Consumer prices of food products could slow considerably by the end of 2023

The continuous increase in food inflation since the end of 2021, and the unprecedented levels reached in recent months represent a challenge for the economic forecaster, both in understanding its determinants and predicting its evolution. In fact, prices of agricultural and energy commodities have risen sharply for more than a year, but some prices have also slipped back markedly since last summer. To analyse how these movements are ultimately reflected in consumer prices, it is important to look first at how they are passed on to agricultural producer prices then to agrifood industry producer prices and, lastly, to distributors' selling prices (consumer price). This Focus models the different stages of this chain of transmission, analysing price-fixing behaviours during the current period and inferring forecasts for the future.

The first link in the chain, agricultural producer prices (excluding fruit and vegetables) rose by 23% in 2022, compared to 2021. The increase was 16% for producer prices in the agrifood industries and 7% for consumer prices of food products (excluding fresh produce). According to the model used in this Focus, the increase in the price of inputs outside the sector –world prices of agricultural commodities, energy, etc.– would appear to account for a significant proportion of these price dynamics during 2022: almost 90% of the momentum in agricultural producer prices, about 70% for agrifood industry producer prices and about half for consumer prices of food products. Wage costs would seem to have been the second most important factor behind these price increases in 2022, contributing notably a little over one third to the rise in consumer prices of non-fresh food products. Margin behaviour may also have been at work in 2022: significant increase in unit margins mainly in the agrifood industries, after margin squeezing in 2021, whereas the dynamics of consumer prices could, on the contrary, reflect a squeezing of the unit margins of distributors from the end of 2021 until the end of 2022. This analysis of margin behaviours obviously remains surrounded by uncertainty inherent in the model being used.

The model selected for this Focus study also highlights the delayed effects on production and consumer prices of movements in commodity prices. Our simulation suggests that increases in agricultural commodity prices are passed on to consumer prices at a rate of about 50% after three quarters, and 80% after one year. Thus, in the forecast for the months to come, the decline in agricultural and energy commodity prices since summer 2022 should exert downward pressure on agricultural producer prices then on agrifood industry producer prices. The latter could then fall back in turn, with a "normalisation" of margin behaviour which could even accentuate the downward trend. This decline would lead to a slowdown in consumer prices of food products (excluding fresh) from Q2 2023, sustained nevertheless by the buoyancy of wage costs and by probable anticipatory margin reconstitution behaviour by distributors. However, these anticipatory movements, resulting from an econometric model, are still dependent on various factors, including the rounds of negotiations between producers, processors and distributors.

Narjis Benchekara, Jérémy Marquis et Guillaume Roulleau

The prices of commodities used to produce food products have experienced unprecedented shocks

Since the end of 2021, food inflation has increased steadily. The year-on-year variation in the consumer prices of food products rose from 1.4% in December 2021 to 14.9% in April 2023, making food the main contributor to headline inflation.

The rise in food inflation was the result of the increased cost of commodities, both agricultural and energy, which began in 2021 as activity recovered and was then accentuated in 2022 with the outbreak of war in Ukraine. Thus the price of agricultural commodities imported by the French economy increased substantially between the beginning of 2021 and summer 2022 (►**Figure 1**). Meanwhile, the increase in the cost of energy affected the agriculture[1] and agrifood industry sectors, both directly and indirectly. Although these sectors are not among the most energy-intensive, energy (oil, electricity and gas) represents a sizeable proportion of their production inputs (►**Figure 2**). And increases in energy prices have been substantial: the market price of gas, which also directly influences the price of agricultural fertilizers, increased 10-fold between the beginning of 2021 and mid-2022. Although most energy prices have fallen back since summer 2022, they nevertheless remain at levels well above those at the start of 2021. This is also the case for agricultural commodities.

The aim of this study is to understand how the increase in the cost of agricultural and energy commodities is transmitted to the consumer price of food products, from the producer sectors to the distributor sector, and to produce a forecast to the end of 2023. First, it should be noted that within the meaning of the CPI, food products (16.2% of the entire CPI in 2023) are subdivided into fresh produce (2.4%) and “other food products”, also called “food products excluding fresh” (13.9%). Prices of fresh food (i.e. unprocessed products including fresh fish, fruit and vegetables) depend mainly on climate conditions in France, and in other producing countries too, and are therefore highly volatile. Prices of “other food products” are subject to determinants that are less volatile, and therefore more easily observable. In the following, only the CPI of food products excluding fresh will be considered (and this will be called, somewhat inaccurately, the food CPI).

1 The agricultural branch considered here corresponds to “agriculture, forestry and fishing” in the national accounts classification (branch “AZ”).

►1. Variation in prices since the beginning of 2021, for different inputs in the agriculture and agrifood branches
(variation in prices in euros, in %)

Prices	between Q1 2021 and Q3 2022	between Q1 2021 and Q1 2023
Imported agricultural commodities		
Wheat	+79	+55
Sugar	+33	+43
Oilseeds	+43	+22
Energy		
Gas	+1014	+190
Brent	+96	+49
Electricity (EPEX)	+707	+145

Note: the price of natural gas corresponds to futures contracts at the next expiry date in the Netherlands (TTF). Electricity prices correspond to the EPEX spot prices for France.
Source: INSEE.

►2. Composition of inputs used by the agriculture branch and by agrifood industries
(share in intermediate consumptions, in 2019, in %)

Share of all inputs used by the industry to produce	Agricultural branch	Agri-food branch
Agricultural inputs	34	33
Inputs from the agri-food industry	15	28
Energy inputs	11	5

Note: the composition shown here is taken from the table of intermediate entries in the 2019 annual national accounts. Energy inputs include intermediate consumptions in products that derive from the manufacture of coke and refined petroleum products and products from the “energy, water, waste” branch. Other inputs may include, for example, intermediate consumptions in industry, especially the chemical industry, also in services.
How to read it: in 2019, 33% of intermediate consumptions in the agrifood industries consisted of agricultural inputs.
Source: INSEE.

The modelling of food inflation (►**Bibliography**) is often sequential, focusing on the price formation chain. Thus an exogenous shock, affecting the price of wheat, for example, is only transmitted with some delay to consumer food prices. Over the recent period, time lags can be seen between the price of agricultural commodities, the producer price of agricultural products, that of agrifood industries, and finally, the CPI of food products excluding fresh (►**Figure 3**). For example, in response to the sudden rise in the prices of agricultural commodities, which began in Q1 2022 and subsided thereafter, there was a rise in the consumer prices of food products, which was less sudden, but continuous.

Variation in agricultural producer prices is modelled first, then in producer prices in agrifood industries –which process the agricultural products– and finally in consumer prices of food products, paid by the consumer. The price determinants for each of these stages are not the same: these successive links (agriculture, agrifood industries, retail trade) have different production functions and margin behaviours.

