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A DISTRIBUTIONAL IMPACT ASSESSMENT OF THE ENERGY CRISIS: THE INTERACTION BETWEEN INDEXATION AND COMPENSATION.[*]

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Abstract

The energy price crisis has once again highlighted the importance of the adjustment of income to the increased cost-of-living. In Belgium, this happens through a regulation that guarantees regular indexation of wages and benefits. In other European countries, the adjustment is a result of collective wage bargaining and (discretionary) government decisions on benefit amounts. Such an indexation cannot be ideal, in that it cannot cover exactly the increased costs for all households, and it causes important heterogeneity and distributional variation in the net impact of the energy price crisis. Moreover, the indexation mechanism is sensitive to government decisions which affect prices. The energy crisis induced many European governments to introduce such price compensations. This paper analyses the interaction effects between indexation and the compensation. Although our analysis focuses on Belgium, the interaction is present in any setting where wage indexation is based on a price index affected by government compensatory measures. Even after taking into account this interaction with the indexation, the measures introduced in Belgium turn out to be largely positive for low income households, but they become negative for a large majority of higher income households. On average the impact of the compensation, including the dampening effect on indexation, is negative for households. The interaction effect of the price compensation measures with automatic indexation also involves an indirect support to firms which will pay lower wages, compared to a situation without government measures.

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1 INTRODUCTION

Since mid-2021 energy prices have been rising in many European countries. The increase was exacerbated by the Russian invasion of Ukraine. Therefore many European countries have introduced measures to lower the energy bill of households. In this paper we show that the effect of such measures goes beyond the energy bill. It also affects the wage formation and the magnitude of benefits. Indeed, both are in many European countries linked to a measure of inflation, such as the consumer price index (CPI). This implies that these compensation measures cannot appropriately be evaluated without taking into account the effect of the interaction between compensation and indexation. In this paper, we disentangle the different distributional effects of the energy price shock, the compensation, and the impact on the indexation of wages and benefits in Belgium. We show that the compensation erodes the gain for high income households from indexation, but still protects low income households, also after interaction with indexation.

The compensation measures introduced in Belgium to lower the energy bill, can be categorized in three groups: conditional price subsidies, an indirect tax change, and lump sum reductions. The first category encompasses the “social tariff”, which results in some households paying a lower price for their energy consumption. The social tariff existed before the energy crisis, and eligibility was based on receiving social assistance, social assistance for the elderly, or some specific disability benefits. During the COVID-19 pandemic, the eligibility was extended to all low-income households. The energy crisis led the government to prolong the extension of the social tariff. The second category of measures encompasses the reduction of the VAT rate on electricity (from March 2022 onwards) and gas (from April 2022 onwards), both from the standard tariff of 21% to the reduced rate of 6%. Finally, the third category contains several lump sum reductions such as an “energy check” and a “heating oil premium” introduced in the spring of 2022, and the “base allowance of electricity and gas” introduced in the fall of 2022.

In Belgium, the link between prices on the one hand and wages and benefits on the other hand is implemented through the so-called automatic indexation mechanism. Most wages, benefits, and monetary tax and social security parameters are linked to the price level in a predetermined way. This allows to ex ante simulate the impact of the compensation for the energy price hike on the formation of the disposable income of households, and arrive at a distributional impact assessment of the energy price crisis that takes into account the price hike, the compensation, the indexation, and the interaction between the latter two.

Our analysis focuses mostly on households. But also many firms have been hit hard by the energy crisis. The increased price of energy resulted not only in higher energy bills, but also increased labor costs as wages in Belgium are directly linked to inflation with the automatic indexation. Reversely, the compensation towards households that reduce the energy bill also dampen the increase of labor costs. Supporting households through price compensations thus results in support for employers.

We do not take into account any other feedback effects of the shock (e.g. increasing prices for other commodities) or the measures (e.g. increased demand for energy or other commodities). Many economists have highlighted how price compensation may increase demand, which puts an additional pressure on the energy prices (for the case of Belgium see Peersman & Wauters, 2022). Therefore, a case has been made for compensations that keeps the price of energy goods unaffected, and that are targeted towards the most vulnerable households (OECD, 2022; Bethune et al. 2022). We do not discuss these alternatives, but provide additional arguments pro or contra such alternatives. An important difference between price compensation and targeted income compensation is exactly the interaction with (automatic) indexation.

