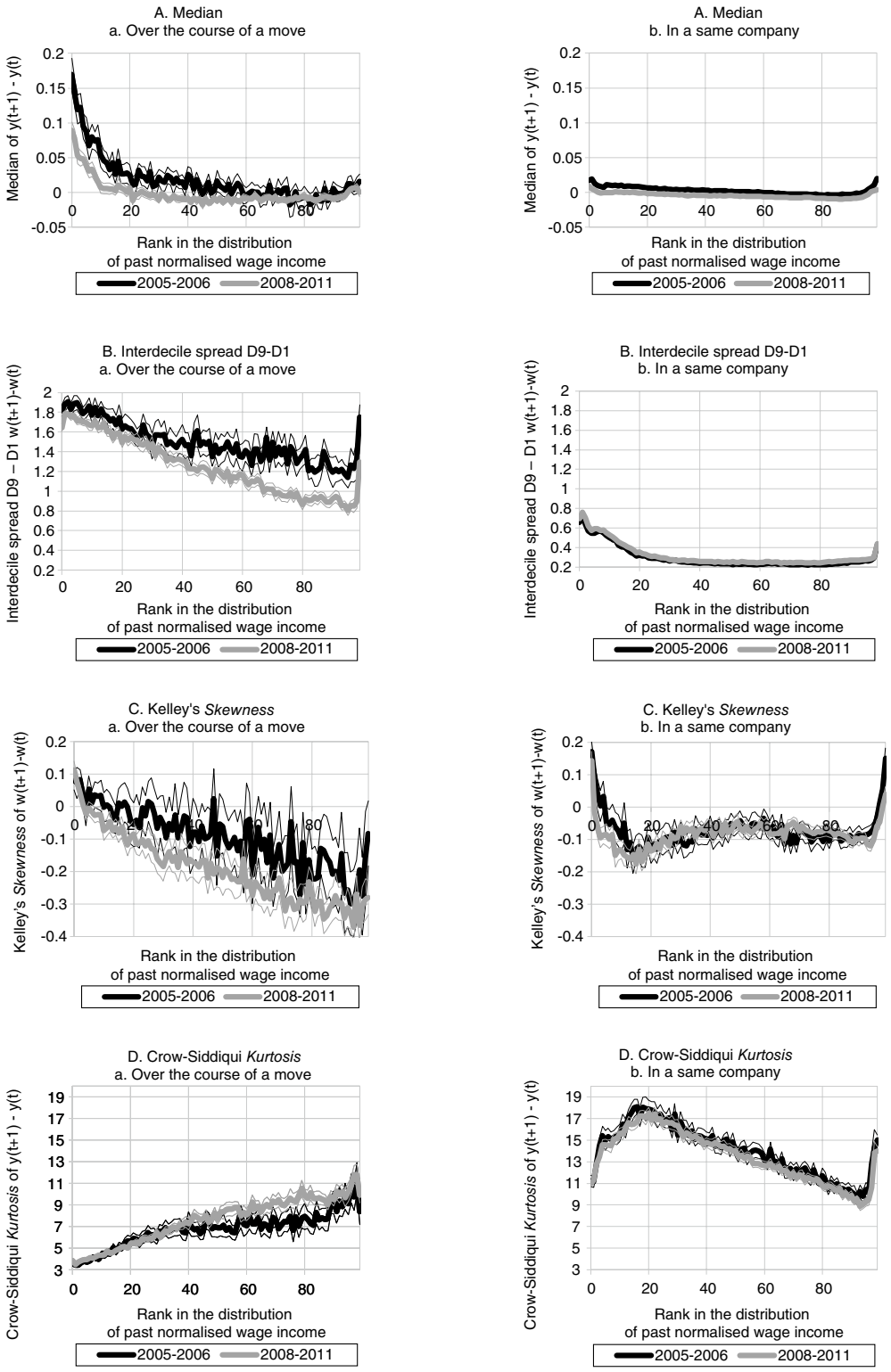
Note: Mobile wage earners are defined as those whose main employer (defined by the SIREN [French company number] and the one associated with the largest number of remunerated days of work in the year) changes between *t* and *t*+1 (cf. box 2).
Reading note: at the 10th rank of the past wage scale, for the years 2005 and 2006, 15% of the wage earners change main employer between *t* and *t*+1. For the years 2008 to 2011 and at the same rank of the scale, they make up 17%.
Coverage: Metropolitan France between 2005 and 2011, all wage earners except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Sources: Insee, "all wage earners" *DADS* Panel

Figure VII
Deciles of the individual evolutions of normalised wage income according to the mobility of the wage earners before and after the crisis.



Note: Mobile wage earners are defined as those whose main employer (defined by the SIREN [French company number]) and the one associated with the largest number of remunerated days of work in the year) changes between *t* and *t+1*. Immobile wage earners are defined as those who work under one sole employer in *t* and *t*+1. The lower and upper bounds of the confidence intervals at 95% are represented by thin lines. The confidence intervals are estimated by bootstrap (100 replications) (see box 2).
Reading note: At the 10th rank of the past wage scale, for the years 2005 and 2006, 10% of the wage earners are confronted with yearly evolutions of normalised wage income lower than -0.84 in the logarithm. For the years 2008 to 2011, at the same level of the scale, 10% of the wage earners are confronted with evolutions lower than -0.55 in the logarithm.
Coverage: Metropolitan France between 2005 and 2011, all relatively stable wage earners in paid employment, except wages directly paid by households.
Sources: Insee, "all wage earners" *DADS* Panel

Figure VIII
Individual yearly evolutions of normalised wage income according to mobility of the wage earners before and after the crisis



Note: Mobile wage earners are defined as those whose main employer (defined by the SIREN [French company number]) and the one associated with the largest number of remunerated days of work in the year) changes between *t* and *t*+1. Immobile wage earners are defined as those who work under one sole employer in *t* and *t*+1. The lower and upper bounds of the confidence intervals at 95% are represented by thin lines. The confidence intervals are estimated by bootstrap (100 replications) (see box 2).
Reading note: At the 10th rank of the past wage scale, for the years 2005 and 2006, 50% of the wage earners who change employer are confronted with yearly evolutions of normalised wage income lower than 55. For the years 2008 to 2011, at the same level of the scale, 10% of the wage earners who change employer are confronted with evolutions lower than 0.7% (graph A).
Coverage: Metropolitan France between 2005 and 2011, all wage earners except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Sources: Insee, "all wage earners" *DADS* Panel.

associated with mobility is not significant, except for a few points at the top of the wage income scale (Figure VII-A). However, over almost all of the wage income scale, the first decile of the individual yearly variations of normalised wage income in a same company decreases very slightly but in a significant way (Figure VII-B). Conversely, the last decile of the evolutions in a same company does not vary over the course of the crisis, except at the top of the wage income scale where it decreases (Figure VII-B), whereas the last decile of the evolutions of normalised wage income associated with mobility decreases greatly over the whole wage income scale, except perhaps at a few points (Figure VII-A). The median of the variations of wage income over the course of moves between companies decreases over the course of the crisis over nearly the whole lower half of the wage income scale (Figure VIII-A.a). Throughout the scale, the median of the evolutions of normalised wage income in a same company also decreases (Figure VIII-A.b), but over the lower half of the scale this drop is much smaller than for mobile wage earners. Finally, the dispersion of the evolutions over the course of a move between companies (Figure VIII-B.a) is always much greater than that of the evolutions of a same company (Figure VIII-B.b).