After absorbing a large proportion of the impact of price rises, the agriculture sector could pass on their change of direction at the end of 2022

The recent sharp increases in commodity prices, whether in agriculture or energy, have primarily affected the agriculture branch, which consumes them directly in its production process. Agricultural producer prices[2] (IPPAP hereafter), which represent "farm-gate" prices, increased by about 23% in 2022 compared to 2021 (►**Figure 3**).

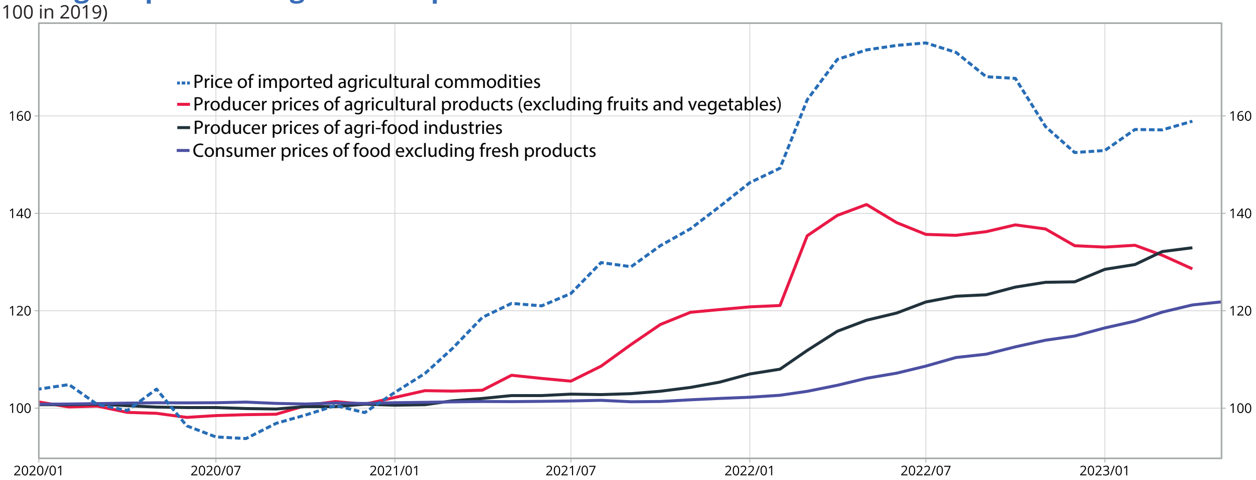
Econometric modelling of the dynamics of the IPPAP identifies the main determinants and analyses the scale and speed at which the increased cost of inputs were passed through to these farm-gate prices (►**Method box** for more details on the different models). In the model used here, the IPPAP is determined in the long term by agricultural commodity prices (including wheat), energy prices (oil, gas and electricity) and labour productivity in the agriculture branch. In the short term, only the prices of agricultural and energy inputs determine fluctuations in the IPPAP.

According to this model, there is a delay in passing on the increase in the cost of inputs to the IPPAP. By way of illustration, a permanent rise of 10% in the world price of agricultural commodities (including wheat) translates in the long term into a rise in producer prices of about 3.5% (►**Box: Price-response function modelled to exogenous shocks**). However, it would take the agriculture branch almost 5 quarters to fully pass on this price increase, and less than 2 quarters to pass on half of it.

2 Agricultural producer prices, considered here and throughout, exclude fruits and vegetables. Like consumer prices of fresh produce, fruit and vegetable production prices are too much subject to the vagaries of the weather for it to be possible to analyse their determinants in detail. In addition, as harvests can vary widely throughout the different quarters of the year, quarterly variations can sometimes be difficult to interpret. The agricultural producer prices finally modelled here therefore include plant products excluding fruits and vegetables (i.e. cereals, wine and horticultural products) and also animal products.

►3. Change in prices along the food production chain

(base 100 in 2019)



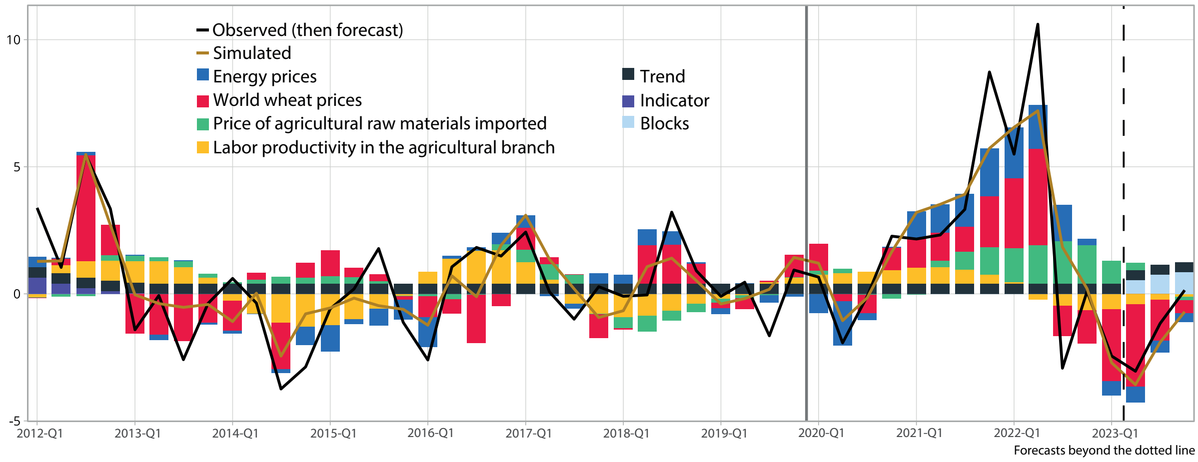
Last point: April 2023, except for the consumer price index, available up to May 2023.
How to read it: in April 2023, the consumer price index for non-fresh food products reached 121.2 points, representing a 21.2% increase compared to its average level in 2019, while in March 2023 the price of imported agricultural commodities increased by 59%.
Source: INSEE.

As an annual average, it would seem that about 55% of the increase in the IPPAP in 2022 can be explained by the increase in the cost of agricultural commodities. The rise in energy prices, meanwhile, appears to account for 30% of the increase in these producer prices in 2022. In other words, almost the entire increase in the IPPAP in 2022 would appear to be due to the increase in the cost of inputs in the agriculture branch, i.e. agricultural commodities and energy (► **Figure 4**).

