Costs and Co-Benefits of Climate Transition Policies: How Accurately Will They Be Measured by Standard of Living and Well-Being Indicators?

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Abstract – The aim of the climate transition is to minimise the long-term losses of well-being that would result from inaction. However, the necessary policies are likely to incur costs in the short and medium term. Standard of living indicators will serve their intended purpose if they accurately reflect these costs. Nevertheless, some of them may be underestimated, resulting in a greater impact than suggested by conventional indicators. Conversely, the well-being cost of the transition could be lower if non-monetary co-benefits emerge quickly enough and/or if preferences shift: reduced access to polluting goods has a different impact depending on whether the intrinsic taste for these goods remains strong or declines. While these questions are relevant to various contexts, the climate transition offers an opportunity to examine them in greater depth.

JEL: C43, E01, E31, I31
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The consideration of environmental issues is often criticised as a weak point in monetary approaches to living conditions (Gadrey & Jany-Catrice, 2016; Laurent & Le Cacheux, 2016), whether in the highly aggregated approach of national accounts or in more microeconomic approaches that also examine the distribution of living standards across households. For national accounts, a recurring request is to enrich them with sustainability indicators, allowing to assess, beyond GDP, whether sufficient efforts are being made to ensure that future well-being levels will be at least equivalent to current ones. This is a complex undertaking, as it addresses a subject that is simultaneously prospective, multi-dimensional and global. Prospective, because it involves assessing the impact of current decisions and actions on future living conditions. Multi-dimensional, as these actions and decisions cover a large number of areas: greenhouse gas emissions and climate action are currently prominent, but the issue of sustainability is much broader. Global, since the sustainability of living conditions in a given country depends on the actions and decisions of all countries, and therefore cannot be measured by accounts for each country in isolation. This explains the slow progress in this area, in spite of some advances (Germain & Lellouch, 2020).

However, there is one aspect of the climate transition that the current statistical system should be able to cover more easily: calculating its local and real-time costs as it progresses. This topic has long been neglected due to the prevalent belief that these costs could be kept to a minimum, a view that is increasingly falling out of favour (Pisani & Mahfouz, 2023). While the climate transition aims to increase well-being in the long term compared to a reference scenario without climate policy, short-term costs are expected, due to the phasing out of highly energy-intensive production and consumption practices that have driven past growth. When measuring these costs, national accounts and income and price statistics should be expected to fulfill their usual role. They have been used to quantify how reliance on fossil fuels and poor environmental practices have facilitated the rise in living standards. They should also be equally capable of measuring the impact that the consumption restrictions necessary for greening would have on living standards.

But are these measures guaranteed to be exhaustive? Conversely, is there a risk of overlooking elements that could offset these costs, if the transition brings non-monetary co-benefits with sufficiently rapid local effects, without needing to wait for the expected long-term global benefits? This transition could also be accompanied by a greening of preferences, which should also be taken into account as such a phenomenon would reduce the impact on well-being from decreasing the consumption of carbon-intensive goods.

This article does not claim to be exhaustive but explores several of these issues. None of them are entirely specific to the climate transition, but the transition provides an opportunity to examine them in greater depth or from a new perspective. The article will start by analysing how the transition could impact the monetary living standards of households, a question also addressed by Dees *et al.* (2023). It will focus on three different vectors of decarbonisation: a green version of the classic process of creative destruction, taxation on carbon-intensive goods, and regulations restricting their consumption. The current method for calculating purchasing power will, in theory, account for the first two types of greening, but not necessarily for the third. This limitation arises from measurement instruments based on income and prices, which fail to take into consideration other factors that can limit consumption opportunities for given levels of income and prices.

As a direct extension of this first observation, other questions may arise concerning indicators related to additional aspects of real income, such as the volume/price decomposition of public services that households benefit from, given that these services will also need to be decarbonised (The Shift Project, 2023), and the devaluation of carbon-intensive assets held by households. These issues are not explored further in this article; we refer interested readers to the report on which this article is based (Blanchet *et al.*, 2023). The second section will therefore move directly onto the issue of the non-monetary co-benefits of the transition. The consideration of non-monetary elements of well-being is a classic subject, and we will review the available options for addressing it. The issue of greening preferences has received much less attention and presents particularly challenging conceptual problems. We will explore this in the third section.

1. Green Transition and Purchasing Power of Disposable Income

The first step is to determine which of the usual statistical indicators would be best suited for capturing the net costs of the climate transition. It is common to focus on the impact on GDP: can greening be compatible with continued GDP growth or will it necessarily lead to a significant slowdown or even a reversal? This first section will instead focus on another indicator used in national accounts, namely the gross disposable income (GDI) of households, and its counterpart measured by social statistics, their standard of living. Both of them can be considered either as average values, for an individual deemed to be representative, or in terms of dispersion across different household types.

With a few differences, these two indicators represent the total primary income of households, which mostly consists of labor income and, for some, capital income. All taxes and contributions paid by households are deducted from this income, while monetary benefits received are added. The resulting figure is then deflated by a chain-weighted price index: price variations for different goods and services are weighted according to their share in the household budget, with updates made for changes in these shares over time. Finally, the purchasing power of income, or standard of living, is adjusted to account for household size and the economies of scale that result from it.

Whether from a macro or micro perspective, this article will aim to compare these indicators with a stylised theoretical representation of consumer utility. Such a comparison cannot be ruled out on the basis that GDI or living standards are not intended to measure well-being. This defensive argument is often used to dismiss their criticism or that of GDP. It is true that none of these indicators are intended to provide a comprehensive measure of well-being, and it is always worth keeping this in mind. However, they are assumed to capture a key component of this well-being: the utility that is derived from income and the consumption it enables. It might be argued, in return, that this utility cannot be quantified in an unequivocal way and that the comparison is therefore meaningless, but this counterargument is also invalid. Although standard of living indicators cannot be expected to directly correspond to a cardinal measure of utility - which we know to be relative - their messages should still be as consistent as possible with *ordinal* preferences. There would indeed be a significant problem if measures of standard of living suggested an improvement between two periods t and t' while, all else being equal, households in period t' would prefer to return to their nominal income and price levels of period t. Such a risk can never be completely eliminated, but it is important to ensure that the green transition does not exacerbate it.

1.1. Growth and Renewal of Goods: The Standard Case of Creative Destruction

In order to fully understand this risk of contradictory messages, it is useful to first revisit what typically allows us to ignore it. If this risk does not immediately come to mind, it is because we often envision a growth scenario where the consumption of goods and services increases in all dimensions, and we assume that having more of all these goods and services is inherently preferable.

In reality, growth is never completely of this type, as it always goes hand-in-hand with the renewal of goods: the consumption of new goods spreads and grows as they replace goods for which consumption reduces until they disappear completely. Growth is therefore a process of addition and subtraction. However, it has most frequently taken the form of a spontaneous creative destruction process driven by the price decrease of new goods, rather than by an increase in the price of existing goods. In such cases, it is reasonable to assume that consumers benefit from this process, and that the additions outweigh the subtractions. The improvement in living standards could even be underestimated due to the difficulty of accurately measuring the contribution of new goods when they are first introduced to the market. It is only once they are fully integrated into the price index that statisticians can measure how their falling prices improve living standards.

This usual line of thinking is illustrated by a first simulation of a three-good model that will be used throughout this article. It considers a generic good 0 and two goods, 1 and 2, between which growth will generate a replacement effect (Box 1 and Figure I). The simulation is based on an initial situation in which good 2 may exist but can only be marketed at a price unacceptable to the consumer, i.e. higher than the reservation price, beyond which the demand for the good is zero. We then assume that a technological shock causes its price to drop significantly below the reservation price at a given time $t_1 = 25$,[1] leading to an immediate jump in both production and demand. After this initial surge, production continues to benefit from ongoing technical progress, resulting in further price reductions and increased consumption until time $t_2 = 100$.