Our contribution is fourfold. First, we show the heterogeneous impact of the rising energy prices and the compensation measures. Second, we show and discuss the heterogeneous impact of income indexation in times of an energy price hike. Third, we show the distributional picture of the energy price shock after compensation and indexation. The distributional impact of indexation changes drastically if we take into account the compensation measures and their cushioning effect on the indexation and, consequently, on the disposable income. In that case, we find that low-income households are better protected against the price energy shock, but high income households lose from the introduction of compensation measures. We highlight that the introduction of compensation can be viewed as support to employers. Indeed, firms gain from the compensation because of a decrease in their labor costs.

The analysis draws on a static microsimulation model that covers income and expenditures: the EUROMOD model extended with an Indirect Tax Tool (Sutherland & Figari, 2013; Capéau et al., 2021) based on an imputation of expenditure patterns observed in the Household Budget Survey (HBS) to households in the Statistics on Income and Living Conditions (SILC).

In the next section we discuss the data and methods used in our analysis. In section 3 we first discuss the impact of the energy price increase itself (section 3.1). Then we investigate the effects of the compensation measures, and show how they affected the energy bill differently across the income distribution (section 3.2). Section 3.3 then illustrates how the indexation mechanism, in absence of any compensation measure, would protect households against the price increase. Low income households are undercompensated by indexation while high income households gain on average from the indexation of wages and benefits. In section 3.4, we discuss the main result of our paper, the interaction between the introduction of the compensation measures and the indexation of wages and benefits. While on average households lose from the combined effect of price compensation and the dampening effect on indexation, the lower income households gain, at cost of high income households. Finally, we conclude by discussing the implications of our findings for the evaluation of the compensation policies.

2 DATA AND METHODS

Our analysis of the distributional impact of the energy price shock and compensation policies and mechanisms in Belgium relies on two datasets, the Statistics on Income and Living Conditions (SILC) of 2019, with incomes of 2018, and the Household Budget Survey (HBS) of 2018.

The analysis of a joint change in prices and incomes requires a dataset that contains both detailed information on incomes, and detailed information on expenditures. The former is available in SILC, the latter in HBS. Therefore, we perform a statistical matching exercise to impute expenditure patterns on SILC.[1] The result is a SILC dataset enriched with detailed income shares of expenditures (that is ratios of expenditure to commodity groups at the COICOP 6 digit level over disposable income) for each

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[1] We utilize the methodology of Akoğuz et al., 2020 and Capéau et al., 2021 but applied to SILC 2019 and HBS 2018. The method is slightly adapted since we make use of a more detailed version of the HBS provided by the Belgian statistical office (Statbel). For details, see Capéau et al., 2022

household. We thus have for each household the income share for several categories of energy consumption, namely electricity, gas, and heating oil for both the main and second dwelling.

Important for our analysis is that the enriched SILC reproduces the expenditure pattern over the income distribution. In Table 1 we show the average monthly energy expenditures in euro, the average share of energy expenditure over total expenditures, and the average share of energy expenditure in total disposable income for both the original HBS, as well as the enriched SILC. The imputation method preserves well the energy expenditure pattern across the total expenditures and income distribution, with the expenditure shares ranging from around 6.5% in the first deciles up to around 4% in the last decile and the income shares ranging from around 7.5% in the first decile to around 1.5% in the last decile. In absolute terms, the energy expenditures are slightly higher in the enriched SILC, compared to the original HBS.

Table 1: comparison between energy expenditure shares in HBS and in enriched SILC

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Tot**
					HBS						
Energy expenditure (euro per month)	126	128	137	140	142	145	149	143	156	156	143
Share of energy in total exp. (%)	6.6	6.5	6.2	5.4	4.9	5.1	4.8	4.8	4.3	3.9	5.1
Share of energy exp. in disp. inc. (%)	7.8	6.1	5.5	4.6	4.1	3.6	3.3	2.9	2.6	1.5	3.3
					Enriched SILC						
Energy expenditure (euro per month)	140	143	159	151	155	158	163	159	159	150	154
Share of energy exp. in total exp. (%)	6.3	6.4	6.4	5.2	4.5	4.9	4.4	4.4	4.4	3.9	4.9
Share of energy exp. In disp. inc. (%)	7.4	6.2	5.6	4.5	3.8	3.6	3.4	3.0	2.7	1.9	3.6

Note: Deciles are based on equivalized household disposable income and contain 10% of the population of individuals. Average shares are 'smoothed averages', i.e. the ratio of average energy expenditure over average total expenditures/disposable income.
Source: Own calculations based on SILC 2019 and HBS 2018 provided by the Belgian statistical office (Statbel).