The econometric model of the IPPAP and comparing it with the observed price can also reveal margin behaviour (upwards or downwards) by the agriculture branch, in relation to historical average behaviour. The model used here assumes that the IPPAP fluctuates in the short term around an "equilibrium price", resulting from the long-term relationship of the model: a situation where the IPPAP is below this equilibrium price, in relation to usual behaviours, corresponds to margin squeezing, while the opposite situation corresponds to margin expansion (► **Method box**). During 2022, the gap between the observed IPPAP and its equilibrium price widened (► **Figure 5**). This decline could reflect an attempt to squeeze margins in the agriculture branch, in the face of rising input prices. The econometric model of the adjustment dynamics picks up most of this behaviour: the IPPAP simulated by the model also appears to be lower than the equilibrium price for most of 2022. However, the difference between it and the equilibrium price is on average less than for the IPPAP observed: with regard to this model, the dynamics of the observed price can therefore represent a slightly greater margin squeeze than usual. However, this analysis should be considered with caution as it is subject to several limitations: the quarterly account data do not at this stage indicate any particular margin squeezing for the agriculture branch as a whole; the unexplained part of the model (difference between the observed IPPAP and the simulated IPPAP) may therefore pick

► 4. Variation in agricultural producer prices and econometric contributions of its determinants

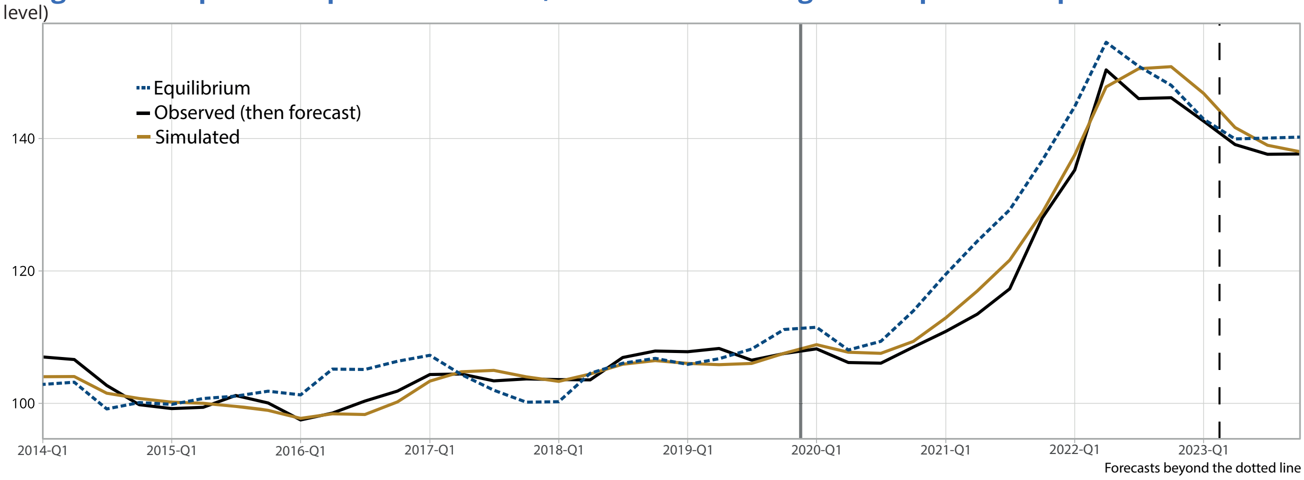
(quarterly changes in farm-gate prices in %, contributions in points)



Estimation period ends at solid line.
Last point: Q4 2023.
Note: the model is estimated between Q1 1990 and Q4 2019. The gold line corresponds to the model simulation, the black line to quarterly variations observed then forecast. After the vertical dotted line, in the forecast area, the black line (observed) corresponds to the forecasts made by the model (gold line) to which blocks have been added representing a hypothesis of convergence between the price of production and the equilibrium prices.
How to read it: in Q2 2022, agricultural producer prices increased by around 10.6% whereas the model of these prices forecast a rise of 7.2%. Energy prices probably account for almost 25% of this price increase.
Source: INSEE, INSEE calculations.

► 5. Agricultural producer prices: observed, simulated and long-term equilibrium price

(in level)



Last point: Q4 2023.
How to read it: in Q4 2022, the agricultural producer price index was 146, whereas the econometric model forecast 151.
Source: INSEE, INSEE calculations.

up atypical margin behaviour, as has been mentioned, but also other types of behaviour, or finally, simple modelling errors. In addition, the equilibrium price does not perfectly reflect the long-term determinants of the IPPAP:[3] the model should not be considered as a structural representation of agricultural producer prices, but rather it attempts to record average behaviours over the long term, from which forecasts may be drawn for the coming quarters.

As a forecast for 2023, the decline in commodity prices during H2 2022 should result in the IPPAP decreasing slightly, as a result of the delayed effect, as has already been the case in Q1 2023 (►**Figure 4**). The IPPAP is expected to stabilise at the end of the year, assuming constant agricultural and energy input prices over the forecasting period. However, as the observed IPPAP has remained lower than the simulated version since the beginning of 2022, its decline in 2023 could be less significant than the model suggests: thus the IPPAP is likely to be closer to its equilibrium price (►**Figure 5**).

Having squeezed their margins for some time, the agrifood industries would seem to have compensated recently with a higher price than expected

Production costs in the agrifood industries (IAA) increased by about 15% in 2022 compared to 2021. As it is in the nature of the IAAs to process the production of the agriculture branch, the econometric model of the IAA producer price includes the IPPAP excluding fruit and vegetables, as seen above, and also the cost of energy and even also the unit wage costs of the branch.

Given the model of the IPPAP proposed in the last section, an increase in the cost of agricultural commodities is passed on to the IAA producer price directly, in short-term fluctuations in the model, but also indirectly, *via* the producer prices in the agriculture branch. Thus, a permanent rise of 10% in the price of agricultural commodities would result in the long term in a 1% increase in IAA production costs, indirectly via the IPPAP. Transmission would be complete after 3 quarters, and more than half would be transmitted at the end of 2 quarters.