Since the first decile of the evolutions of wage income over the course of a move between companies does not vary, or increases over the course of the crisis, whereas the last decile decreases, the magnitude of the uncertainty associated with mobility, in the sense of the dispersion of the individual evolutions of the wage earners who change employer, decreases over the course of the crisis (Figure VIII-B.a). Contrastingly, the variations of the first and last deciles of the evolutions of wage income in a same company are small, so that, for wage earners who do not change company, the extent of the uncertainty on future wage income barely increases between 2005-2006 and 2008-2011 (Figure VIII-B.b). The variations of the extent of the uncertainty over the course of the crisis are therefore much greater for mobile wage earners than for immobile wage earners. The asymmetry of individual yearly evolutions of wage income according to mobility does not vary over the course of the crisis, except for the wage earners at the lower end of the wage income scale who do not change employer, for whom Kelley's Measure of Skewness decreases (Figure VIII-C). The weight of the distribution tails increases for the variations over the course of inter-firm moves for the wage earners from the intermediary to higher ranks of the distribution of past wage income, but it does not vary for the others (Figure VIII-D). For these mobile wage earners in the middle of the wage income scale, the drop in the dispersion of the evolutions of wage income over the course of the crisis concerns the most frequent progressions more than rare events. Wage dynamics, for the wage earners in the upper half of the scale, and working time dynamics for all the wage earners, both contribute to these variations (see the online complement C2).

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This article is a first application over French data of the original non-parametric method proposed by Guvenen et al. (2016). In contrast with most works on individual dynamics of wage income and wage, this method does not rely on a hypothesis of conditional log-normality, and therefore allows for focusing on the asymmetry and weight of rare events in these dynamics, and on their variation over the course of the crisis of 2008.

For the individuals who are relatively stable in paid employment analysed in this article, the individual dynamics of wage income are less favourable over the course of the crisis than over the years before. The greatest variations with the crisis concern first and foremost the lowest-paid wage earners in the past, and to a lesser extent the very high wage incomes, which may contribute to a rise in wage income inequalities measured over a cross-section. The dynamics of wage income are also slightly more uncertain between 2008 and 2012 than between 2005 and 2007, which also tends to exacerbate inequalities.

Over the course of the crisis, these are the least favourable individual evolutions of wage income and, to a lesser extent the most favourable – and only for the highest and lowest-paid wage earners in the past – which decrease the most. For these wage earners located at the top and bottom of the distribution of past wage income, these most and least favourable evolutions decrease faster than the median evolutions, such that the weight of the least favourable evolutions in the uncertainty on future wage income increases. Consequently, the shape of this uncertainty varies over the course of the crisis: the distribution

of the evolutions of wage income is more downwardly asymmetrical than over the course of the years before. In other words, the relative significance of the very unfavourable evolutions in the individual dynamics of wage income is accentuated over the course of the crisis, for the low past wage incomes on the one hand and the high past wage incomes on the other. This phenomenon is however of a smaller magnitude than that documented by Guvenen et al. (2014) for the United States, and does not concern all of the wage earners. This difference could result from disparities in behaviour between French and American wage earners and employers, but also from differences in the institutions which frame the labour market: the inequalities of wage income and of wages are actually greater in the US than in France, and the unemployment rate is smaller in the US over the period which precedes the crisis. The weight of rare events, finally, decreases slightly or does not vary during the crisis, in both France and the US: the variations of the distribution of the individual evolutions of wage income therefore result from relatively common evolutions rather than from extreme and rare shocks.

At the bottom of the distribution, these variations over the course of the crisis result above all from variations in the dynamics of working time, whereas for the highest-paid wage earners the weight of wages is greater. To the extent that, for the lower end of the distribution of past wage incomes, this major role of the dynamics of working time may reflect a risk of job loss, our approach could be widened by taking into account unemployment benefits. This would perhaps allow for a more complete overview of income dynamics linked to presence on the labour market.

Wage earners mobility, finally, contributes to the variation of the wage income dynamics during the crisis. In fact, changing employer is more frequent over the course of the crisis than during the years before. The evolutions of wage income associated with mobility are always more uncertain than those of the wage earners who stay in a same company. This increased frequency of inter-firm moves therefore contributes to the increase of the uncertainty on wage income highlighted over all of the wage earners. However, the uncertainty associated with changes of employer decreases over the course of the crisis, which comes to moderate this effect. To the extent that we do not distinguish between forced moves – for example due to the closing of a company – and chosen moves, this evolution, which results from both working time and wages, remains difficult to interpret. □

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ANNEX

DESCRIPTIVE STATISTICS

Table A1-I
Number of observations, share of women, division by age brackets, wage income and wages

	Period	Number of observations accumulated over the period?	Share of women (in %)	Share of age brackets (in %)				Logarithm of average wage income (standard deviation)	Logarithm of average FTP wage (standard deviation)
				23-29 years old	30-39 years old	40-49 years old	50-59 years old		
Initial sample	2005-2006	5,811,551	47.4	26.1	27.3	26.3	20.3	9.50 (1.15)	10.0 (0.46)
	2008-2011	10,196,836	48.2	26.2	26.3	26.4	21.2	9.50 (1.16)	10.0 (0.46)
Censoring at 1/8 of minimum wage	2005-2006	5,426,296	46.7	24.6	27.7	26.9	20.7	9.71 (0.75)	10.0 (0.45)
	2008-2011	9,554,635	47.7	24.5	26.7	27.1	21.7	9.72 (0.75)	10.0 (0.45)
Relatively stable wage earners in paid employment	2005-2006	3,778,227	45.9	16.0	29.8	30.7	23.3	9.93 (0.58)	10.1 (0.44)
	2008-2011	5,742,026	47.1	16.2	28.9	30.6	24.3	9.93 (0.59)	10.1 (0.43)

Coverage: Metropolitan France between 2005 and 2011, all wage earners except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Sources: Insee, "all wage earners" *DADS* Panel.

Table A1-II
Division of the sample by business sector, professional categories and degree level

	Period	Share of wage earners in the private sector (in %)	Division into socioprofessional categories (in %)				Division of degree level (in %)		
			Executives	Intermediary professions	Employees	Labourers	Lower than baccalaureate (bac)	Bac to bac+2	Bac + 3 and more
Initial sample	2005-2006	77.4	15.4	23.9	32.0	28.7	51.2	34.4	14.4
	2008-2011	77.9	15.7	21.1	34.6	28.2	49.4	35.9	14.7
Censoring at 1/8 of minimum wage	2005-2006	76.9	16.0	24.6	31.3	28.2	50.9	34.6	14.5
	2008-2011	77.5	16.4	21.7	33.8	27.8	48.8	36.1	15.0
Relatively stable wage earners in paid employment	2005-2006	74.8	18.4	26.4	28.4	26.5	50.5	34.5	15.1
	2008-2011	75.8	18.3	24.0	31.2	26.2	47.9	36.4	15.8

Note: The naming of the socioprofessional categories used in these annual declarations of social data changed between 2008 and 2009, causing a break in the trend including on the socioprofessional category with one figure. To the extent that we do not use the socioprofessional category in our analysis of the evolutions of wage income, this break does not pose a problem for the method used. The main point is to show that the selection made by the study of relatively stable wage earners does not differ substantially between 2005-2006 and 2008-2011. Wage-earning heads of companies are grouped together with the executives.
Coverage: Metropolitan France between 2005 and 2011, all wage earners except agricultural wage earners and apprentices and trainees, except wages directly paid by households.
Source: Insee, "all wage earners" *DADS* Panel.

Crisis adjustment strategies in France: The contribution of establishment-level data

Delphine Brochard and Corinne Perraudin *

Abstract – This paper explores the employment and wage adjustments and business reorganisation implemented by French establishments between 2008 and 2010, using data from the Dares *REPONSE* survey. Drawing up a typology of adjustment practices based on a statistical classification, it reveals a diversity of practices illustrating the complementarity of these adjustments. Then the paper analyses the characteristics of the different classes of establishments and the links between practices, the flexibility levers available to the establishments and their economic and financial dependency relationships, taking into account the diversity of economic and social contexts. While recourse to temporary contracts and subcontracting does not seem to be significant, the use of flexible pay components (individual pay rises and performance bonuses) and worker versatility affect the adjustments made by establishments. Likewise, being majority foreign-owned, being a subsidiary of a (listed or unlisted) group, or being part of a subcontracting chain emerge from the analysis as significant factors affecting these adjustments.