1. *This date could also be interpreted as the date at which good 2 is introduced into the basket of consumer goods used to calculate the price index.*

Box 1 – **A Model Made Up of Three Goods**

Throughout the article, our discussions will be based on a model made up of three goods: two goods between which the replacement phenomenon will take place, with prices p_1 and p_2 and which are consumed in quantities q_1 and q_2, and an aggregate of all other goods consumed in quantity q_0. For the greening scenarios, good 2 will be the green good and good 1 the polluting ('brown') good. Preferences are represented by a nested CES (Constant Elasticity of Substitution) function, which will be maximised under the budgetary constraint $R = q_0 + p_1 q_1 + p_2 q_2$ and, in some simulations, a regulatory cap $\overline{q}_1$ on the consumption of good 1. Goods 1 and 2 are combined in a first CES, while a second CES combines them with good q_0. Incompressible minimum consumption or usage terms B_0 and B are added to this second CES. They can also take negative values, in which case the good 0 or the composite good are non-essential, i.e. it is possible to not consume them at all. The overall utility function $U(q_0, q_1, q_2)$ is expressed as follows:

$$\left[a_0\left(q_0 - B_0\right)^{\frac{\sigma_0 - 1}{\sigma_0}} + \left(1 - a_0\right)\left(\left(a q_1^{\frac{\sigma - 1}{\sigma}} + \left(1 - a\right) q_2^{\frac{\sigma - 1}{\sigma}}\right)^{\frac{\sigma}{\sigma - 1}} - B\right)^{\frac{\sigma_0 - 1}{\sigma_0}}\right]^{\frac{\sigma_0}{\sigma_0 - 1}} \quad (1)$$

In all simulations, except the last one where preferences are unstable, the parameter values for this function are assumed to be fixed with values $a_0 = 0.25, a = 0.55, B_0 = 1, B = -1, \sigma_0 = 0.5$ and $\sigma = 2$.

What relationship should we expect to find between this representation of utility and standard of living indicators?

Generally speaking, the relationship can only be exact in the specific case of a homogeneous function U of degree 1. In this case, it is possible to write $U = \sum_i U_i' q_i$, from which we can derive the form $U = \lambda \sum_i p_i q_i$ and $dU/U = \sum_i p_i dq_i / \sum_i p_i q_i$, which reflects the variation in volume at current prices. In this case, the chain-linking of these variations would reproduce the change in U between any two dates.

When the utility function can be expressed as $V = g\left(U\left(q\right)\right)$, where g is any monotone function and the same homogeneity of degree 1 of U is maintained, this scalar equivalence is lost, but there is still consistency between the measurement of the standard of living and ordinal preferences: in this case, an increase in income deflated by a chain-weighted price index still corresponds to an increase in both U and V, all else being equal. This case is that of "homothetic" preferences, in which an equal increase in all of the quantities consumed has the same effect on well-being, regardless of the initial consumption structure.

This result no longer holds up if such a homotheticity property is not satisfied, which will be the case for specification (1). For example, if the saturation of satisfaction is reached more quickly for a particular good, the gain in well-being is not the same if we double all consumption from a state in which the good in question is already being extensively consumed and from a state in which it is rarely consumed. This will be the case if B and/or B_0 are not equal to zero. In this case, a discrepancy may arise between preferences and the standard of living measurement with a chain-weighted price index, one manifestation of which is the issue of path dependence - the fact that the comparison of standards of living between two dates *t* and *t'* depends on the path taken between the two periods (see Blanchet & Fleurbaey (2022) for a more detailed description of this). However, it is still useful to check that the extent of such discrepancies remains limited. This is the approach that will be taken in this article.

With this point in mind, the use of this very simple model may give rise to three further objections, but of unequal significance:

- The first is that it only seems to concern a representative agent, with all of the well-known limitations that come with this concept (Kirman, 1992). Indeed, given that green or brown goods may often be indivisible (electric versus non-electric car), our simulations will more likely represent a phenomenon of increasing adoption expressed in terms of average weighting in the basket of an aggregated "household" agent. However, the qualitative insights from this model remain translatable to the micro level and would apply directly to divisible goods: the number of car trips rather than car ownership, lowering home temperature rather than changing the heating system, or reductions in any other consumption category with high greenhouse gas content. Everything presented can therefore be used for evaluating the redistributive effects of climate policies, in the spirit of Douenne (2022) and analyses in terms of inflation inequality (Jaravel, 2021).
- The second objection is the fact that reasoning is done in partial equilibrium. This second limitation would indeed be very problematic if we wanted to offer a comprehensive prediction of the effects of different greening policies. For example, the greening of preferences that will be studied at the end of the article would have general-equilibrium effects on supply and demand and therefore on income and prices. These effects would need to be simulated if we wanted to provide a comprehensive forecast of their overall impact on well-being. However, the objective of this article is more limited. Assuming that the balances of these effects on income, prices and consumption patterns will be directly observed by the statistician, the only question raised is whether the usual standard of living indicators will synthesize them in a way that will properly reflect their impact on the utility of household(s). This question essentially boils down to whether or not the nominal income deflators are valid, which will be illustrated by projections with constant nominal incomes. Only one feedback element will be simulated, in the case of taxation: the effect on nominal income of a recycling of the tax revenue.
- The final limitation is that it neglects intertemporal effects. Whether individual or representative, the consumers we model choose their consumption pattern on each date based on current prices or constraints without considering their future trends and without having the ability to smooth their response to those trends. This approach is clearly just

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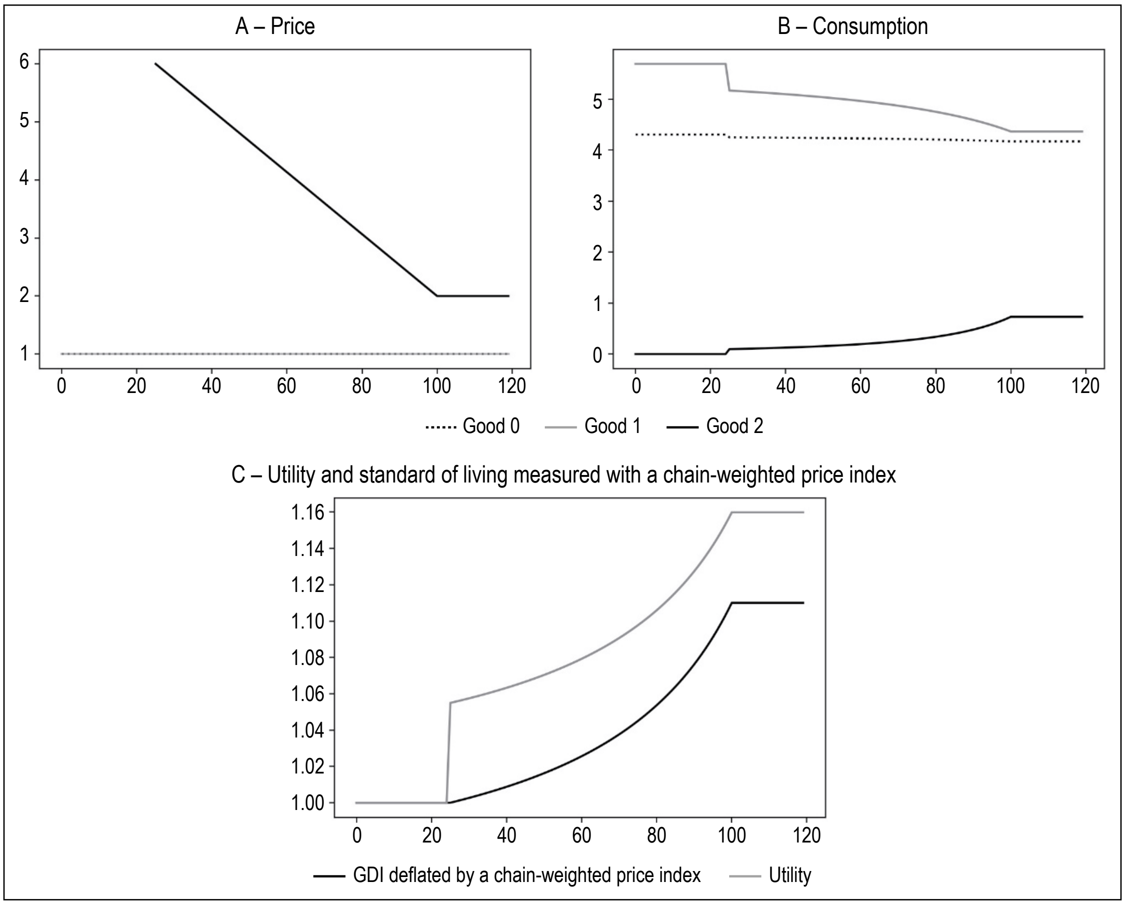
Box 1 – *(contd.)*

a simplified vision of a reality that is made more complex by the effects of anticipation and other intertemporal reasoning, particularly when the greening involves durable goods, with electric cars once again serving as the standard example: the higher purchase cost may be partially offset by cheaper running costs, although the ability to benefit from such compensation depends on financial assets, current resources or borrowing capacity, and potentially the resale value of the good. Here, the price of the good should be considered as an indicator of average usage costs over the service life of the good, taking all these elements into account. When the green good is more expensive, it indicates that its lower energy consumption or lower maintenance costs would not be sufficient to offset the higher purchase cost or the cost of the debt required for its purchase. A more explicit modeling of these intertemporal effects has not been attempted in this preliminary overview.