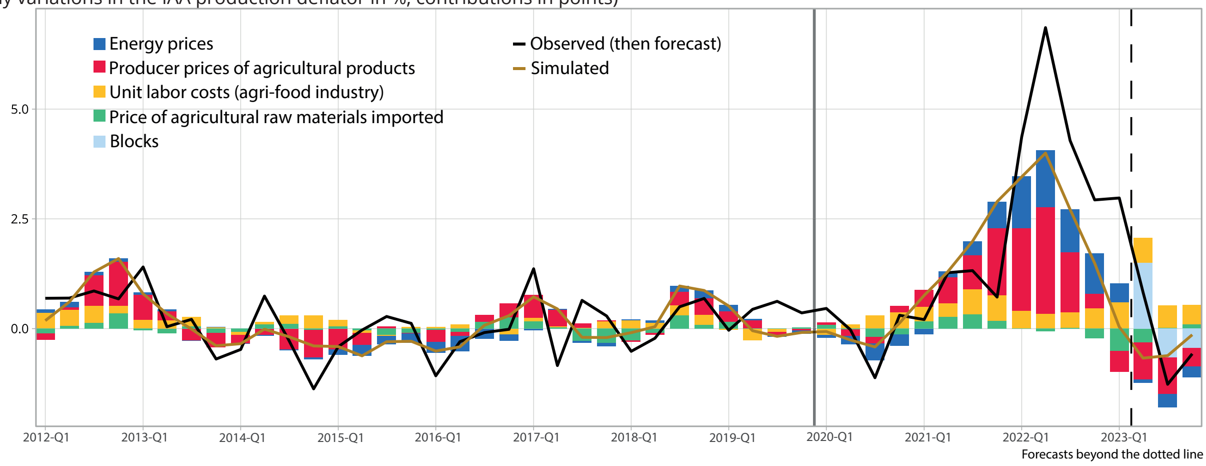
On average over 2022, increases in the IPPAP accounted for about 45% of the variation in IAA production costs, against 25% for energy costs and 8% for unit wage costs. However, the model does not successfully explain all movements in IAA production costs over the past two years: it slightly overestimated those at the end of 2021 and significantly underestimated those in 2022 (►**Figure 6**).

As in the previous analysis of the IPPAP, while the unexplained movements in IAA production costs may correspond, in 2021 and 2022, to a poor specification in the model in the context of very strong inflation, they may also be due to “unusual” margin behaviour in the sector in this same context. Looking first at a period running from the end of 2020

3 As such, the energy cost variable does not perfectly take into account the nature of the energy contracts in the agriculture branch.

►6. Variation in IAA production prices and econometric contributions of their determinants

(quarterly variations in the IAA production deflator in %, contributions in points)



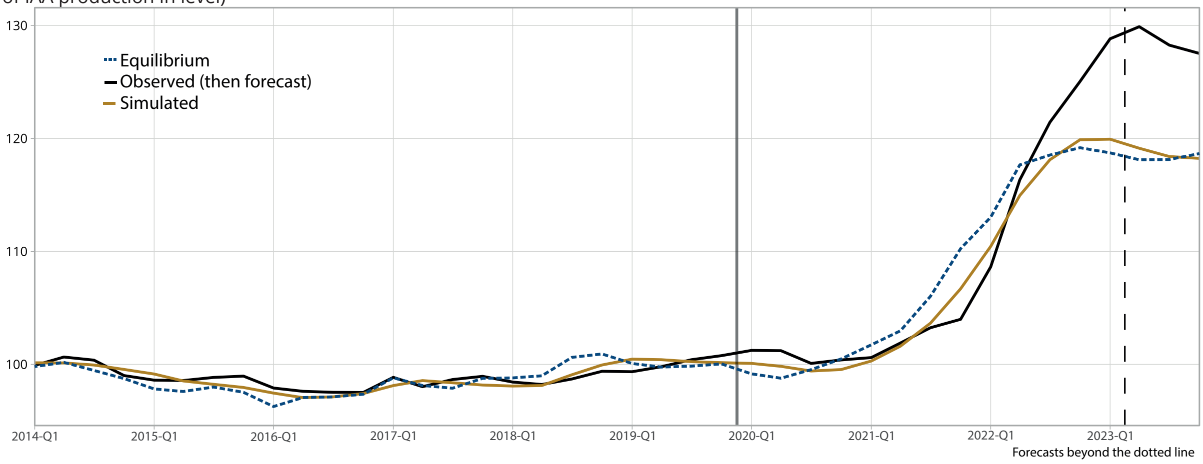
Estimation period ends at solid line.
Last point: Q4 2023
Note: the gold line corresponds to the model simulation, the black line to quarterly variations observed then forecast. After the vertical dotted line, in the forecast area, the black line (observed) corresponds to the forecasts made by the model (gold line) to which blocks have been added representing a hypothesis of convergence in H2 between the producer price and the equilibrium prices.
How to read it: in Q2 2022, IAA production costs increased by about 7% whereas the model forecast a rise of 4%. Energy prices account for about 32% of this increase.
Source: INSEE, INSEE calculations.

and including all of 2021, the observed IAA producer prices were systematically below the “equilibrium price” resulting from the long-term relationship of the model (►**Figure 7**). Since Q2 2022, however, the observed price has exceeded the equilibrium price, and is at much higher levels, which would suggest a marked recovery in the branch’s margins. While this interpretation remains subject to the same limitations as those indicated in the previous section, it is nevertheless corroborated by the results from the national quarterly accounts concerning the margin rate of the IAA, which clearly recovered over the course of 2022. Variations in the margin rate of the branch, quarter by quarter, appear in this respect to be relatively well correlated to the residual variance in the model (►**Figure 8**).

In 2023, according to the econometric model, IAA production prices should start to fall back from H2: the IPPAP and the cost of energy, which pushed IAA production prices upwards in 2022, are now expected to exert downward pressure, in line with the recent downturn in the IPPAP and its forecast declines, and also in line with the recent drop in the cost of energy (assuming that fixed oil and gas prices are forecast and despite a partial modelling of the delayed adjustment to the price of electricity and gas contracts against prices). It is also possible that this fall forecast in IAA production prices is more pronounced than suggested by the econometric model: in the same way that the observed price seems to have recently deviated from its equilibrium price, it could return to it even more quickly in 2023. In other words, the agrifood industries are expected to partially “normalise” their margins from Q3 2023. This is the forecasting assumption that has been made in this *Economic Outlook*, consistent with the next round of renegotiations, knowing that beyond the limitations of the analysis already mentioned above, there are two forces that could alter these downward pressures: the buoyancy of wage costs, and a smaller drop in agricultural producer prices.