JEL Classification: D22, J53, J31, M54, G34.
Keywords: economic crisis, business practices, employment adjustment, wage adjustment, flexibility, corporate governance.

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The employment impact of the shockwave that hit France in 2008 is commonly studied through an approach focused on the labour market, in which employment and wage adjustments are regarded as being substitutable, and institutional constraints are put forward as an explanation for the country's trajectory. These (often comparative) studies present France's trajectory as typically exemplifying employment adjustment strategy (mainly affecting those on fixed-term and, above all, temping contracts) or external flexibility, as opposed to internal flexibility involving variations in hours worked (as in Germany and Austria) and/or hourly wages (Askenazy et al., 2013; Cochard et al., 2010; Gautié, 2011; Horny et al., 2010; Marchand & Minni, 2010; OECD, 2010). These adjustment characteristics are attributed to wage and employment regulations (Askenazy et al., 2013; Bentolila et al., 2012; Boeri & Jimeno, 2016; Fabiani et al., 2015) and to the industrial relations system (Boulin & Cette, 2013; Delpech et al., 2016; Dustman et al., 2014), which are supposed to give companies more or less flexibility and to affect the relative cost of alternative strategies.

The descriptive analysis of the effects of the crisis at firm level provides another perspective on adjustment mechanisms and their determinants. By examining the diversity of adjustment practices in the light of the specific context of each firm, it identifies a broader variety of practices and explanatory factors. The Dares *REPONSE* survey (a French survey of labour relations and collective bargaining) provides an opportunity to perform such an analysis. The latest *REPONSE* survey for the period 2008-2010 enables us to explore the employment and wage adjustment practices implemented by establishments with 10 or more employees (in the non-farm business sector), and to link these practices with a rich set of variables related to the internal organisation and the environment of firms. Initial analyses conducted respectively by Deroyon and Romans (2014) and Amossé et al. (2016) clarified the link between adjustment practices and labour relations within establishments, enabling the impact of the latter to be qualified. Indeed, these studies show that, while employment and wage adjustments have frequently gone hand in hand with collective bargaining, the latter seems to have facilitated rather than hindered the adjustments.

The aim here is to complete these findings by studying the influence of two other contextual factors on crisis adjustment practices: The organisational flexibility tools put in place by the establishment, and the economic and financial dependency relationships in which it is embedded. As shown by Atkinson and Meager (1986)'s seminal study, firms have developed a range of flexible labour management practices that go beyond the usual dichotomy between internal and external flexibility. As the development of these practices vary according to the industry, the size of the establishment and the skill level of the workforce (Bunel, 2008), these practices offer a range of adjustment opportunities to establishments grappling with the economic crisis, and are therefore likely to promote heterogeneity in adjustment mechanisms (Kümmerling & Lehndorff, 2014). Another possible source of heterogeneity lies in the economic and financial dependency relationships in which establishments are engaged (Grimshaw & Rubery, 2005). Whether they stem from the firm's governance structure –via the composition of its shareholder base, its listing on the stock exchange or its subsidiary status– or from its inclusion in a subcontracting chain, these relationships undermine the employer's autonomy and influence labour management decisions (Perraudin et al., 2008b).

To assess the impact of these various factors, we consider a broad range of adjustments, including actions on employment, wages and business reorganisation, as well as the possible combination of these adjustments within establishments. Using a typology of adjustment practices based on a statistical classification of establishments having seen a stagnation or decline in their business activity from 2008-2010, this paper presents a diversity of practices revealing the complementarity of the different adjustments made. It then describes the links between these practices, the flexibility levers available to establishments, and their economic and financial dependency relationships, while taking into account the diversity of economic and social contexts. It shows that, while recourse to temporary contracts and subcontracting does not seem to be a discriminant factor, the use of flexible pay components (individual pay rises and performance bonuses) and worker versatility emerge from the analysis as significant factors. Likewise, being majority foreign-owned, being a subsidiary of a (listed or unlisted) group, or being part of a subcontracting chain affects the adjustments made by establishments.

A variety of adjustment practices

According to the *REPONSE* survey, only a small proportion of establishments report being affected by the first phase of the economic crisis: In fact, less than one quarter of establishments declare a decline or a strong decline in business from 2008-2010, and slightly more than a third declare no change. To assess the impact of the recession on the behaviour of establishments without restricting the sample size too much and thereby reducing its representativeness, we focus our study exclusively on these establishments (Box). The preliminary analysis shows that adjustments, no matter what the practices considered, are more frequent in establishments that have not reported an increase in business than in the overall survey sample. The most widespread adjustment practices are workforce reductions (27% of establishments), business reorganisation (28%) and wage moderation (29%). Only 17% of the establishments froze or reduced wages, and recourse to the French legal framework for short-time working is even more infrequent (7%). These types of adjustments are made mostly by establishments facing a serious

Box – **Sample and data**

The Dares *REPONSE* survey (a French survey of labour relations and collective bargaining) allows us to study the various aspects of the employment relationship at establishment level. It provides information on how employee representative bodies work, human resource management practices, and work organisation, in connection with economic strategies and performance results. The 2010-2011 survey covered establishments with 11 employees or more, operating in the non-farm business sector in mainland France, excluding Corsica and individual family employers. Data were collected from 4,023 establishments between January and July 2011. The sample studied in this paper is restricted to establishments which reported no growth in their business volumes over the period in question, and information on adjustment practices of interest, *i.e.* 2,372 establishments. As a result of this restriction, establishments in the manufacturing and construction sectors, and small establishments, are slightly over-represented in the study sample (cf. Online Complement C1, table C1-1). The "management representative" section of the survey provides information on the key changes between 2008 and 2010, in terms of workforce (all types of contract included), pay, and business reorganisation.

The change in workforce is considered from a global perspective, with no distinction possible between fixed-term contracts and open-ended contracts. The question is as follows: *"What trend has been observed in your establishment's workforce over the last three years (2008, 2009, 2010), including all employees: An increase, no change, or a decrease?"* With regard to pay, the questionnaire includes a question relating specifically to the economic crisis: *"In the last three years (2008, 2009, 2010), in response to the economic crisis, has your establishment adopted any of the following policies towards any or all categories of employees? Wage moderation; a pay freeze; pay cuts; no, none of these".* Due to the small number of establishments reporting pay cuts (barely more than 1%), this adjustment practice was grouped together with pay freezes. This question does not enable us to distinguish changes in different (fixed or flexible) pay components. However, it appears from its wording that the question excludes incentive bonuses and profit sharing, which vary not on a discretionary basis but automatically depending on the firm's performance and profits, respectively. Lastly, the questionnaire provides information on the incidence of business reorganisations, through the following question: *"Over the last three years (2008, 2009, 2010), has your establishment implemented any of the following organisational changes?* Three of the options proposed relate to defensive reorganisations: *"Job redundancies"; "Refocus on specific businesses (abandonment of diversification)"; "Repatriation of subcontracted work".* The selection of at least one of these options is considered here as meaning that the business has been reorganised.

To determine the extent of recourse to the legal short-time working scheme, these data were matched with the administrative database *SINAPSE* (which is managed by the DGEFP - General Delegation for Employment and Vocational Training). It is therefore possible to know how many hours were actually unworked and paid under the "standard" or "long-term" short-time working scheme, for reasons other than accidents or exceptional bad weather (see Beauvoir & Calavrezo, 2012). On this basis, a binary indicator of recourse to short-time working over the period 2008-2010 was developed for each establishment.