Figure I – **The new good effect: the standard case**



Reading note: Good 2 appears on the market at date 25 thanks to an innovation that brings its price significantly below its reservation price. It is therefore immediately adopted to a significant degree, resulting in a fall in the consumption of good 1, and also favouring the consumption of good 0. These changes have an immediate effect on the consumer's well-being that is not reflected in their real gross disposable income. The latter nevertheless does reflect the increase in well-being from the subsequent reduction in the price of good 2 until date 100. If goods 1 and 2 were perfectly substitutable ($\sigma \rightarrow \infty$), the model would have simulated a full and immediate switch from good 1 to good 2 as soon as the price ratio of the two goods exceeds the ratio of the services they provide $a/(1-a)$. In this case, deflation by chain-weighted prices would accurately account for all the impacts on the consumer's standard of living: no impact while the price of good 2 remains above the price at which the switch takes place, a completely neutral change during the switch, followed by an increase in well-being linked to the subsequent fall in its price, which is captured well by our indicators. The only possible source of bias is the late introduction of good 2 into the basket of consumer goods taken into consideration by statisticians.
Sources: Authors' calculations.

In such a scenario, there is an initial positive impact on utility, as defined by equation (1) in the box, that is not measured by nominal income deflated by the chained price index. This limitation is well-known when it comes to measuring prices and volumes: it is impossible to assess the initial impact of a new good the first time it appears in the consumer basket, when its first appearance occurs at a non-marginal level. However, the subsequent process in which the reduction of the price of the good leads to a further increase in its consumption is well captured and is indeed a process of growth in which the gain induced by the growing consumption of good 2 outweighs the decreasing consumption of good 1.

The underestimation of the impact of new goods highlighted by this initial simulation has been extensively discussed in debates about measuring the effects of new ICT (information and communication technologies) or the digital economy.[2] This issue arises either when dealing with goods that provide innovative services and immediately capture significant market shares as soon as they are introduced, or when their inclusion in the price index is delayed until their market share begins to rise significantly. It is possible that a similar underestimation could apply to the greening process, particularly for green technologies that are becoming increasingly competitive compared to polluting technologies. However, a significant difference is expected with this optimistic version of the process of creative destruction. The reason is that green goods typically do not offer new services but rather serve as alternatives to existing polluting goods, often at a higher initial cost. It is this initial extra cost that may justify public intervention aimed at reducing the consumption of polluting goods. How these costs are reflected in measures of the standard of living will depend on the method used to achieve this greening.

Setting aside, at this stage, the case of voluntary sufficiency resulting from a change in preferences, we will consider the two most frequently discussed options of "forced" greening. The first scenario involves the implementation of a tax on good 1, now assumed to be the polluting good (henceforth called the 'brown' good), with or without redistribution of the collected funds. The second scenario consists of a quantitative constraint on its consumption, which is often preferred when taxation faces too much resistance.

1.2. Forced Replacement Through Taxation or Regulation

If the incentive for greening takes the form of a Pigouvian tax, we remain within a framework governed by price signals. Unlike the situation we previously simulated, in which the price of good 2 decreased, the price signal now consists in an increase in the price of the brown good. The expected impact is therefore a reduction in living standards, even if there is some redistribution of tax revenues, due to the deadweight loss effect. The fact that redistribution does not avoid welfare losses is particularly easy to understand in the extreme case where the tax entirely eliminates the consumption of the brown good: there would be no additional tax revenue to redistribute, while utility and the standard of living would obviously decline.

The impact of such a tax is simulated with and without this redistribution of its revenue (Figure II). Of course, this assessment does not take into account the utility gains that are expected to arise both in the long term and at a level broader than that of the local consumer. The goal of the tax is indeed to improve the state of the world in the long term by taking into account externalities that are not reflected in market prices. However, the focus here is on measuring the effect of the tax on the utility of a consumer who does not directly benefit from this improvement, or who is unaware of it. This effect is fairly well captured by the standard of living indicator. The slight discrepancy observed can be attributed to the non-homogeneity of the utility function, which causes a slight drift in the chained price index, but this bias is not significant in our case.

What would happen then if, rather than taxing the brown good, the same consumption trajectory was achieved by a regulatory measure that reduces the consumption of the brown good by the same amount, but without any price signal? The overall consumption trend is identical to that under the taxation scenario with revenue recycling, as nominal income remains unchanged and allows for the same consumption shift possibilities towards the green good and the all-purpose good. Utility therefore evolves in the same manner, still downwards, but this time without any measured decrease in real income (Figure III). Although there is a change in the weighting of the goods making up the price index, it does not affect the index in the absence of price changes, even though the increasingly restrictive nature of the regulation leads to the same continuous decline in utility that would occur with a price increase.

Overall, while a significant proportion of the effects of the transition on nominal income and its purchasing power are likely to be relatively well captured by national accounts – specifically those stemming from variations in nominal income or prices – some negative impacts may be missed. These are the effects not automatically and fully converted into income and price

2. *See, for example, Aghion* et al. *(2018) and, for literature reviews, Ahmad & Scheyer (2016) or Blanchet* et al. *(2018).*

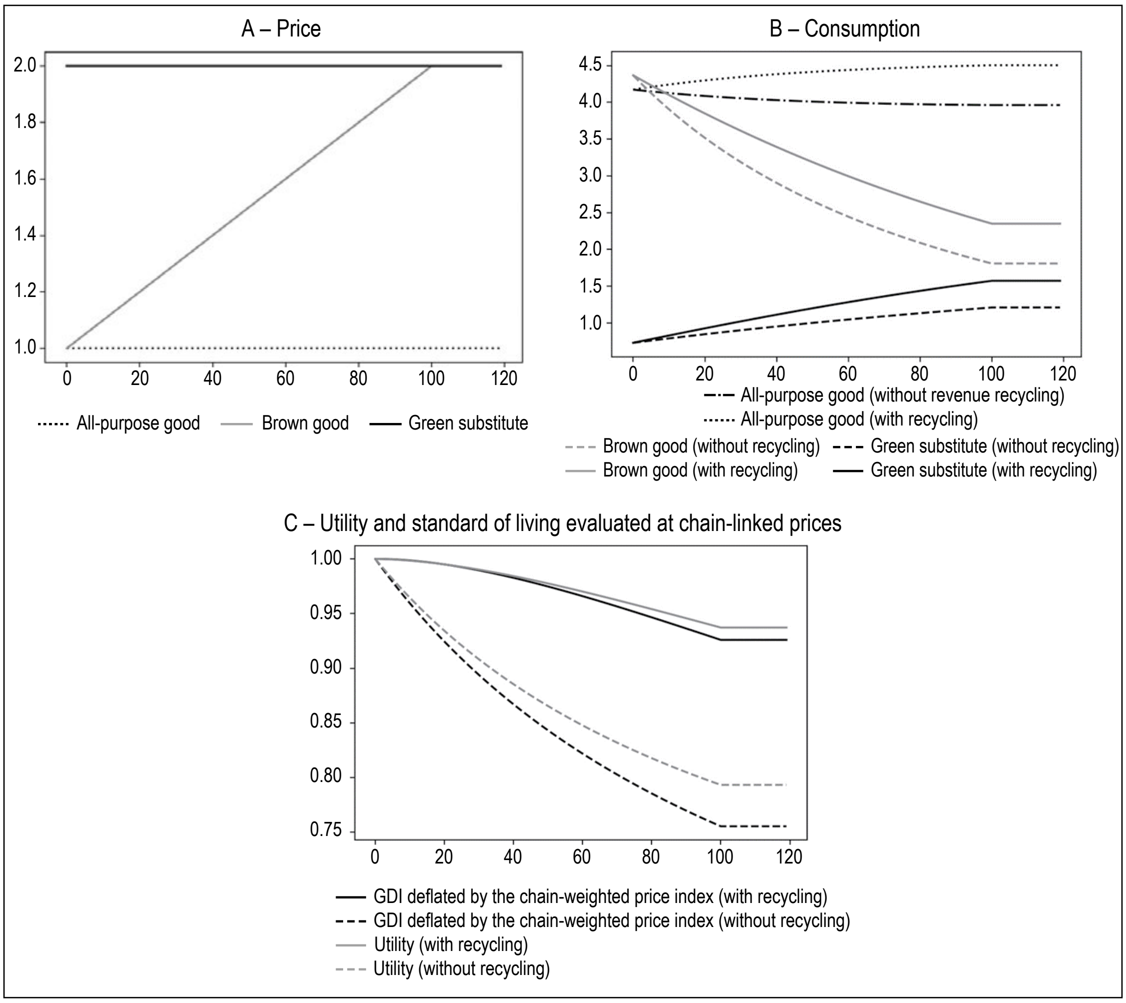
signals. This issue touches on a classic critique of measuring standards of living: the impact of non-discretionary consumption or mandatory expenditures, which limit the possibilities of consuming other goods. Purchasing requirements and bans are two facets of this problem. A more systematic approach to measuring living standards would incorporate these by calculating the income losses equivalent to such restrictions, assuming constant prices (Box 2). Although systematic application of these calculations in routine production may be difficult, we should at least be clear about what the measurement ignores at both macro and micro levels. Just as one might expect inequality in exposure to the effects of taxation or other sources of price modifications, inequality in the impacts of regulatory measures should also be taken into account.