►7. IAA production costs: observed, simulated and long-term equilibrium price

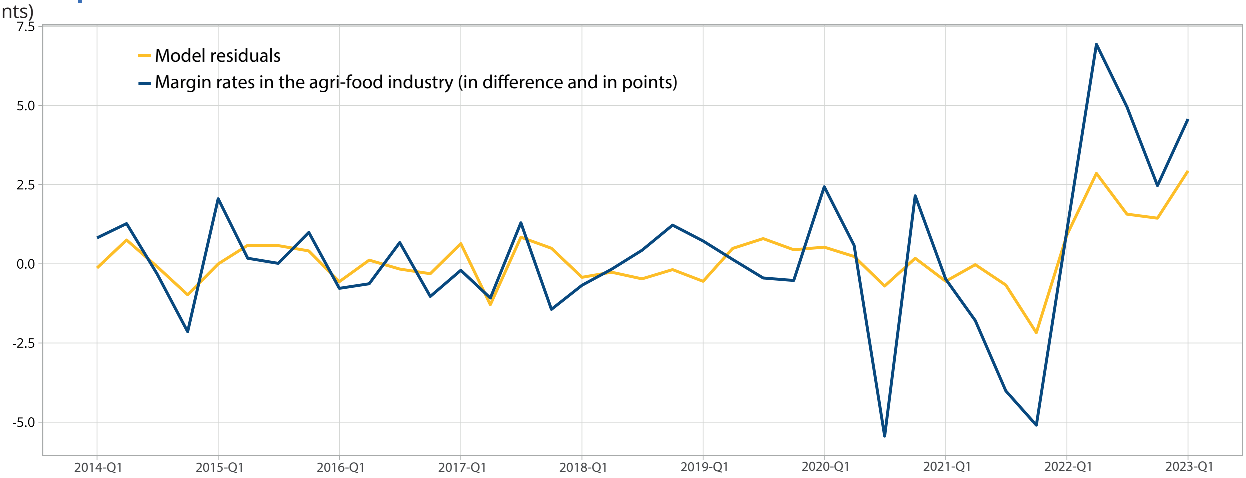
(deflator of IAA production in level)



Last point: Q4 2023.
How to read it: in Q4 2022 the observed level of IAA production costs was 125 compared to 120 for the simulated price.
Source: INSEE, INSEE calculations.

►8. Margin rate of agrifood industries, difference from one quarter to another, and model residual of producer prices in the sector

(in points)



Last point: Q1 2023.
How to read it: in Q4 2022, the difference between the margin rate from one quarter to another was 2.5 points, whereas the model residual was 1.4 points.
Source: INSEE, INSEE calculations.

The change in consumer prices of food products is consistent with the increase in the cost of distributors' inputs, even if renegotiations could shorten the usual transmission times

Since 2022, the consumer price index for food products excluding fresh (food CPI hereafter) has accelerated sharply, rising from +1.1% year-on-year in January 2022 to +14.9% in May 2023. However, this acceleration began almost 3 quarters later than the rise in agricultural commodity costs, and continued after the summer of 2022 despite the downturn in prices and the relative slowdown in IAA production costs.

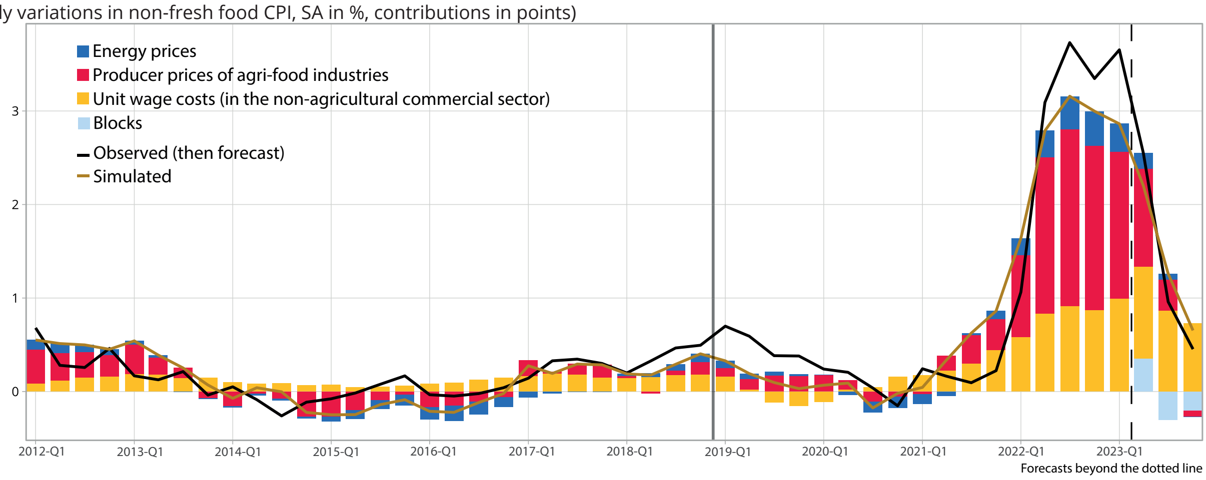
Since the retail trade sector distributes the production of the IAAs, an econometric model of the food CPI includes among its determinants IAA production costs (of which the movements are described in the previous section), as well as the wage costs of the non-agricultural market sector and distributors' energy costs, although the impact of this on prices remains weak. Transmission of the increase in the cost of agricultural commodities to the food CPI is thus indirect, *via* the IAA production prices. Thus, according to the model used, a permanent increase of 10% in the price of agricultural commodities (including wheat) would result in the long term in an increase of about 0.3% in the food CPI *via* the indirect channels of the agriculture sector and IAA production prices. Transmission is complete after 5 quarters, half complete after 3 quarters.

In addition, in the current inflationary context, in order to take into account shortening of price transmission times between producers and distributors, the restoring force of the model is assumed to be dependent on the balance of opinion of retail trade companies regarding expected change in their selling prices of food products, as reported in the business tendency surveys (▶**Method box**). With this choice of model, the speed of return to the equilibrium price (where shocks are transmitted instantaneously) can be all the higher as many retail companies plan to increase their selling prices in the food sector.

Over recent quarters, unprecedented changes in IAA production costs would appear to have strongly supported the food CPI: on average in 2022, they seem to account for 65% of the change in the food CPI, against 11% for energy and 36% for wage costs (▶**Figure 9**). The sum of the contributions exceeds 100% as other factors also had a role to play. Thus the model captures most of the recent dynamics, suggesting that distributors have transmitted the increased costs of inputs in a consistent manner (in comparison with past inflationary episodes). This trajectory is below the equilibrium price, defined by the long-term relationship, indicating a partial absorption of the shock by the margins although below what the model predicted (▶**Figure 10**). At the beginning of 2023, however, the food CPI would appear to have moved slightly above this equilibrium price, enabling distributors to partly offset their smaller profits from previous quarters.