The indicators used in the *REPONSE* survey do not show whether employment adjustments affected all employees equally across the board. Two further sources have been used to analyse these adjustments in greater detail, and to determine whether they affected all categories of employees, while maintaining the overall cohesion of the data used to develop the classification. On the one hand, the "employee" section of the *REPONSE* survey provides information on the incidence of collective redundancy plans through the following question: *"In the last three years, have there been any collective redundancies in the establishment where you work?"* If at least one employee from a given establishment replied "yes" (between 5 and 10 employees were surveyed per establishment), that indicates that the establishment carried out a collective redundancy plan between 2008 and 2010. On the other hand, establishment-level data from the 2008-2010 *DADS* (Insee) enable us to identify changes to the structure of jobs over the period, in terms of qualifications and (open-ended and fixed-term) contracts.

decline in business (cf. Online Complement C1, Table C1-1).

The breakdown per sector and per establishment size also reveals a wide diversity of behaviours. The particularly gloomy situation in the manufacturing sector comes out very clearly, regardless of the adjustment considered. With regard to size, while the largest establishments have more frequently resorted to business reorganisations, short-time working, workforce reductions and wage moderation, the smallest establishments have been more likely to freeze or reduce wages (cf. Online Complement C1, Table C1-2).

The study of statistical associations between adjustment practices shows that the establishments often make a combination of adjustments (Table 1). If, overall, just over a quarter of the establishments have reduced their workforce, the conditional frequencies show that these establishments account for almost half of those that have reorganised their business, frozen or cut wages, or taken recourse to short-time working. Likewise, business reorganisations are carried out by around two out of five establishments that have frozen or cut wages, or have taken recourse to short-time working. They are two times less frequent among establishments that have not placed any restrictions on wages. Therefore –far from being an alternative to workforce reductions– wage freezes and cuts, business reorganisations, and short-time working often seem to be complementary practices, which prompts a more in-depth investigation of their combined used by establishments.

Five classes of establishments and three crisis adjustment practices

An ascending hierarchical classification (AHC), based on a multiple correspondence analysis (MCA)[1], was performed to identify typical combinations of adjustment practices. As a result, five classes of establishments were identified, according to their adjustment practices (Table 2). Two of these classes stand out for not taking recourse to short-time working, not cutting wages and workforce, and carrying out very few business reorganisations. They include two thirds of the establishments and slightly over half of the employees in the sample. The largest class is characterised by "**workforce stability**" (50% of establishments and 39% of employees), while the other, smaller, group is distinguished

1. The MCA was carried out on unweighted data, the aim being to analyse the links revealed by the raw data without replicating observations through the use of weighted variables. The AHC is based on variables corresponding to the establishments' projections on the first two factorial axes of the MCA, which means that the establishments are classified based on the adjustment variables shown in table 2. The first two axes were selected, firstly, because they contain a larger share of information than the average axis (i.e.17%) and, secondly, to ensure that the less frequent modalities of the active variables did not influence the definition of the typology classes too much. Nevertheless, several variants were produced, and lead to comparable results.

Table 1
Conditional frequency of adjustments in establishments reporting no change or a decline in activity between 2008 and 2010

% of establishments

		Changes in pay			Changes in workforce			Business reorganisation	Recourse to short-time working
		No restrictions	Moderation	Freeze or reduction	Increase	No change	Decrease		
Changes in pay	No restrictions	100	0	0	22	58	20	22	4
	Moderation	0	100	0	18	52	30	34	7
	Freeze or reduction	0	0	100	13	40	47	39	19
Business reorganisation		42	35	23	17	37	46	100	11
Recourse to short-time working		28	27	45	9	41	50	45	100
Total		54	29	17	19	54	27	28	7

Reading note: 27% of the establishments that reported no change or a decline in activity between 2008 and 2010 saw a decrease in their total workforce from 2008 to 2010; These establishments make up 47% of those that either froze or cut wages over the period.
Coverage: Establishments with 11 employees or more in the non-farm business sector, reporting no change or a decline in activity from 2008 to 2010 (weighted figures).
Sources: Dares *REPONSE* survey 2010-2011, "management representative" section, and *Sinapse*.

by a "**workforce increase**" (16% of establishments and 18% of employees).

Conversely, the three other classes present typical combinations of adjustment practices. The first combination consists of "**all adjustment practices**": wage freezes or cuts (for 75% of the establishments), workforce reduction (80%), recourse to short-time working (64%) and business reorganisation (77%), thus illustrating the possible complementarity of the different adjustment practices. However, this class contains 8% of the establishments studied (13% of employees). Further analysis reveals the nature of the workforce reductions reported by the management representatives. According to the information in the "employee" section of the survey, over half of these establishments conducted a collective redundancy plan over the period and, according to *DADS* data (annual declarations of social data), neither permanent nor high-skilled employees were spared (see Online Complement C1, Tables C1-3 and C1-4).

The second combination, involving 15% of the establishments (22% of employees), consists of workforce adjustments (for 75% of the establishments), wage moderation (70% of the establishments) and business reorganisations (76% of the establishments). Wage freezes and cuts are rare, as is recourse to short-time working. The joint occurrence of business reorganisations and workforce reductions suggests the use of "**restructurings combined with wage moderation**", without recourse to short-time working**.** According to the data on "employees", almost one third of these establishments have conducted a collective redundancy plan. Again, according to the *DADS*, neither permanent nor high-skilled employees were spared.

A third and final combination, representing 11% of the establishments (8% of employees), is characterised above all by wage freezes or cuts (for 84% of the establishments), without, in most cases, any changes to the scope of the business. Recourse to short-time working is more frequent than average in this combination (18% *vs*. 7%), but is much less common than in the first class (64%). Likewise, workforce reductions (33%) are far less widespread than in the previous two combinations. The establishments in this class have mostly introduced "**primarily wage-oriented adjustment combinations**". According to the information in the "employee" section, almost one third of the establishments have conducted collective redundancy plans and, according to the *DADS*, the job cuts affected the least qualified segment of the workforce most.

Table 2
Frequency of adjustments per class of establishment

% of establishments

	All adjustment practices	Restructuring with wage moderation	Primarily wage-oriented adjustments	Workforce stability	Increase in workforce	All
Changes in pay						
Freeze or reduction	75	4	84	3	0	17
Moderation	18	70	4	23	31	29
No restrictions	7	26	12	74	69	54
Changes in workforce						
Increase	1	7	2	3	100	19
No change	19	19	65	85	0	54
Decrease	80	74	33	12	0	27
Short-time working	64	2	18	0	0	7
Business reorganisation	77	76	15	10	24	28
% of establishments	8	15	11	50	16	100
% of employees	13	22	8	39	18	100

Leading note: The class of establishments typically combining "all adjustment practices" contains 8% of establishments reporting no change or a decline in activity from 2008 to 2010, *i.e.* 13% of employees. 80% of these establishments reduced their workforce, compared with 27% of the total sample.
Coverage: Establishments with 11 employees or more in the non-farm business sector, reporting no change or a decline in activity from 2008 to 2010 (weighted figures).
Sources: Dares *REPONSE* survey 2010-2011, "management representative" section, and *Sinapse*.

Complementary rather than substitutable adjustments

Taken together, these three combinations of adjustments serve to qualify the observation made at macroeconomic level, namely that there is a preference for workforce reductions (external flexibility) rather than adjustments to wages and hours worked (internal flexibility). While the "restructuring with wage moderation" class is similar to this first model, it exists alongside a second class combining all of the adjustment practices, and a third class that mainly implements wage adjustments with or without short-time working. One third of the establishments in this class combine wage adjustments with workforce reductions.