2. Non-Monetary Co-Benefits

The list of effects that were discussed in this first overview appears rather negative. While income and price statistics should spontaneously capture anything occurring via these two variables, they risk missing the effects of regulatory constraints. This limitation should be given special attention: underestimating the costs to households could result in poor anticipation of resistance to change and to inadequately sizing the measures needed to make the transition more bearable.

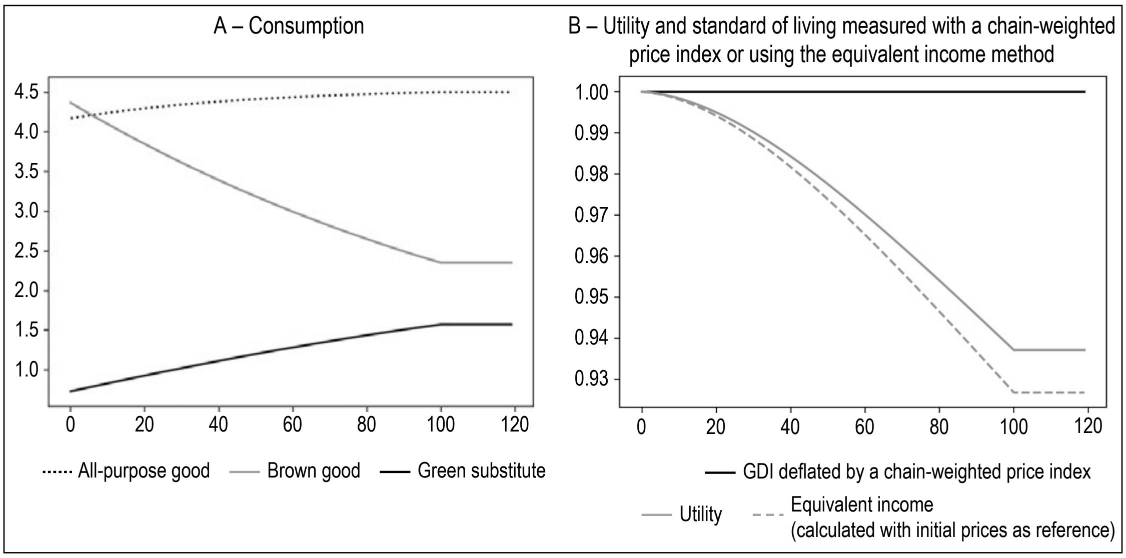
However, could other factors play in the opposite direction? There are two aspects to this question. The first involves highlighting the possible non-monetary effects of the transition, some of which could be favourable. It is necessary to list these effects and to assess to what extent they might offset the monetary costs.

Figure II – **Impact of the taxation of the brown good on standard of living and well-being**



Reading note: The price of the green good (good 2) does not benefit from any advances in greening technology. Greening results from an increasing tax on the brown good (good 1) with or without redistribution of the tax revenue. The redistribution of tax revenue does not prevent a decline in utility, though the decline is of course smaller than if redistribution had not taken place. Income deflated by the chain-weighted price index takes account of this decrease in utility and of the fact that it is more marked in the absence of redistribution, even if the equivalence is only approximate given the non-homothetic nature of the utility function.
Sources: Authors' calculations.

Figure III – **Impact of a regulatory constraint on the consumption of the brown good**

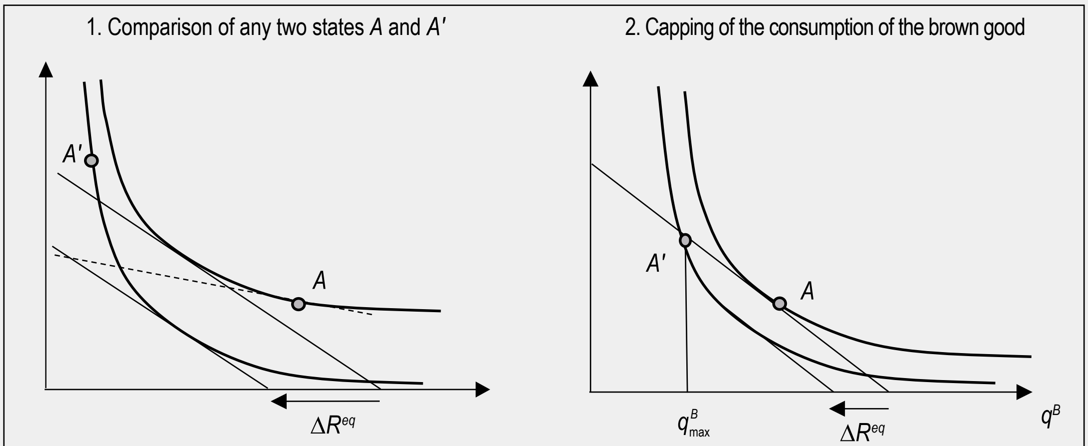


Reading note: The same reduction in consumption of the brown good is achieved by limiting its consumption via a regulatory measure. This results in a shift in consumption towards the green good, but also towards the other good. This forced change in the consumption structure leads to a fall in utility that is equal to that which would result from a Pigouvian tax with revenue being fully redistributed to households. However, no effect on real GDI is recorded, since neither nominal income nor prices are changed. On the contrary, evaluating the impact of the consumption constraint using the equivalent income method (Box 2) does capture the decline in utility, although there is a discrepancy due to the non-homotheticity of preferences.
Sources: Authors' calculations.

Box 2 – **Monetary Evaluation of The Impact of a Regulatory Constraint**

From a theoretical point of view, the evaluation of a monetary equivalent of a regulatory constraint can be viewed as a specific application of the concept of equivalent income. Equivalent income provides a scalar ranking of consumption options that is consistent with ordinal preferences. It consists in associating each utility isoquant with the minimum income level required to achieve that level of utility under a given reference price system (Figure A.1). Each reference price system corresponds to a set of parallel budget lines in the goods space. Utility isoquants are then cardinalised by the position of the line tangent to them. This position can be measured, for example, by the intersection point of this line with the horizontal axis, which corresponds to considering the associated good as the numeraire. This approach allows for comparing the utilities associated with two arbitrary points A and A'. This comparison will be consistent with ordinal preferences, which is something that is not always guaranteed by standard of living indicators which use chained prices or, even more so, fixed base-year prices. For example, in this figure, point A' would be considered better than point A if one uses base prices corresponding to the point A situation – since it lies above the corresponding budget line (dashed line) – although it is on a lower isoquant. Chain-weighting reduces this risk of erroneous classification, but not completely, as the comparison of standards of living between points A and A' may depend on the path taken to move from one to the other (path dependence).