▶9. Variation in the consumer price of non-fresh food products and econometric contributions of its determinants

(quarterly variations in non-fresh food CPI, SA in %, contributions in points)

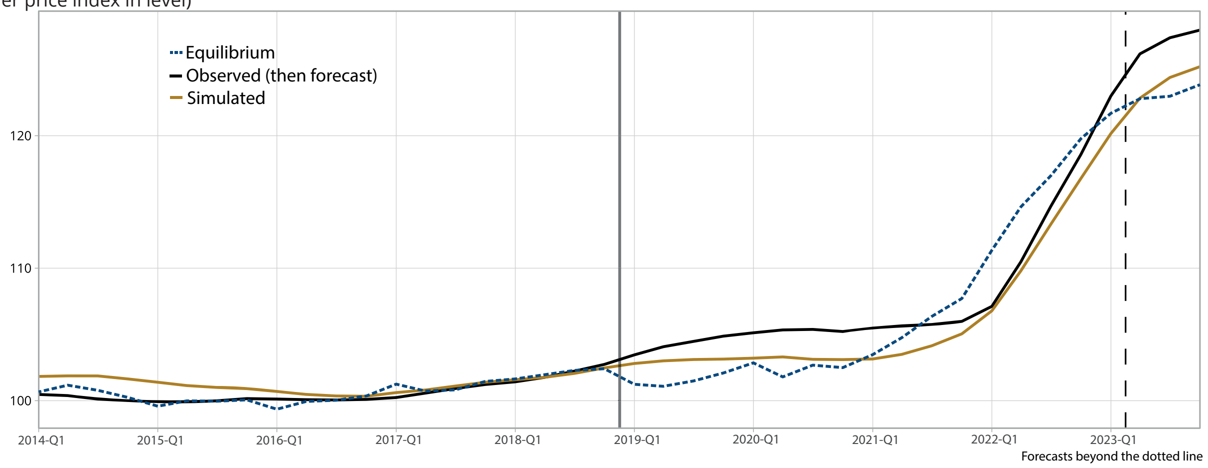


Last point: Q4 2023.
How to read it: in Q4 2022, the non-fresh food CPI, seasonally adjusted, increased by +3.7%, whereas the model predicted +2.8% for these prices. Agrifood producer prices would appear to account for about 62% of this price rise. In the forecast, blocks have been added to try and incorporate the impact of negotiations between distributors and suppliers over price transmission times (▶**figure 10**).
Source: INSEE, INSEE calculations.

As a forecast for the rest of 2023, the model of the food CPI suggests a slowdown, especially *via* the drop in IAA production prices. However, the effect of the EGalim 2 Law, promulgated in 2021, is also worth considering. This law makes agriculture producer prices non-negotiable in the prices of major retailers, during renegotiations with suppliers. In practice, this would involve a shortening of transmission times between the price of certain inputs and the price paid by the final consumer. This recent change has potentially already been picked up in the restoring force of the econometric model, by introducing the balance of opinion on expected change in the selling price of food products. This balance of opinion, taken from the outlook survey in retail trade, increased significantly in February and March 2023, during negotiations on the transmission of price increases, then began to fall in April with the announcement of new negotiations –in June– this time relating to the slowing of commodity prices. Despite the addition of this balance of opinion, a model estimated on the past can only partially incorporate the effect of such a recent law. It is possible that in view of the change predicted by the model, the food CPI would be more dynamic in Q2, when the price rises already measured for April and May seem to indicate that the model underestimates the effect of the negotiations. In H2 2023, prices could then be less dynamic than the simulated prices: the downward effect of the June negotiations would not be fully captured by the model, mirroring the start of the year (►Figure 9). ●

►10. Consumer price of non-fresh food products: observed, simulated and long-term equilibrium price

(consumer price index in level)



Note: in the forecast, a block has been added to the variations proposed by the model, to gradually join up with the equilibrium price.
Last point: Q4 2023.
How to read it: in Q4 2022, the consumer price index for non-fresh food products stood at 119, whereas the econometric model predicted 117.
Source: INSEE, INSEE calculations.

Method box

In this model of the consumer price index of food products excluding fresh products (hereafter food CPI) three stages of price formation are differentiated: the agriculture branch that produces, the agrifood industries that process the agricultural production, then the retail trade that distributes the processed products to the final consumers (mainly households). With this transmission chain, the rise in agricultural commodity prices (e.g. wheat) has an indirect impact on the food CPI: it initially increases the producer prices of agricultural products, which in turn feed into the production costs of the agrifood industries which are ultimately passed on by the distributors to the consumers.

Using error-correction models (ECMs), links between these prices and their other determinants can be estimated for each of these stages by defining a long-term relationship (adjustment against an "equilibrium" price) and the short-term dynamic. If the branches of the economy are considered to be in a situation of monopolistic competition (many companies competing on the market but with very different goods), the production price of branch P^* is fixed in the long term on the marginal cost of production C_m^* (which is a function of the cost of inputs, unit wage costs, etc.) weighted by a *"markup"* –μ^*– indicating the level of profit in the branch.[1] Thus, in equilibrium, after moving to the logarithm:

$$\log(P^*) = \log(1+\mu^*) + \log(C_m^*) \quad (1)$$

The theory behind error-correction models is that the production price applies to the "long-term target" or "equilibrium target" of the equation (1). In this context, the "long-term target" means that the marginal cost of production and the level of profit in the branch –the markup– are on fixed rate growth paths. In other words, $\Delta\log(C_m^*)$ and $\Delta\log(1+\mu^*)$ are constants.

However, the model assumes that the branch does not adjust to this long-term target immediately but with a certain momentum which can be estimated. The general form of the equations is then:

$$\Delta\log(P_t) = \underbrace{\alpha + \beta_1 \Delta\log(P_{t-1}) + \beta_2 \Delta\log(C_{m_t})}_{\textit{short-term dynamics}} - \rho\left[\underbrace{\log(P_{t-1}) - \log(1+\mu_t) - \log(C_{m_t})}_{\textit{long term target}}\right] + \epsilon_t \quad (2)$$

Empirically, it will be a matter of both approximating a "long-term target" for the production price that is consistent with the theory presented in the equation (1), and then estimating the dynamics of the production price in equation (2). In practice, concerns over parsimony in the choice of explanatory variables, the need to be able to manage them easily in forecasting, constraints over the temporal depth of the data, etc., will ultimately result in the selection of econometric models that deviate from the theoretical form above. These models should not be interpreted as structural forms but rather they aim to capture average behaviours over a long period, in order to infer relevant information for forecasting.

Compared to existing food inflation models (see for example **►Milin, 2017**, **►Charsonville and al., 2017** or **►Ulgazi and Vertier, 2022**),the models presented below take inspiration from them, but differ from them, notably in:

- the introduction of energy costs into the model;
- the consideration of "non-linearity" in some equations by introducing variables derived from the business tendency surveys.

These innovations represent first attempts to overcome the difficulties of forecasting in an unprecedented inflationary situation.

1 The *markup* is the ratio of the factory-gate price to the marginal cost of production. It is not synonymous with the margin rate (ratio of gross operating surplus to value added) as production costs already theoretically include "normal" return on capital.

Incorporating the cost of energy into modelling agricultural producer prices and IAA production prices

Inflationary tensions, which began in 2021 and have been aggravated by the war in Ukraine since February 2022, affected energy particularly strongly, with the result that it was necessary to include it specifically in the model of agricultural and agrifood production prices. Including energy in this way is certainly not a new notion, but it is often approximated simply by changes in the price of Brent. This approximation is justified economically insofar as, in the past, there was a strong correlation between the price of gas and the price of oil (▶**Bortoli and Milin, 2016**). However, the current energy crisis shows a decorrelation (at least partial) between gas and oil prices (▶**Sheet: Energy and commodities**). Also, the models presented here include an energy cost variable aggregating both the price in euros of gas in Europe and the price of Brent, depending on the energy mix in the sector (agriculture, agrifood industries or distributors).