These findings are in line with those of Deroyon and Romans (2014), who, based on the same survey, show that wage and employment adjustments are not mutually exclusive, and that wage freezes and reductions, and recourse to short-time working, are — all things being equal — positively associated with the probability of collective redundancy. They are also consistent with the conclusions of Calavrezo and Zilloniz (2016), showing that most of the firms that took recourse to short-time working between late 2007 and late 2010 nevertheless saw their workforce shrink over the period. This possible complementarity between wage bill reduction levers is also revealed by Teague and Roche (2014), using a similar methodology in a very different macro-institutional context. Classifying Irish establishments according to the adjustment mechanisms used, they distinguish two classes of equal size. One includes establishments that focus on cutting wages, working hours and jobs (general retrenchment programs), while the other includes establishments that opt to freeze wages and, to a lesser extent, reduce overtime. This complementarity is also revealed by the study conducted in Germany and the Netherlands by Tidjens et al. (2014), showing that, while downward adjustments on the intensive margin (hours per capita) and/or the extensive margin (permanent or temporary workforce) are more widespread than reductions in base or variable pay, the latter are usually combined with employment adjustments. This study also underlines the fact that adjustments to temporary employment are most commonly associated with adjustments to permanent employment.

These adjustments may of course have been made at different times, in line with a gradual deterioration in market conditions, as suggested by qualitative analyses (Perez et al., 2015; Roche & Teage, 2014). These monographic studies describe sequential processes in which the most easily implementable and the most socially consensual adjustments are made first (such as the non-renewal of temporary contracts, the abolishing of overtime, recourse to vacation leave, and wage moderation or freezes). According to an approach that is more like an "improvised adaptation" (Roche & Teage, 2014) than a trade-off strategy, the "toughest" adjustment (such as voluntary departures and collective redundancies) are only envisaged when the impact of the crisis worsens.

Adjustments between constraints and opportunities

Having identified typical adjustment combinations, the next step is to shed light on the reasoning behind these practices. The approach adopted consists in examining the diversity of practices in the light of the specific context of each firm, considering this context as a set of constraints and opportunities that influence managerial decisions (Amossé et al., 2008). Empirical studies exploring the response of firms to the economic crisis –in various macro-institutional settings– point to a variety of explanatory factors, which suggest differences in terms of crisis exposure and adjustment margins, and clarify the structuring effects of size, sector and the skill level of the workforce. After reviewing these factors relating to the environment and internal organisation of the establishments, we will look at how they influence the adjustment practices implemented.

The environment and internal organisation of the establishments

The analysis involves four main categories of variables. Most of the corresponding indicators (based on the findings of the *REPONSE* survey) relate to 2010, that is the end of the period observed (see Online Complement C2). Therefore, they cannot be considered as having determined the adjustment practices identified. However, they do help us understand the key features of the organisational configurations in which these practices are promoted and

developed, and, in so doing, help to clarify the reasoning behind them.

Market conditions and economic health of the establishment

The market conditions in which the establishment operates may influence the scale and type of adjustments made. The descriptive analysis showed that adjustments, no matter what their nature, are not specific to establishments directly affected by the crisis. However, the greater the decline in business, the more frequent these adjustments are. Not surprisingly, this is consistent with the general findings of the literature. Besides the magnitude of the shock, the predicted duration of its effects can also play a role. If the impact of the crisis is severe and the duration of its effects difficult to predict, employers may overreact by stepping up the adjustments they make (Greenhalgh et al., 1988). If the impact is believed to be temporary, businesses may decide to implement a workforce retention policy to retain specific employees (OECD, 2010, p. 42), or maintain wage levels to keep employees motivated (Askenazy et al., 2013).

In addition to the shock and the resulting uncertainty, more structural factors relating to the establishment's competitive environment and to its profit margins may influence adjustment decisions. Various studies highlight the impact of the degree of competitive pressure on the products market, which in theory affects the trade-off between selling price adjustments and cost adjustments (Babecký et al., 2009; Bertola et al., 2012; Dias et al., 2013; Fabiani et al., 2015). According to these studies, firms that have limited market power — due primarily to the fact that they operate in international highly competitive markets— tend to make tougher adjustments to wage costs. A firm's adjustment margins also depend on its economic health. In France, Deroyon and Romans (2014) show that the propensity of establishments to reduce their workforce is higher if their profitability is below that of their competitors, and lower if their productivity is greater.

Therefore, besides the trend in activity from 2008 to 2010, various indicators are used to assess not only the volatility and scope of the market, but also the establishment's performance in terms of profitability, compared with its main competitors.

Nature of labour relations

The impact of the institutionalisation of labour relations is generally taken into consideration in wage bargaining models, where union presence and the centralisation of collective bargaining are assumed to constrain firms' choices regarding employment and wages (Cahuc, 1990). In view of this, several studies have explored the impact of these institutional constraints on firms' adjustment strategies, particularly in terms of wage rigidity and passing the adjustments not made on the wages onto employment (Babecký et al., 2009; Bertola et al., 2012; Dias et al., 2013; Fabiani et al., 2015). However, the results of these studies are inconclusive. For example, Babecký et al. (2009) show, based on European data, that wage bargaining at any level increases the probability that alternative means of adjusting wage costs will be used, rather than cutting base wages. This may suggest that trade union involvement in wage setting creates a rigidity that firms must work around to adjust their wage costs. However, the positive effect of union presence in terms of recourse to alternative strategies remains significant after introducing controls for wage rigidity in the regression. Therefore, this union effect cannot be reduced to a pressure on wages.

In fact, the institutionalisation of labour relations does not tip the balance of power in favour of employees, especially during an economic crisis when the social dialogue can be used by management for its own purposes (Béthoux et al., 2015; Delteil & Dieuaide, 2012). This is especially true in France, where the Auroux laws made collective bargaining obligatory. Thus, based on the *REPONSE* survey, Deroyon and Romans (2014) and Amossé et al. (2016) show that wage and employment adjustments have frequently been associated with negotiations between management and labour.

Two indicators are used to assess labour relations in the establishment or its parent firm: Firstly, the presence of at least one trade union delegate and, secondly, the intensity of social dialogue, as measured by the number of formal and informal negotiations that took place from 2008-2010 (regardless of the issues addressed).

Organisational flexibility tools and workforce characteristics

An establishment's adjustment margins also depend on its organisational practices. The

classification proposed by Atkinson and Meager (1986) distinguishes four types of flexibility in working arrangement and practices. The first type, "numerical flexibility", refers to a set of practices that enable firms to vary their volume of employment by adjusting their intensive or extensive margins through recourse to part-time employment, fixed-term contracts and working time flexibility. The second type, "functional flexibility", consists in developing worker versatility through training, so that the existing workforce can be assigned to different tasks depending on the needs of the business. The third type, "distancing", involves outsourcing the employment relationship through recourse to subcontracting, service providers or temporary work. The final type is "pay flexibility", which refers to reversible and incentive remuneration practices. Firms may combine the different flexibilities and segment their implementation across the workforce. Thus, in their "flexible firm" model, Atkinson and Meager distinguish a "core" group of workers, for which functional flexibility goes hand in hand with monetary incentives, apart from "peripheral" groups of workers upon which numerical flexibility and distancing strategies are based (Atkinson and Meager, 1986, p. 4-5).

The effect of these organisational practices on crisis adjustment mechanisms is not as clear in the literature as one might expect. To be more precise, while the effect of flexible pay components on the probability of wage adjustments in times of economic crisis has been clearly established (Babecký et al., 2010; Bertola et al., 2012; Fabiani et al., 2015), that of flexible employment practices (by far the most widely studied) is much less clear-cut. In theory, firms should adjust their temporary workforce rather than their permanent workforce or wages (see, for example, Bertola et al. 2012). Because there is less employment protection for temporary workers, turnover in the temporary workforce is less costly for the firm. However, this does not seem to have been a significant factor during the economic crisis. Thus, Fabiani et al. (2015) show, based on European data, that while a high percentage of temporary workers encourages firms to cut temporary jobs, it does not reduce the probability that they will cut permanent jobs too. A similar finding was observed by Dias et al. (2013) in Portugal, Kwapil (2010) in Austria, Deroyon and Romans (2014) in France, and Zalgelmeyer et al. (2012) in Germany, all of whom argue that there is no significant link between the share of temporary workers in the payroll and the decision to reduce the overall workforce.