Figure A – **Equivalent income: general principle and application to a regulatory constraint**



This equivalent income method applies directly to cases where the switch from A to A' does not result from a change in ➔

Box 2 – *(contd.)*

income or relative prices but rather from a cap on the consumption of the good on the x-axis. The impact can be measured by using the price system that the individual actually experiences as the reference price system (Figure A.2). The constraint forces the individual to reduce their consumption of the brown good below what they would do ordinarily on the basis of income and prices alone. This results in a shift towards consuming the other good, assuming the individual exhausts their budget, but that shift would not be sufficient to keep utility unchanged, especially if the two goods are not easily substitutable. The variation in equivalent income accounts for this.

This approach resembles another form of equivalence calculations for different climate policy instruments, that of the carbon price equivalent used by the IMF (Black *et al.*, 2022). Economy-wide carbon price equivalents (ECPE) correspond to the level of carbon tax that would result in the same reduction in emissions as the policy or policies under consideration, which could therefore involve the introduction of standards or constraints. Although the two approaches may overlap, they should not be confused. In the carbon price equivalent approach, two policies are considered to be equivalent if they lead to the same reduction in emissions. In this article, we use equivalent income to determine whether these policies have the same effect on well-being. Two policies can be simultaneously equivalent in both meanings of the word if they both lead to the same mix of brown, green and generic consumption: indeed, in this case, the same reduction in emissions would correspond exactly to the same variation in utility. However, this overlap is not guaranteed. For example, a non-recycled tax and a constraint that both lead to the same reduction in brown consumption would be equivalent according to the ECPE, but not in terms of the effect on well-being, since the non-recycling of the tax revenue would generate a negative income effect for the consumption of all goods. Generally speaking, the lack of overlap may therefore offer a criterion for choosing between the various options for decarbonisation: the policy that is the least detrimental to well-being must be prioritised for a given environmental impact. Moreover, from a social well-being perspective that takes inequalities into account, an additional difference would be the fact that the various options do not affect everyone in the same way: the same overall reduction in emissions can be achieved with varying degrees of equality.

The second aspect concerns the possibility that the transition may be accompanied by changes in preferences: everything discussed so far has been based on the implicit assumption of stability in preferences for polluting and green goods. Yet, an additional vector of greening is voluntary sufficiency (Pommeret *et al.*, 2023; Oliu-Barton *et al.*, 2024), meaning a change in preferences in favour of green goods or even towards reduced overall consumption.

These two aspects partially overlap: preferences may shift in a way that reduces the importance of polluting goods while increasing the weighting of green goods, and that also gives more weight to the non-monetary co-benefits of the transition. For the sake of clarity, we will separate these two topics, starting with the evaluation of the non-monetary impacts of the transition if preferences were to remain stable. In doing so, we do not claim to provide a systematic inventory of these co-benefits but will limit ourselves to a few methodological observations.

First of all, regarding the list of these non-monetary effects, it should be mentioned again that our focus is on the issue of current standard of living and well-being. Therefore, we are only considering co-benefits that have sufficiently immediate effects to counterbalance the equally immediate costs. The longer-term benefits fall under the issue of sustainability. In addition, the non-monetary effects of the transition are not all necessarily co-benefits; some may actually exacerbate costs. Positive impacts include immediate gains in terms of health, leisure and the improvement of our living environment. Many negative effects can nevertheless also be anticipated. For example, restructuring caused by the transition to greener production will result in a mix of job losses and job creation, potentially leading to periods of unemployment and/or transitions to different types of work (Hentzgen *et al.*, 2023). Changing jobs can have an impact on well-being that goes beyond the effects on income; this is even more true for those who experience unemployment, since the loss of well-being associated with being unemployed is greater than the difference between previous wages and unemployment benefits. Another example is the potential need for increased housing density as part of a shift towards greater sufficiency. While income per consumption unit could view this positively due to larger economies of scale from shared living arrangements, it would not align with actual well-being: the historical trend towards reduced cohabitation suggests that individuals are willing to sacrifice purchasing power for the benefits of living alone, which they may be forced to give up.

From a methodological point of view, regardless of whether these non-monetary effects are positive or negative, the issue remains the same: how to integrate them with monetary indicators? This is the topic traditionally addressed in the

« beyond GDP » literature, which proposes four options for incorporating these non-monetary factors into the measurement of well-being, as previously outlined in Blanchet & Fleurbaey (2020).

The first approach is the use of dashboards, which entails presenting a range of indicators that shed light on various aspects of living conditions and well-being, without attempting to aggregate them. For instance, in their comparative analysis of various avenues for achieving greener consumption with potential positive effects on well-being, Creutzig *et al.* (2022) order these effects according to the categories of the Sustainable Development Goals currently promoted by the United Nations. However, the problem with this approach is the sheer volume of information it generates and the difficulty in prioritising it. Synthesised information is also required. And, in the end, when these dashboards are used to make trade-offs between policies with different effects on different aspects of well-being, these decisions ultimately rely on some form of implicit aggregation and non-transparent hierarchies of these dimensions.

The second approach is that of composite indices. It has to be mentioned given its long-standing prominence in the search for alternatives to GDP. It employs a number of techniques to statistically make comparable things that are not inherently so, and then aggregates them into a single index according to conventional rules. The method is considered to be transparent since the aggregation rules are based on fairly basic arithmetic. Its limitation lies in the fact that the resulting relative valuations may not reflect individual preferences or relevant social choices, since they are the uncontrolled result of a purely statistical aggregation rule.

Conversely, full respect of individual preferences appears to be an advantage of the third approach, namely the measurement of subjective well-being. It eliminates the need to formulate principles for aggregating different components of well-being, relying instead on what individuals report about their overall well-being, using a cardinal approach. Individuals indicate how favourable they perceive their living conditions to be, typically by scoring their perceived overall well-being on a scale of 0 to 10, without needing to make their personal weighting of different well-being dimensions explicit. The appeal of this method lies in the fact that it directly leads to the end result, while also allowing to account for the unequal distribution of subjective well-being. This is something that composite indicators based on macro data are unable to do. Even when they try to include inequalities measured across different dimensions, composite indicators fail to capture the cumulative impact of deprivations when they are correlated across axes. These advantages make the method particularly useful for addressing many questions, and it is a natural candidate for assessing the "all-encompassing" impact of climate transition (Perona, 2022).

However, relying on declared well-being poses the problem of the relativity of the scales on which individuals assess their situation. The fact that an individual A could feel less happy than another despite having the same circumstances is certainly interesting to measure. However, problems arise when this leads to inconsistencies with ordinal preferences, which is precisely what we are trying to avoid. For example, an individual A might prefer their current situation over that of another individual A', yet rate their own well-being less favourably than A' if they are naturally more demanding than A'. It would be manifestly wrong to conclude that a society predominantly composed of individuals of type A is worse-off than if it were primarily composed of individuals of type A'. The method risks producing results that conflict with the actual ordinal preferences of individuals.

This problem is addressed by the fourth type of approach, which has already been introduced in Box 2 in the context of calculating a monetary equivalent for the rationing of the polluting good. The method of equivalent income allows for a monetary translation of anything that affects the ability to generate utility from income, with prices and rationing constraints being just specific cases. The situation where utility is affected by both prices and one or more non-monetary factors is discussed in Box 3. The approach involves setting reference values for prices as well as for the non-monetary factor(s), and then calculating the income that would allow achieving the current level of utility in the hypothetical situation in which the individual is exposed to these reference values rather than their current values. For instance, if an individual with income R is in a poor state of health H and if a good state of health H^{ref} is taken as reference, his equivalent income R^{eq} will be the amount that would guarantee the equality $U\left(R^{eq}, H^{ref}\right) = U\left(R, H\right)$. This income would be lower the worse the health state H is, while it would increase if an improvement in the environment leads to better health. This method provides a monetary valuation of this improvement, consistent with ordinal preferences related to health and monetary living standards. It is rooted in the tradition of cost-benefit analysis.