More formally, let e_{ijt} (resp. p^e_{ijt}) be the quantity (or price) of energy *i* (electricity, gas or oil) used by sector *j* on date *t*. The cost of energy nrj_{jt} for sector *j* on date *t*, as included in the models below, is written:

$$nrj_{jt} = nrj_{jt-1} + \sum_i \frac{e_{ijt}}{\sum_i e_{ijt}} \Delta p^e_{ijt}$$

In this calculation, it is also assumed that the price of electricity varies like that of gas. Data on the amount of energy used by the different sectors (e_{ijt}) are obtained *via* the Tables of Intermediate Inputs (TEI) in the annual national accounts.[2]

Finally, the real cost of gas and energy paid by companies in the sector is measured very imperfectly from gas prices in Europe. In fact, as shown by the business tendency surveys (▶**Bjai and al., 2022**), energy contracts (gas and electricity) are for the most part subject to a fixed price over a certain contractual period. Thus, using sector results from the business tendency surveys, the model weights the price of gas according to the prevalence of types of contract in the sector and the frequency of renegotiations in the case of companies that have adopted a fixed-price contract for a contractual period. Despite these adjustments, the cost of energy modelled in this way is only an approximation of the real cost paid by companies in the sector.

Incorporating variables derived from the business tendency surveys to adjust the speed of transmission of prices

In the models presented hereafter, the elasticities governing relationships between prices are, by necessity, estimated over periods of time when inflation is low –typically, the period 1990-2019– which can detract from the model's predictive quality in a context of high inflation.

By using a linear relationship for the forecast estimated over a long period between, for example, the producer price of agricultural products and production costs in the agrifood industries, it is implicitly assumed that the reaction of companies to an increase in the prices of inputs in the current period is the same as during the estimation period, when inflation was much lower. However, a period of high inflation could involve different mechanisms (see for example the stylised facts of ▶**Borio and al., 2023**): prices would be more volatile, there would be more co-movement of prices between sectors, inflation would be more persistent and above all, price transmission would be faster. The theory of "coordination failure" as a cause of price rigidity (▶**Ball and Romer, 1991**) is a way of explaining these different speeds of transmission. In this model, prices would be rigid because a company adjusts its prices according to its anticipation of the behaviour of its competitors: in a low-inflation regime, the company will prefer to wait rather than raise its prices unilaterally, so as not to lose market share, whereas in a period of high inflation, the company will pass on the price rise regardless of the behaviour of its competitors.

2 For the recent period when the TEI is not available, values are approximated based on 2019 data.

The methods used to model these non-linearities in detail can be relatively sophisticated (**▶Ihle and Cramon-Taubadel, 2008**, for a comparison of non-linear threshold models and "Markov" regime-switching models). Rather than using these methods, and for the sake of parsimony, the error correction models presented hereafter assume that the strongest price diffusion in times of high inflation can be captured using data from the business tendency surveys, in particular the balance of opinion on expected change in selling prices in the sector concerned. Thus, the more the share of companies reporting that they want to raise their selling price increases, the faster prices would be transmitted. The introduction of this balance of opinion, which captures the level of coordination in price fixing, has led to a significant improvement in the predictive quality of models since the end of 2021. This involves adding a multiplicative coefficient to the restoring force of the ECM, which depends on the balance of opinion in question.

The next part describes the econometric models used for the following three prices: agricultural producer prices excluding fruit and vegetables (called IPPAP), the price of production in the agrifood industries (deflator of IAA production within the meaning of national accounting), consumer price of food products (food CPI excluding fresh). For each econometric equation, the production or consumption prices modelled (or entered as explanatory variables) are considered as a quarterly average and seasonally adjusted. Lastly, the modelled price-response functions are presented, illustrating the speed at which prices adjust to different exogenous shocks.

Econometric modelling of agricultural producer prices

In the long term, production prices of agricultural products (as a quarterly average, seasonally adjusted, and excluding fruit and vegetables) adjust to the price of wheat and imported food commodities, and to the price of energy in the "agriculture, forestry and fishing" branch (defined above) and the labour productivity of this branch. The price of wheat and the price of energy also contribute to short-term dynamics, as shown in the following equation:

$$\Delta p_t^{AZ} = \underset{(17)}{0.61} + \underset{(7.3)}{0.42}\,\Delta p_{t-1}^{AZ} + \underset{(9.2)}{0.12}\,\Delta ble_t + \underset{(2.9)}{0.04}\,\Delta nrj_{AZ,t}$$
$$\underset{(-5.4)}{-0.20}\left(p_{t-1}^{AZ} - \underset{(7.2)}{0.16}\,ble_{t-1} - \underset{(3.3)}{0.19}\,mpa_{t-1} - \underset{(6.3)}{0.08}\,nrj_{AZ,t-1} + \underset{(-9.4)}{0.41}\,\omega_{t-1}^{AZ} + \underset{(-3.4)}{0.063}1_{t\in 2009Q3} - \underset{(7.0)}{0.004}\,t\,1_{t>2005}\right) + \epsilon_t^{AZ}$$
$$\text{Estimation: Q1 1990} - \text{Q4 2019},\ R^2 = 0.64,\ DW = 1.9,\ \sigma_{p^{AZ}}^2 = 0.139,\ RMSE = 0.039$$

where:

- p^{AZ} is the logarithm of the producer price index of agricultural products, excluding fruit and vegetables and seasonally adjusted (source: INSEE);
- *ble* is the logarithm of the world price of wheat on the Chicago market in euros (source: Chicago Board Of Trade);
- nrj_{AZ} is the logarithm of the price of energy in the "agriculture, forestry and fishing" branch in euros defined above (source: INSEE);
- *mpa* is the logarithm of the imported food commodities price index in euros (source: INSEE);
- ω^{AZ} is the logarithm of labour productivity in the "agriculture, forestry and fishing" branch, i.e. the ratio of the value added of this branch to the employment of natural persons (source: national quarterly accounts, INSEE).