The *REPONSE* survey allows us to study the link between labour flexibility strategies and crisis adjustment practices, but the indicators it provides are imperfect. The data on recourse to these practices relate to 2010 alone, in other words the end of the period being studied. As there was a resurgence of the crisis in that year, we can nonetheless consider that it at least partially captures usual practices. The employment of external workers, which is proper to distancing strategies, is measured based on the number of temporary workers in relation to the establishment's workforce, and on the use of subcontractors for part of the establishment's core business. With regard to functional flexibility, the survey provides information on worker versatility, and on the level and objectives of training expenditure. It also contains data on wage flexibility. It provides information on the key criteria used by management to review wages (financial performance or branch recommendations), and on recourse to wage flexibility practices. Only those practices adopted at the management's discretion are considered (individual pay rises and bonuses). Recourse to numerical flexibility is reported in advance through the *DADS*, which show the proportion of workers on fixed-term contracts in 2008 and the proportion of part-time workers in 2009, in relation to the total workforce.

Economic and financial dependency relationships

Empirical research into the economic crisis has shown the impact of parent-subsidiary links on the adjustment practices of establishments in France. Deroyon and Romans (2014) show that –all things being equal, and considering the trend in business volumes– establishments that belong to a group are more likely to be affected by workforce reductions. This also came out in the interviews conducted after the *REPONSE* survey, which revealed that some adjustments were made within the framework of relocation strategies implemented by groups in pursuit of profits (Perez et al., 2015). This effect is studied specifically by Cabannes et al. (2013), who show that subsidiaries, especially among groups with an international presence, have made greater adjustments both to their business volumes and their workforce, and this cannot be explained entirely by a greater fall in demand. According to the authors, this suggests

the use of trade-off and repositioning strategies, inducing a reallocation of tasks within groups, which provides international firms with additional flexibility.

These findings are consistent with previous research showing that, during recessionary periods, gross job destruction is greater in firms belonging to a group than in independent firms (Boccara, 1998; Duhautois & Lagarde, 2004; Picart, 2004). More generally, they echo previous studies that highlight the influence of inter-firm relationships on employment management practices, in a context of blurred organisational boundaries (Grimshaw & Rubery, 2005). As demonstrated by Perraudin et al. (2008b), the financial links established by governance structures, and the trade links inherent in supply chains, reshape the way power and control are exercised within and outside the firm, undermining the employer's autonomy and influencing labour management policy.

These economic and financial dependency relationships are assessed by means of several indicators. The governance structure of the firm to which the establishment belongs is determined by whether or not it is part of a group, its main shareholder category, and whether it is listed directly on the stock market or indirectly via the parent group or network. The contribution of subcontracting activities to the firm's turnover is used to determine whether or not it has subcontractor status. Lastly, the constraints that weigh on the establishment are also assessed by asking whether, in 2010, it was subject to "specific, quantified targets" in terms of "profitability", "wage costs" or "quality", and, if so, whether these were "priority targets".

Characterisation of establishment types

These variables enable us to establish the respective characteristics of the establishments associated with the three adjustment practices identified in the typology. The comparison of relative frequencies within the different classes of establishment reveals the most discriminant characteristics (see Online Complement C1, table C1-4). To identify those that –all things being equal– are significant, the descriptive analysis is completed by estimating a multinomial logit model (table 3). While it does not allow any conclusions regarding causal links, the model helps us to assess the characteristics that significantly affect the probability of an establishment belonging to one of the three adjustment classes, rather than to the two classes in which adjustments are typically not made (which are the baseline). Only these characteristics are discussed.

Of the establishments that belong to the class in which **all adjustment practices** are typically used (wage freezes or cuts, workforce reduction, short-time working and business reorganisation), over half operate in the manufacturing sector. Compared with all the other establishments, they have little control over their market conditions (international market, small market share, limited leeway for setting prices, future developments in their business difficult to predict). They are also struggling with significantly depressed demand: Almost a quarter of them report a strong decline in their business over the period in question (*vs*. 7% overall). In addition, their profitability is less likely to be higher than that of their competitors. Labour relations, although characterised by a strong union presence and a relatively well-developed social dialogue, do not have a significant impact, all other characteristics being equal.

With regard to flexibility levers, these establishments are characterised by a low level of recourse to numerical flexibility, either through short-term contracts or part-time working. In fact, according to data from the *DADS*, the fall in the number of short-term contracts explains relatively few of the workforce reductions in this class. Conversely, these establishments more frequently take steps to develop worker versatility (57% of establishments in this class, *vs*. 45% overall). This enables them to reassign tasks according to the needs of their business. This functional flexibility may be regarded as a necessary condition for the frequent business reorganisations typical of this class, whether they involve bringing subcontracted work back in house (27% *vs*. 8% overall) or refocusing on the establishment's core business (36% *vs*. 13% overall). Worker versatility may also have facilitated the workforce reductions that accompany these internal adjustments, as the remaining workers can be assigned to new tasks. Conversely, recourse to external labour through temping agencies and subcontractors, which is a key feature of this predominantly industrial class, does not seem to have an effect per se. While these findings must be treated with caution, since they are based on data from 2010, we can at least conclude that they do not make the combined adjustments typical of this class either more or less probable; in particular, the use of external labour does not prevent payroll

reductions[2]. Lastly, the wage freezing and wage reduction policies typical of this class are associated with frequent recourse to wage flexibility practices. Nevertheless, the effect is significant only for non-executive staff.

Economic and financial dependency relationships also feature highly: Almost half of the establishments in this class belong to a firm that is part of a (most often unlisted) group, and 40% are subcontractors, whose subcontracting activities account for the majority of their turnover. They are more often than average majority-owned by foreign businesses or financial institutions, or by families, but the fact that they have foreign capital in their ownership structure is the only significant feature. The combined effect of subsidiarisation and majority foreign ownership may, as Cabannes et al. (2013) suggest, be the implementation of trade-off strategies across groups operating in several countries. The fact that the capital holders are far away may also make these firms less concerned about the social acceptability of their decisions (Pfeffer, 2007, p. 126).

Establishments belonging to the class in which **restructuring with wage moderation** are typically used (workforce reduction, business reorganisation, and wage moderation) are, compared with the sample as a whole, more likely to be large and well-established. They are characterised by a strong union presence and an active social dialogue. Their market conditions, although difficult, seem to be less strained than in the previous class. Considering the indicators selected, the only significant features are their limited leeway when it comes to price setting, and their declining business volumes over the period observed. They are also more likely to have smaller profit margins than their competitors.

In terms of flexibility levers, this type of establishment is similar to those in the previous class with, however, one interesting difference. In this class, where the typical response consists of wage moderation rather than wage cuts or freezes, recourse to a flexible wage system for executives is the only over-represented and significant feature. In addition, these establishments are distinguished by their workforce (which is more likely to be skilled) and by their high training expenditure. Like the establishments in the previous class, they seem to be remarkably dependent, either economically or financially. A third of them are subcontractors, although they are less dependent on their subcontracting activities than the establishments in the previous class. Half of them belong to a group, which may or may not be listed on the stock exchange. However, in this case, the majority are listed. In fact, this class contains the highest proportion of establishments belonging to a listed group (19% *vs*. 13% overall). Besides wage cost targets, they are also frequently subjected to profitability indicators.