However, the problem that this method poses lies in its implementation. A number of techniques or combinations of techniques are possible: relying on preferences revealed through behaviours; using contingent valuation techniques, i.e. directly asking individuals how much they would be willing to pay or receive for specific changes in their situation or environment; or combining objective data with subjective satisfaction measurements presented earlier. The idea is to measure how individuals are willing to trade off material factors against other aspects of their living conditions by empirically analysing how these factors impact subjective well-being. This can be done through surveys that combine direct measures of perceived well-being with objective components. Utility function calibrations from existing literature may also be used.

The cost of implementing these different techniques makes it difficult to imagine applying them for routine production of measures. Among the practical applications of this approach, one notable example is the work by Serres & Murtin (2014), who attempt to calculate the extent to which increased life expectancy associated with a reduction in local pollution – resulting from decreasing greenhouse gas emissions – could offset the economic costs of these reductions. They find that the compensation is only partial, but this does not exhaust the topic, as their focus is limited to just one of the co-benefits of the transition.

3. Transition and Well-Being with Changing Preferences

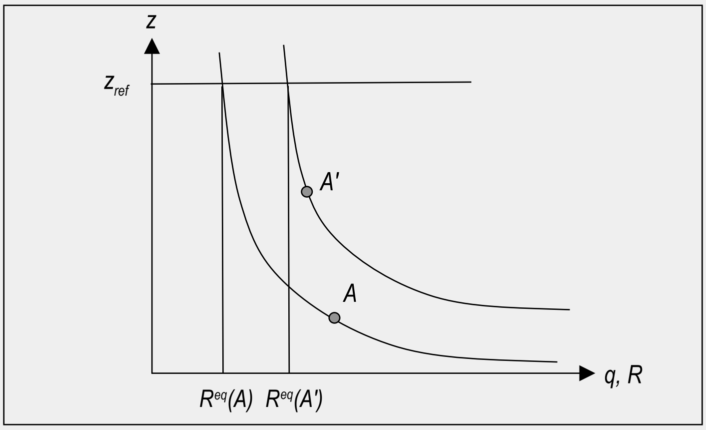
Even without co-benefits such as those described in the previous section, the cost of the transition in terms of perceived standard of living or well-being could still be reduced if this transition is accompanied and/or driven by a greening

Box 3 – **Equivalent Income Applied to Non-Monetary Co-Benefits**

To maintain the possibility of a two-dimensional representation, we consider that preferences are governed entirely by the capacity of income R to purchase a composite all-purpose good q and a single non-monetary co-benefit described by the variable z: this could be, for example, the state of the environment or the state of health as affected by the state of the environment. If we use the composite good as the numeraire, this method just needs a reference value z_{ref} for the variable z. The equivalent incomes associated with the states A and A' correspond to the x-coordinates of the points at which the isoquants and the horizontal $z = z_{ref}$ intersect.

In this example, there is a decrease in income between state A and state A', but it is more than offset by the increase in variable z.

Figure B – **Equivalent income when well-being depends on a market good and a non-monetary factor**



It should be noted that, in practice, some of the effects on well-being associated with improvements in the state of health may already be measured by some of our usual indicators via the associated reduction in healthcare expenditure. Gross disposable income should indeed capture any reductions in health insurance spending if these lead to a reduction in taxes that finance them. However, the effect of a reduction of medical expenses paid by households, which would free up income for other expenses, would only be taken into account with an approach in terms of discretionary income treating these medical expenses as constrained spending. Finally, the so-called “adjusted” disposable income approach, which integrates the monetary equivalent of individualised transfers, would, in principle, miss all of these effects, since the decrease in taxes would be completely offset by the decrease in health benefits.

of preferences. If the consumption of meat or air travel dramatically decreases simply because individuals spontaneously stop eating meat and travelling by plane, their well-being will not be negatively affected, regardless of what happens in terms of prices or regulations.

But how can one quantify the dampening effect brought about by such changes in preferences? Attempting to measure the cost of living or real income growth in the context of changing preferences is like trying to compare the size of different objects using an elastic ruler that expands or contracts as you move from one object to the next. There does not seem to be any solution to this problem, which is undoubtedly why, until recently, it was largely ignored by the literature (Samuelson & Swamy, 1974; Balk, 1989), in spite of the fact that past growth has clearly been accompanied by radical changes in preferences.

The COVID-19 crisis provided a first reason to stop ignoring this subject: it drastically changed preferences concerning different types of goods and services, with some goods suddenly becoming essential, while others became dispensable (Baqaee & Farhi, 2020; Baqaee & Burstein, 2021; Blanchet & Fleurbaey, 2022). This raised two questions: how can standard statistical indicators that implicitly rely on the stability of preferences be interpreted in such a context and which actual measures of utility or well-being can we try to compare them with? These two questions are even more critical in the context of the green transition, since changes in preferences are no longer an exogenous disruptive factor that we can afford to ignore, for lack of a better option. In the green transition context, we indeed expect them to play an active role (Konc *et al.*, 2021; Mattauch *et al.*, 2022a; Mattauch *et al.*, 2022b) and policies (including sufficiency) are being considered to encourage them. Continuing to ignore them is a position that is increasingly untenable. But how can they be taken into account?

The two approaches that we have just put forward for handling non-monetary co-benefits – the measurement of subjective well-being and the equivalent income method – each offer a solution to this issue and both are worth considering.

One could choose to rely on the subjective measurement of well-being. For example, if there is taxation, it would be reasonable to assume that the subjective indicator would incorporate both the negative impact of the tax and the fact that individuals quickly learns to put its effects into perspective or to derive information about the consequences of climate change and integrate this into their preferences. More generally, one could even say that the very nature of these subjective indicators allows them to take account of all possible ways in which preferences may change. This is how we are accustomed to interpreting the most well-known of their stylised messages, the Easterlin paradox (1974), which states that beyond a certain stage of development, economic growth has only a minor impact on subjective well-being. One possible explanation of this paradox is that needs and aspirations increase as material living conditions improve, and that it is the gap between living conditions and those aspirations that determines declared well-being. This is not necessarily a change in ordinal preferences, but at the very least a change in the way they are translated into cardinal terms.

If such an explanation of the Easterlin effect is correct, it could play out in the opposite direction along a green transition path: the scenario of chosen sufficiency would involve a slow-down or even a decline in consumption at the same time as growth slows down or declines, thereby limiting the fall in subjective well-being. This calls for a keen examination of how these subjective indicators would behave along a transition trajectory with changing preferences.

We can also investigate what would say standard of living indicators calculated according to the equivalent income method introduced earlier.

First of all, what can we say about the impact of these changes in preferences on the usual standard of living indicator, calculated as nominal income deflated by a chained price index, given that statisticians will continue to calculate it anyway? If preferences remain constant, the tax generates a substitution effect that mitigates some of the impact that would have occurred if substitution were not an option. In principle, that impact is taken into consideration by the chained index, although path dependence introduced by chain-weighting can still be an issue, even with constant preferences. The greening of preferences would strengthen this substitution effect, adding a second factor to moderate the effects of the tax, but at the same time introducing a second path dependence issue. Consider an initial state A with brown preferences, a final state A' with greener preferences, a tax increase between these two periods, and two different scenarios for the trajectory of preferences: one where their greening occurs before the tax increase and another where the greening follows the tax increase. It is clear that the message conveyed by the chain-weighted indices would not be the same in these two scenarios: in the first case, the increase in the price of the brown good would be reflected in the price index with a weight that will already have begun to decrease, whereas this would not be the case in the second scenario. The fall in the standard of living would therefore be deemed to be smaller along the first trajectory than along the second, even though both trajectories have the same starting and ending points.

Thus, while the standard indicator may not necessarily be silent on a potential moderating effect of the change in preferences, its message will be partial and unstable.