Econometric model of IAA production prices

A long-term relationship is estimated between agrifood industry production prices and agricultural producer prices (excluding fruit and vegetables), energy costs and unit wage costs. The short-term equation incorporates food commodity prices, agricultural producer prices and unit wage costs directly. Finally, the restoring force of the model is weighted by the absolute value of the balance of opinion relating to expected change in selling prices in the IAAs, as a result of the monthly tendency survey in industry, in order to take into account the non-linear effect of a period of high inflation on the transmission of prices. The model is therefore as follows:

$$\Delta p_t^{C1} = \underset{(-14.7)}{-0.36} + \underset{(6.1)}{0.39}\,\Delta p_{t-1}^{C1} + \underset{(2.2)}{0.03}\,\Delta mpa_{t-1} + \underset{(5.8)}{0.11}\,\Delta p_t^{AZ} + \underset{(2.7)}{0.09}\,\Delta csu_t^{C1}$$
$$\underset{(-5,1)}{-0.28} \times (1 + s_t^{C1}) \times [p_{t-1}^{C1} - \underset{(16)}{0.27}\, p_{t-1}^{AZ} - \underset{(10)}{0.32}\, csu_{t-1}^{C1} - \underset{(6.9)}{0.04}\, nrj_{C1,t-1} + \underset{(-5.689)}{0.03}\; 1_{t<2000}] + \epsilon_t^{C1}$$
$$\text{Estimation}: Q1\,1993 - Q4\,2019\,,\; R^2 = 0.70\,,\; DW = 2.1\,,\; \sigma^2_{p^{C1}} = 0.09\,,\; RMSE = 0.01$$

where:

p^{C1} is the logarithm of the deflator of IAA production (source: national quarterly accounts, INSEE);

nrj_{C1} is the logarithm of the price of energy in the IAAs in euros defined above (source: INSEE);

csu^{C1} is the logarithm of unit wage costs in the IAAs (source: national quarterly accounts, INSEE);

s^{C1} is the absolute value, divided by 100, of the balance of opinion relating to the expected change in IAA selling prices (source: monthly tendency survey in industry, INSEE).

Econometric model of consumer prices of food products excluding fresh

In the long term, the consumer price of food, excluding fresh produce, is indexed on a unitary basis on IAA production prices, unit wage costs in the non-agricultural market sector (SMNA) and energy costs (although the coefficient is low). A linear trend is added over the period before 1998 to capture the differences in the legal framework for price formation (in particular with the Galland law defining the threshold for resale at a loss). The short-term dynamics are based on the variation in the IAA production price. As was the case when modelling IAA production costs, the restoring force of the model is weighted by the absolute value of the balance of opinion, among retail businesses, on expected change in the selling prices of food products, in order to integrate the non-linear effect of a period of high inflation into the speed of price transmission. The model adopted is as follows:

$$\Delta ipc_t^{Alim} = \underset{(134)}{0.52} + 0.61\,\Delta ipc_{t-1}^{Alim} + \underset{(5.0)}{0.15}\Delta_{p_t}^{C1}$$
$$\underset{(-3.4)}{-0.11} \times (1 + s_t^{GZ}) \times [ipc_{t-1}^{Alim} - \underset{(7.2)}{0.35}\, p_{t-1}^{C1} - \underset{(13.5)}{0.65}\, csu\_smna_{t-1} - \underset{(4.0)}{0.02}\, nrj_{GZ,t-1} - \underset{(8.2)}{0.003}\, t1_{Q<1997} + \underset{(-17.0)}{0.08}\, 1_{Q<1997}] + \epsilon_t^{Alim}$$
$$\text{Estimation}: Q1\,1993 - Q4\,2018\,,\; R^2 = 0.71\,,\; DW = 2.0\,,\; \sigma^2_{ipc^{Alim}} = 0.0982\,,\; RMSE = 0.06$$

where:

ipc^{Alim} is the logarithm of the consumer price index of food, excluding fresh produce (source: INSEE);

nrj_{GZ} is the logarithm of the price of energy in distribution in euros defined above (source: INSEE);

s^{GZ} is the absolute value, divided by 100, of the balance of opinion relating to expected change in the selling price of food products in retail trade (source: monthly tendency survey in retail trade, INSEE);

csu^{SMNA} is the logarithm of unit wage costs in the non-agricultural market branches (source: national quarterly accounts, INSEE). ●

Box: price-response function modelled to exogenous shocks

In addition to providing a better understanding of the determinants of food product prices in the past and as a forecast, the error-correction model is used to assess the diffusion of an exogenous shock, quarter by quarter. The exercise consists in simulating a permanent 10% increase in world food commodity prices and studying change in the different prices modelled over several quarters. The response of the modelled prices may come from a direct effect –as food commodity prices are some of the explicit determinants in the econometric model– but also from an indirect effect –among its determinants the modelled price contains a price which is itself affected by the exogenous shock. It should be noted that the simulations carried out do not include loopback effects from the increase in wages generated by the increased cost of food products. In addition, the balance of opinion from the business tendency surveys on probable price changes is assumed to be equal to its long-term average, which cancels out its impact on the speed of diffusion of the shocks in the simulations.

A +10% shock on agricultural commodities leads, in the long term, to a 3.5% rise in agricultural producer prices (excluding fruit and vegetables), a 1.0% rise in production prices in the agrifood industries and about 0.3% in the non-fresh food CPI (►**Figure 11**). At the end of one year, most of the shock has been transmitted: the agriculture sector would appear to have transmitted over 90%, compared to almost 80% for distributors. The impact on IAA production prices is stronger after one year than in the long term (+1.1 points against +1.0 point in the long term), with the short-term momentum generating a slight over-reaction in the price. ●

►11. Response to a permanent +10% increase in world agricultural commodity prices
(cumulated impact in %)

Quater	1	2	3	4	5	6	7	8	9	10	LT
Producer prices of agricultural products	1.22	2.17	2.83	3.24	3.46	3.56	3.60	3.59	3.58	3.56	3.51
IAA production prices	0.13	0.70	0.99	1.10	1.12	1.09	1.06	1.02	1.00	0.99	0.98
direct effect	*0.00*	*0.32*	*0.35*	*0.27*	*0.16*	*0.07*	*0.02*	*-0.01*	*-0.02*	*-0.01*	*0.00*
indirect effect	*0.13*	*0.39*	*0.64*	*0.84*	*0.96*	*1.02*	*1.04*	*1.03*	*1.02*	*1.00*	*0.98*
CPI Food	0.02	0.10	0.19	0.27	0.32	0.36	0.37	0.38	0.37	0.37	0.33
direct effect	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
indirect effect	*0.02*	*0.10*	*0.19*	*0.27*	*0.32*	*0.36*	*0.37*	*0.38*	*0.37*	*0.37*	*0.33*

Note: the impact of the shock includes indirect effects that correspond to the share of the increase that derives not from agricultural commodities but from the previous price in the food production chain. For example, the indirect effect for the IAA production price is equivalent to the contribution of the increase in agricultural production prices. These simulations do not include loopback effects caused by wage increases. The permanent increase takes place in Q1.
Source: INSEE.

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