These findings partially reflect those of other studies that examine the impact of stock market listing on labour management methods. Conway et al. (2008) and Perraudin et al. (2008a) show, based on data from the 2004-2005 *REPONSE* survey, that stock market listing is associated both with a skilled labour force and high training expenditure, and with flexible wage systems and the outsourcing of work to temping agencies and subcontractors. This allows for greater flexibility in operating costs, and thus protects the bottom line. However, stock market listing does not seem to be associated with workforce retention policies in the event of a strong decline in business, as shown by Reynaud (2012) and Deroyon and Romans (2014).

The combined adjustments typical of this class can be seen as resulting from a defensive strategy in a strongly downward context. The aim is to protect profits by reducing both the workforce (which, according to the *DADS*, mainly affects permanent and skilled workers) and the scope of the business (49% have got rid of job functions and 38% have shifted their focus back to their core business), while keeping the remaining workers motivated by implementing a wage moderation policy rather than freezing or cutting wages. The presence of trade unions, which is relatively strong in this class, seems to have facilitated rather than prevented these adjustments.

Establishments belonging to the class **in which primarily wage-oriented adjustments** are typically used (wage freezes or cuts and, to a lesser extent, short-time working and workforce reductions) have a less clear-cut profile than those in the previous two classes. All things

2. This finding may be connected with the structural use made of flexible forms of labour mobilisation, as suggested by the findings of Argouarch' & Debauche (2010), who study the effects of temporary work on employment adjustment practices, based on French data. They show that in the event of a business shock, the temporary workforce absorbs the majority of the fluctuations in the first few months following the shock; then, gradually, the permanent workforce is adjusted too, so that, two years after the shock, the distribution of adjustments between the temporary workforce and the permanent workforce is similar to the respective proportion of each employment form prior to the shock.

Table 3
Characterisation of establishment types (multinomial logit model estimation)

	"All adjustment practices" *vs.* "no change or increase in workforce"	"Restructuring with wage moderation" *vs.* "no change or increase in workforce"	"Primarily wage-oriented adjustments" *vs.* "no change or increase in workforce"
Constant	- 5.30 ***	- 3.49 ***	- 2.76 ***
Sector			
Manufacturing	1.56 ***	0.20	0.74 ***
Construction	- 0.34	- 0.10	- 0.01
Trade	*ref*	*ref*	*ref*
Transport	- 0.08	0.04	0.12
Education, health, social, culture	0.81 *	- 0.47 *	0.34
Other services	0.63 *	0.05	0.24
Size of establishment			
Less than 20 employees	*ref*	*ref*	*ref*
20 to 49 employees	- 0.10	0.26	- 0.27
50 to 199 employees	- 0.29	0.05	- 0.56 **
200 employees or more	0.35	0.41 *	- 0.37
Age of establishment: 50 years or more	0.26	0.42 ***	0.14
Market conditions and economic health			
Trend in activity from 2008-2010			
No change	*ref*	*ref*	*ref*
Decline	1.42 ***	1.09 ***	0.90 ***
Strong decline	2.67 ***	1.51 ***	1.42 ***
Difficult to predict trend in activity	0.69 ***	0.15	0.59 ***
Market openness	0.69 ***	- 0.08	0.09
Leeway to set prices	- 0.34 *	- 0.23 *	0.25
Profitability compared with competitors			
Lower	0.14	0.41 ***	0.33
Equivalent	*ref*	*ref*	*ref*
Higher	- 0.57 **	0.01	0.04
Nature of labour relations			
Presence of union delegates in the establishment	0.27	0.46 ***	0.18
Presence of collective bargaining			
Absent or weak	- 0.31	- 0.71 ***	- 0.46 *
Moderate	*ref*	*ref*	*ref*
Strong	0.26	0.10	- 0.51 ***
Flexibility tools and workforce characteristics			
Over 10% of employees on part-time contracts (DADS 2009)	- 0.45 **	0.10	- 0.22
Over 8% of employees on fixed-term contracts (DADS 2008)	- 0.44 **	0.11	- 0.02
Worker versatility	0.49 ***	0.21 *	- 0.06
Executive pay flexibility	0.26	0.30 **	- 0.02
Non-executive pay flexibility	0.86 ***	0.13	0.79 ***
Wage review criteria			
Financial performance	0.92 ***	0.50 ***	0.57 ***
Branch recommendations	- 0.41 **	- 0.45 ***	- 0.45 **
Proportion of executives and intermediate professions (DADS 2008)			
0 to 15%	- 0.24	0.07	- 0.09
15 to 50%	*ref*	*ref*	*ref*
Over 40%	- 0.11	0.46 ***	- 0.17
Training expenditure			
Less than 1.5%	0.11	0.06	- 0.29
1.5% to 3%	*ref*	*ref*	*ref*
More than 3%	0.10	0.25 *	- 0.31
None	0.17	- 0.12	0.02
Economic and financial dependency relationships			
Inclusion in a group			
Listed group	0.13	0.61 ***	0.05
Unlisted group	0.38 *	0.45 ***	0.04
Does not belong to a group	*ref*	*ref*	*ref*
Main shareholder category			
Foreign firms or organisations	0.96 **	0.47 *	0.71 *
French firms or organisations	0.21	0.11	0.07
Family	0.56	0.29	0.50 *
Employees, state or other	0.27	0.00	0.40
No shareholders	*ref*	*ref*	*ref*
Subcontracting establishment			
Yes (+50% of business)	0.44 **	0.00	- 0.28
Yes (-50% of business)	- 0.05	0.55 ***	0.22
No	*ref*	*ref*	*ref*
Priority target			
Profitability	0.19	0.28 **	- 0.11
wage costs	0.72 *	0.62 **	- 0.22
Quality	- 0.87 ***	- 0.32 *	- 0.31
Number of establishments in the class studied	312	496	214
Number of establishments in the reference class	1 350	1 350	1 350

Note: Results of the multinomial logit model estimation, where the probability of a firm belonging to an adjustment class is estimated in relation to its inclusion in the "workforce stability" or "workforce increase" classes (which are the baseline). With regard to flexibility tools, recourse to temporary workers and recourse to subcontractors are never significant, and have therefore been removed from the final specification presented here.
Estimated coefficients are reported using *, ** and ***, corresponding to significance thresholds of 10%, 5% and 1% respectively.
Unless otherwise specified, the variables are taken from the 2010-2011 *REPONSE* survey, and relate to 2010.
Coverage: Establishments with 11 employees or more in the non-farm business sector, reporting no change or a decline in activity from 2008 to 2010.
Sources: Dares *REPONSE* survey 2010-2011, "management representative" section, *Sinapse*, and *DADS* 2008-2009.

being equal, few characteristics are significant. As in the first class, establishments are more likely to operate in the manufacturing sector, although in a lesser proportion (28% *vs*. 59%). As in the second class, there is a size effect; however, it works in the opposite direction, since this class features the highest proportion of small establishments (54% have less than 20 employees, compared with 43% overall). This may explain why the social dialogue in these establishments is only moderately active. While these establishments are comparably less exposed to competitive pressure, this does not seem to be a significant factor. Their market conditions are characterised above all by a decline in activity (60% have seen some decline or a strong decline in their business volumes, compared with 41% overall) and by unpredictability (26% compared with 20% overall). The use of organisational flexibility tools is less widespread than in the previous classes. The only specific characteristics of this class are that wages are revised according to the firm's financial performance, and non-executive pay is flexible. It should be noted that, again, these practices are combined with wage reductions or freezes. The fact that these establishments have a limited range of flexibility levers due to their frequently small size (Bunel, 2008) may explain why they focus their actions on wages. These findings are similar to those obtained by Lai et al. (2016) based on British data (the *WERS* survey), which shows that, all things being equal, small and medium-sized firms are more likely to have been affected by the economic crisis than large firms, and to have responded with wage adjustments (in the form of wage freezes or cuts), rather than by reducing the workforce or the hours worked, or by changes in work organisation. According to these authors, SMEs have more latitude when it comes to setting wages due to more informal practices and less institutionalised labour relations; they may also be more compelled to make wage adjustments, which –because there is little leeway for workforce reductions and less opportunity to use other flexibility levers– could be seen as a matter of survival (Lai et al., 2016, p. 126). The descriptive analysis provides another element of interpretation: While, on the whole, these establishments had little recourse to negotiation over the period observed, they are the most likely to have conducted negotiations on working time. This suggests that these establishments may have adjusted hours worked beyond their recourse to the short-time working legal framework.