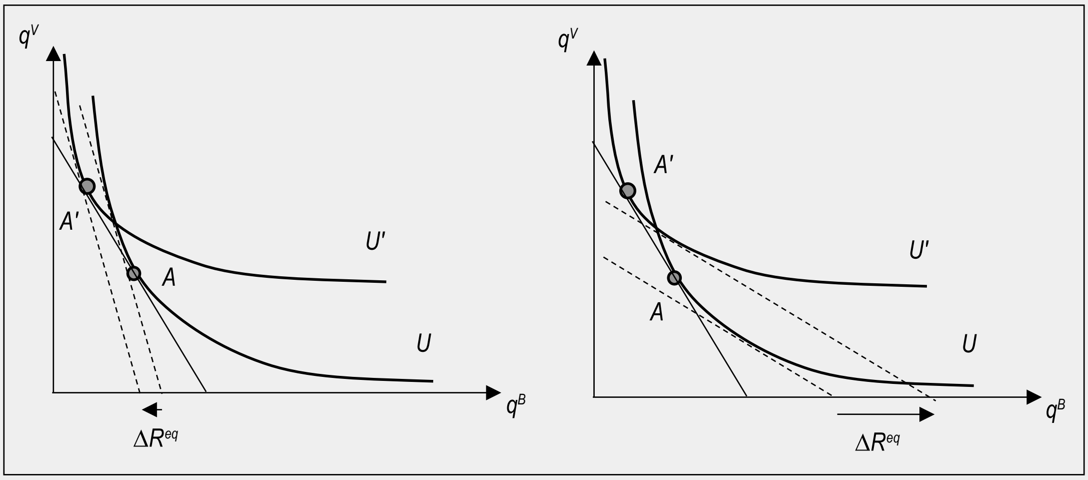
Would the equivalent income method help to circumvent this problem? From a technical point of view, there is nothing preventing its implementation, as it does not require considering individuals with identical preferences (Fleurbaey & Tadenuma, 2014). There is no need to assess how each individual would feel with preferences that are not their own. Instead, it is on the basis of their own preferences that they assess the hypothetical level of income that would make them indifferent between their current state and a situation in which they would be faced with the price system that has been chosen for reference. Comparisons are then made based on these equivalent incomes, whether they are interpersonal comparisons between two individuals living at the same time or comparisons over time for the same individual with two successive preference systems.

Uncertainty about the final message is not entirely resolved however, but it takes a different form: the result of the comparison will depend on the chosen reference price system. That dependence is shown in Box 4 and can be illustrated by one last simulation from the model used throughout this article (Figure IV). This simulation also allows for a comparison with the evolution of standard of living indicators measured with a chain-weighted price index, in the context of one of the two scenarios of the simulations in Figure III: the introduction of a tax without recycling its revenue - which arguably represents the least favourable situation

Box 4 – **Equivalent Income with Variable Preferences**

We consider a green good and a brown good coupled with a change in preferences in favour of the former, assuming for now that income and prices remain unchanged (Figure C). Initial and final preferences are represented by the functions U and U'. The change in preferences leads to a shift from point A to point A'. The classification of these two points using the equivalent income method depends on the reference price system: point A appears above point A' with the reference prices in the left-hand figure and below it with the reference prices in the right-hand figure. This indeterminacy may appear unsolvable, but it is simply a reflection of the fundamental indeterminacy resulting from the change in preferences: A is preferred over A' for an individual with the initial preferences, and A' is preferred over A for an individual with the final preferences. In cases where prices remain the same in both states, these prices can be used as reference prices, in which case the two states will be judged equivalent. This is ethically relevant: two individuals with different preferences but having the same income at given prices are considered to be equally well off, even if their consumption choices differ.

Figure C – **Effect of a change in preferences, at given prices and income, depending on the chosen reference price system**



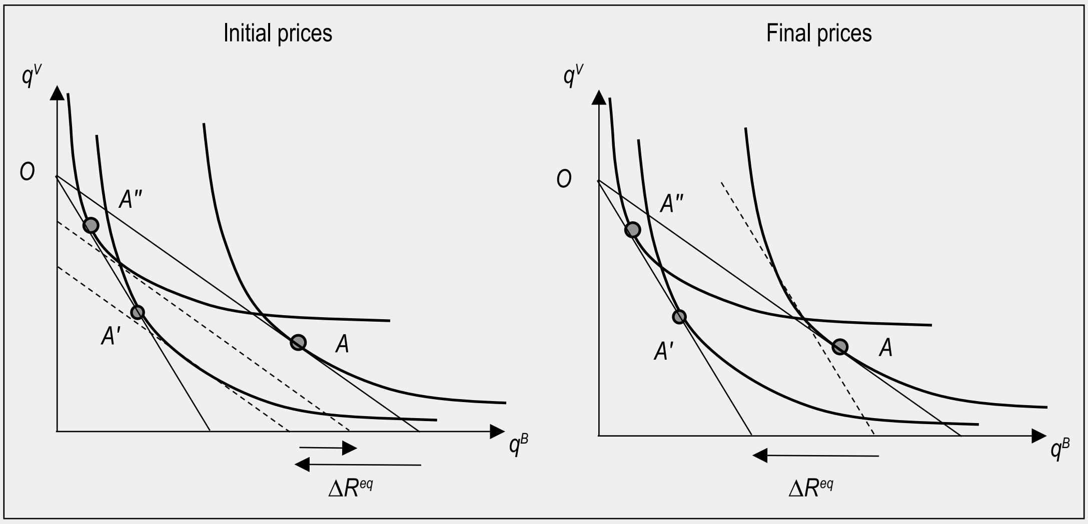
➔

Box 4 – *(contd.)*

This solution is no longer possible when the change in preferences is accompanied by a change in prices. This would be the case in particular if the greening of preferences goes hand-in-hand with the introduction of a tax on the brown good. Consider a two-stage process (Figure D) in which the tax first pivots the budgetary constraint and leads to a shift from point A to point A' with preferences remaining unchanged, after which a change in preferences results in a shift to a point A'' without any change to the budget line.

If final prices are used as the reference prices (right-hand figure), the transition phase from point A' to point A'' has no effect on the equivalent income and only the decrease in the equivalent income between point A and point A' would be observed. In other words, the compensatory effect of the preference change is not accounted for. On the contrary, some compensation is measured if initial prices are chosen as reference (left-hand figure), resulting in a back-and-forth movement that remains partial on the figure but would be complete if the change in preferences were such that, ultimately, the individual entirely forgoes the brown good.

Figure D – **Effect of environmental taxation on equivalent income with variable preferences, with reference prices equal to the initial prices or final prices**



We have focused here on a pure change in preferences, that necessarily goes in the direction of greener behaviour. This calls for three remarks:

- This type of greening should be differentiated from that which would result from a pure income effect with no change in preferences, which would be the case if environmental quality were a superior good to which consumers attached greater importance the higher their income. In this case, we would remain within the framework of a fixed-preference analysis. However, this scenario still encounters challenges due to the non-homothetic nature of preferences, complicating the interpretation in terms of utility of real volume or standard of living indicators.
- The preferences considered here as a standard of well-being are the true preferences of the households, which must be distinguished from so-called behavioural preferences, which are those revealed by consumers' actual choices (Fahri & Gabaix, 2020). A discrepancy arises between the two when individuals fail to internalise all the consequences (for themselves) of their choices, typically due to a lack of information. If true preferences are stable and only behavioural preferences change, for example as a result of a nudge that corrects the discrepancy between the two, we remain within a framework of fixed preferences, and the effect of the nudge is generally positive. For further reading, see Pommeret *et al.* (2023).
- As for the change in true preferences, it can occur spontaneously, influenced by communication campaigns or driven by peer effects. It may also result from the introduction of taxes or regulatory changes that increase awareness of environmental issues, thus enhancing their effectiveness (Konc *et al.*, 2021). However, opposite reactions may also be observed, where taxation or constraints lead to a rejection phenomenon (Ehret *et al.*, 2022).