Lastly, compared to the establishments in the previous two classes, they seem to be less economically or financially dependent. In fact, they are more often family-owned, independent and seldom enter into subcontracting arrangements. It should be noted, however, that the presence of foreign capital increases the likelihood of an establishment belonging to this adjustment class (as was the case for the previous two classes).

What underlying logic?

The comparison of these three profiles of establishment allows us to assess the specific impact of their internal organisation and their environment on the adjustment practices adopted.

The effect of the economic context (market conditions and economic health of the establishments) is in line with expectations. The adjustments made by the establishments seem to be closely connected with the scale of the business shock and the resulting uncertainty. The over-representation of manufacturing in the first and third classes (all adjustment practices, and primarily wage-oriented adjustments) can be interpreted as the effect of expectations on the long-term nature of the crisis, as the manufacturing sector has structural difficulties that the economic crisis has only made worse. It could be argued, then, that these expectations are associated with adjustments such as wage freezes or cuts (common features of the two classes). Poor profitability and high competitive pressure are characteristic of classes with a high incidence of workforce reductions (classes one and two). Establishments with limited market power –due primarily to the fact that they operate in international markets– do see more extensive adjustments to wage costs.

The impact of the institutionalisation of labour relations confirms the findings of Deroyon and Romans (2014) and Amossé et al. (2016), based on the same survey. The presence of trade unions and an active social dialogue are either positively associated with adjustments, or do not have a significant effect. Trade union presence is more specifically characteristic of establishments that typically pursue the restructuring and wage moderation option, which suggests that, while such a presence may have had an impact on wages, that impact was modest: It is associated with wage moderation, but does not hinder wage freezes or cuts.

Less expected was the influence of organisational flexibility on crisis adjustment practices, which goes against the predictions in the Atkinson and Meager model (1986)[3]. Firstly, recourse to external workers via temping agencies and subcontracting (a practice specific to "distancing strategies") is insignificant, all things being equal[4]. While the use of external workers may have limited the scale of adjustments borne by the core workforce, contrary to expectations it did not lessen the probability of workforce reductions. On the contrary, the descriptive analysis suggests that establishments that rely heavily on external workers are over-represented in classes one and two, which focused on workforce adjustments. However, this effect disappears when the establishment's environment is taken into consideration.

Furthermore, "numerical flexibility" (fixed-term contracts or part-time working) is negatively associated with an adjustment practice that combines all levers, but does not have a significant effect on the other two types of practice. The descriptive analysis shows that the two classes of establishment that typically make no or very few adjustments to their workforce — and are the baseline — make the most intensive use of these two flexible forms of employment. It also shows that, in the classes characterised by workforce adjustments, short-term contracts account only partially for workforce reductions. On the whole, therefore, the use of fixed-term contracts does not increase the probability of adjustments to the total workforce.

Lastly, recourse to wage flexibilization and functional flexibility is significant, but the effects are no more in line with the predictions in the flexible firm model. Wage flexibilization is associated with wage adjustments (restrictive wage policies), but the effect differs according to whether it applies to executive or non-executive staff. Wage flexibilization for non-executive staff is associated with establishments that typically implement wage freezes or cuts (classes one and three), whereas wage flexibilization for executive staff is more likely to take the form of wage moderation (class two). This distinction arises from the different uses made of these tools depending on the type of employees concerned. As shown by studies relating to previous editions of the *REPONSE* survey (Barreau & Brochard, 2003; Brochard, 2008), the use of reversible and individual pay components is part of an incentive policy for executive staff. However, for non-executive staff, it is more likely to be driven by the desire for a more flexible wage bill. As expected, functional flexibility –which is reflected in worker versatility– seems to encourage the reorganisation of productive processes (classes one and two). However, it is also associated with workforce reductions, even if spending on training is high. For example, in class two, the skilled and permanent workforce has been a major contributing factor to job losses. Therefore, it may be assumed that versatility, by enabling the remaining workforce to be reassigned, acts as a lever for workforce reductions, more than it helps overall to maintain a stable workforce.

Economic and financial dependency relationships, which are connected with the establishment's governance structure or its status as a subcontractor, have a specific and clear-cut effect. Being majority owned by foreign investors, being a subsidiary of a (listed or unlisted) group, or being part of a subcontracting chain significantly affects the adjustments made by establishments. To be more precise, while the majority presence of foreign investors in the establishment's capital is a characteristic feature of all classes associated with adjustment practices (as opposed to classes having seen little or no adjustments), being part of a larger group is associated more specifically with practices such as workforce reductions (classes one and two). This confirms a finding that is well established in the literature. The impact of stock market listing is significant only in class two, where restructuring operations accompanied by wage moderation are typical. This may signal a commitment to maintaining financial incentives for a more frequently skilled workforce, whose remuneration is performance-based (Conway et al., 2008). As for the impact of being a subcontractor, which is a characteristic feature of classes

3. It is worth repeating that these findings must be treated with caution, since data from the REPONSE *survey regarding recourse to organisational adjustments relates only to the end of the period observed. It cannot be ruled out that such recourse may have increased or decreased in response to the economic crisis. This problem arises particularly in relation to numerical flexibility, since workers on fixed-term contracts are counted in the overall workforce, the variations in which we are trying to explain. The* DADS *alleviate the problem by providing information on the use of fixed-term contracts (in proportion to the total workforce) at the start of the period (2008), and on the use of part-time working midway through the period (2009). As for the other organisational adjustments, the indicator selected identifies the recourse by establishments during a resurgence of the crisis (marked by a rebound in temporary work). While the degree of recourse to these practices certainly varied as a result of the crisis, it may be assumed that their actual existence within the establishment is more stable.*

4. The variables relating to the use of temporary workers and subcontractors are not significant. They have been removed from the final multinomial logit estimation and are therefore not shown in table 3.

one and two, the extent of the establishment's dependency on its subcontracting activities is a decisive factor: The most dependent establishments are also those that have made the most drastic adjustments (class one). Conversely, establishments that are the least dependent on external actors (parent company, stock market, principal) seem to be less affected by job losses and to favour primarily wage-oriented adjustments.

* *
*

When viewed at establishment level, the responses to the economic crisis seem to be more heterogeneous than suggested by the analysis of aggregated data, both in terms of adjustment practices and underlying logic. Adjustments to the workforce, hours worked and wages are more complementary than substitutable, and are influenced not only by the economic and social context, but also by the labour flexibilization practices implemented within the establishment, and by its economic and financial dependency relationships. From an analytical perspective, two key lessons can be drawn from these findings.

Firstly, they challenge the theory that the effects of the crisis are split between a "core group" of protected workers, and "peripheral" groups of vulnerable workers who absorb most of the adjustments. They suggest –in line with critical studies of Atkinson et Meager's flexible firm model (1986)– a segmentation of human resource management practices within the "core" workforce (for a review of the literature, see Kalleberg, 2001).

Furthermore, these findings support the theory that organisational boundaries are "blurred" (Grimshaw & Rubery, 2005), and that economic and financial dependency relationships deserve more consideration in the understanding of labour management practices. They provide further illustration of the constraints imposed by a governance structure or a subcontracting relationship that reduces the leeway of firms directed or controlled by external actors (Sacchetti & Sugden, 2003; Perraudin et al., 2014). □

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- An anonymised file of the article (including the main text, illustrations, bibliography and appendices if any), mentioning only the title, abstract, JEL codes and keywords on the front page.

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