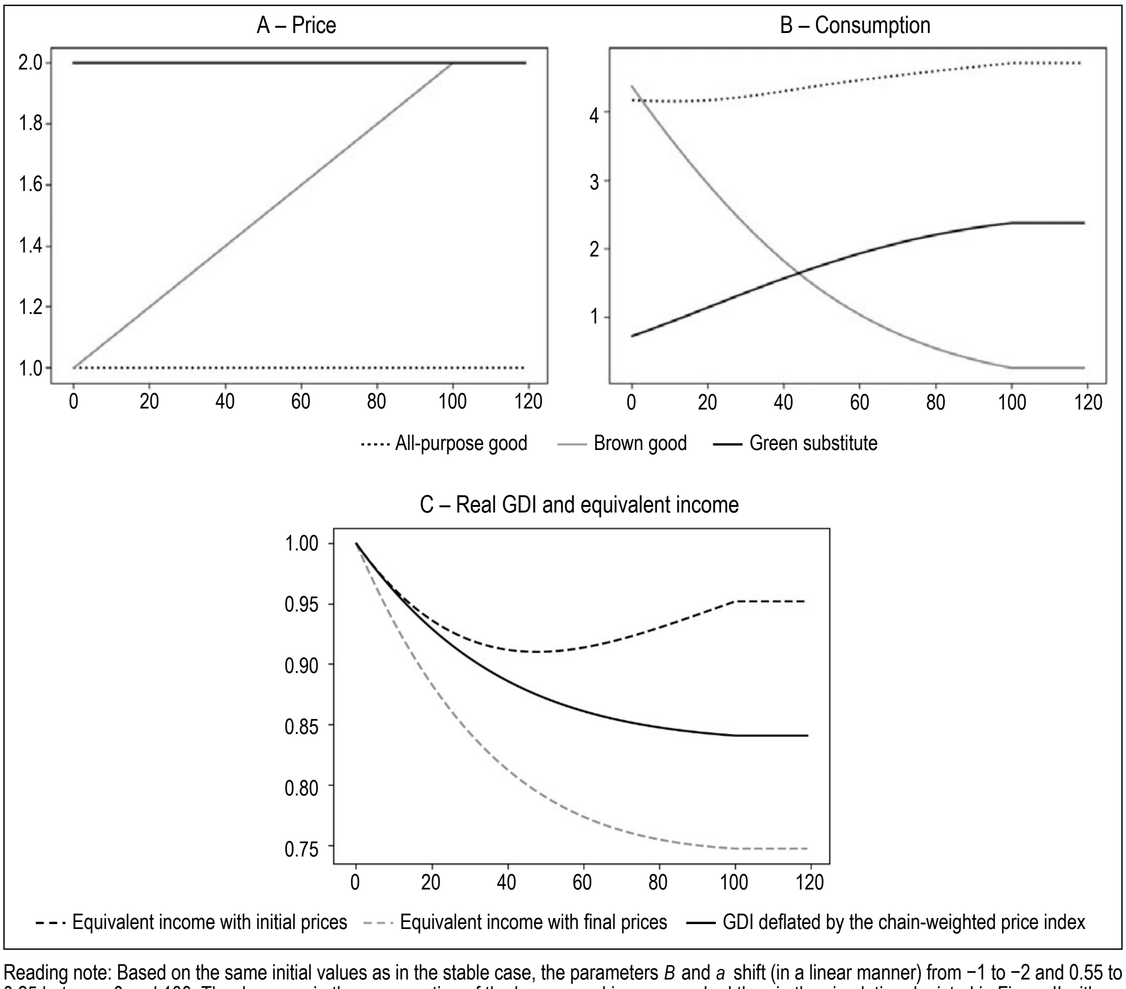
for consumers - coupled with preferences that become greener as the tax increases. The change in preferences involves a joint change of parameters B and a of the utility function from -1 to -2 and 0.55 to 0.25, respectively, between 0 and 100. The fall in B indicates a reduced need to consume the service provided by both the green and the brown good (for example, reduced need to travel by car, regardless of whether that car is electric or not) and the fall in a means that, in order to produce this service, an increasing preference is assigned to good number 2, which is considered to be the green good.

We compare the evolution in income deflated by a chain-weighted price index with two versions of equivalent income, one that takes initial prices as reference and the other based on the current prices at each date as reference (Figure IV-C). It can be noted that, unsurprisingly, the decrease in deflated income is less than in the case of taxation with fixed preferences shown in Figure II. This is because the weight of the taxed good in the index decreases faster than it would with fixed preferences, resulting in a smaller deterioration in living standards, but this offsetting will differ depending on whether the change in preferences occurs before or after the tax is introduced.

The equivalent income approach avoids this form of path dependence since, at each date, it only involves current preferences, regardless of the way they have evolved since the start of the process. However, the outcome depends on the prices used as reference.

- When the reference prices are those of the initial period (upper trajectory), the equivalent income evolves under the influence of two contradictory forces: the tax increase logically reduces equivalent income, but the change in preferences has a positive impact since it allows the consumer to move away from a good that has become expensive compared to its price in the reference system, namely the initial price without the tax. Here, this second effect prevails over the first, since the equivalent income changes its slope as soon as preferences start to become greener. At the end of the transition, the equivalent income remains below its initial value, but, in the limit case where the consumer becomes fully "green" and does not wish to consume the brown good at all, even at its initial price, their equivalent income would return to its initial value since they would have become completely indifferent to the price of the no longer desired brown good.

Figure IV – **Scenario involving the taxation of the brown good (without recycling of the tax revenue) coupled with a greening of preferences**



Reading note: Based on the same initial values as in the stable case, the parameters B and a shift (in a linear manner) from −1 to −2 and 0.55 to 0.25 between 0 and 100. The decrease in the consumption of the brown good is more marked than in the simulation depicted in Figure II with an identical tax trajectory and without recycling. The impact on equivalent income is evaluated by taking either the initial prices or the current prices as the reference prices.

- If one follows the other convention of using current prices as the reference system (lower trajectory), the effect of the change in preferences is fully neutralised in terms of current equivalent income, since it is equal to current income by definition. However, at each period, the change in reference prices leads to updating the value of the initial equivalent income, which increases because the initial situation appears retrospectively more advantageous as the reference price of the brown good increases: compared to the price after tax, brown consumption was initially being implicitly subsidised. As a result, when compared to an initial equivalent income that is increasing, the current equivalent income appears to be in continuous decline.

In the end, there are two different and complementary points of view on the changes at play, which bracket the evolution of real income deflated by a chained price index. One perspective suggests a compensation of costs by changes in preferences, although this viewpoint cannot be entirely privileged either. The measurement of the evolution in standards of living was already affected by unavoidable perspective effects with non-homothetic but stable preferences; this problem can only be amplified when dealing with unstable preferences.

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Overall, replicating the question asked by Ahmad & Schreyer (2016) on consequences, for national accounts, of the digitalisation and the increasing dematerialisation of the economy, can we say that these accounts are perfectly “up to the challenge” of a relevant statistical monitoring of the greening of the economy? What about the broader set of measures for living standards, both on average and at a disaggregated level?

In some respects, the questions raised are easier to answer than those posed by the new production models of the digital economy. The challenge for accountants was the increasingly dematerialised nature of goods and services offered to consumers, and for some of them, the blurring or total disappearance of price signals, with the development of new forms of free or pseudo-free goods and services. In the case of the costs of the climate transition, we return to the more familiar territory of productions and consumptions for which there are physical definitions – liters of fuel oil or petrol, kilowatt-hours, consumption of more or less carbon-intensive foods – and for which we are able to apply unit prices, which is an area in which we know, in principle, how to properly define the volume/price decomposition. Upon first analysis, the toolbox available to national accountants and its extensions at the microeconomic level should therefore provide the basic instruments to account for a significant part of the costs of the transition for households who will bear them.

Nevertheless, even on purely economic grounds, several points may require additional information or new conceptual reflections, whether these points tend towards increasing costs – mainly quantitative rationing – or reducing costs – changes in preferences and the problem that they pose for quantifying standards of living. Looking beyond the strictly economic scope, the issue is compounded by the need to account for a certain number of favourable non-monetary effects of the transition, those that would arise sufficiently rapidly and would directly benefit the individuals who will bear the main costs of this transition. Finally, it should be emphasised once again that the main reason for accepting these costs is the expected gain regarding the planet’s future habitability: this extends beyond the measurement of the present and also beyond the territorial scope covered by national statistics, as the issue is global. This should not prevent national statistical systems from contributing to its understanding, and the quest for adequate sustainability indicators must continue. ☐

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