To decompose the impact of the energy price increase, the impact of the automatic indexation, and the impact of the compensation measures, we simulate several counterfactuals. The simulation of counterfactuals is performed with the EUROMOD model, enriched with the latest Indirect Tax Tool (Akoğuz et al., 2020; Capéau et al., 2021).[2] This set-up allows to bring events, which in reality do not take place at the same time, to one moment in time. By comparing two counterfactuals, we can isolate the impact of different events or policies on households' welfare. The impact must be interpreted as a morning-after impact. From one day to the other, households are faced with a change: a price shock, a new compensation measure and/or an indexation of wages and benefits. First, we will compare households' expenditures in a situation with low prices (as before January 2021), with a situation with high energy prices (more or less the expected prices in December 2022) assuming that no government intervention took place. Next, we add different events to our counterfactuals: indexation of wages and benefits and/or compensation measures. Using this set-up, we assume that all events happens at the same moment in time. The implementation of the price shock, the indexation and compensation is discussed in detail in Appendix I.

Finally, we measure the impact of the price shock, and the monetary and price compensations, as the change in income they provoke minus the change in expenditures needed at the new prices in order to purchase the same quantities:

$$\Delta u = \left(y_1 - y_0\right) - \left(E_1 - E_0\right), \qquad (1)$$

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[2] We complemented the EUROMOD-ITT model with a module on the automatic indexation of wages and benefits, which is not explicitly taken up in the standard model, and we modified the ITT in order to be able to simulate consumer price changes which do not stem from indirect tax reforms.

with y_1 the new income, y_0 the baseline income, E_1 the expenditures necessary to reach baseline consumption given the new prices, and E_0 the baseline expenditures.

When we assume prices will stay high indefinitely, there is an additional impact on the saved income that will be spent at higher prices in the future. In that case we adjust the change in expenditures to keep consumption constant with the ratio of baseline income over baseline expenditure. Equation (1) then becomes:

$$\Delta u = \left(y_1 - y_0\right) - \frac{y_0}{E_0}\left(E_1 - E_0\right). \tag{2}$$

Under the assumption of household specific Leontief preferences over consumption goods in the present and in the future, these measures have a welfare theoretic foundation and coincide with the compensated gain-concept of King (1983). More details are given in Appendix II.

3 RESULTS

In this section we present the results of our analysis, based on the simulations as discussed in section 2. First, we describe the heterogeneity in the simulated impact of the energy price shock. Second, we discuss the compensatory measures and how they affect the distributional picture of the price shock. Third, we discuss how the indexation of wages and benefits would protect households in the case no compensation measures were introduced. Finally, we amend these distributional pictures with the key take-away from the analysis, the importance of the interaction between the compensatory measures and the indexation of wages and benefits.

3.1 IMPACT OF THE PRICE SHOCK ACROSS THE INCOME DISTRIBUTION

The heterogeneity in energy expenses is the driving force behind the distributional picture of the price shock. Table 2 shows the average energy expenditure across deciles, in euro, in % of total expenditures and in % of disposable income. The average energy consumption in euro is more or less equal across the income distribution. This implies that the share of energy consumption in total consumption and in disposable income decreases in income.

Table 2: average energy expenditure across the income distribution before the price hike.

	1	2	3	4	5	6	7	8	9	10	Tot
					Enriched SILC						
Energy expenditure (euro per month)	140	143	159	151	155	158	163	159	159	150	154
Share of energy exp. in total exp. (%)	6.3	6.4	6.4	5.2	4.5	4.9	4.4	4.4	4.4	3.9	4.9
Share of energy exp. In disp. inc. (%)	7.4	6.2	5.6	4.5	3.8	3.6	3.4	3.0	2.7	1.9	3.6

Note: Deciles are based on equivalized household disposable income and contain 10% of the population. Average shares are 'smoothed averages', i.e. the ratio of average energy expenditure over average total expenditures/disposable income.

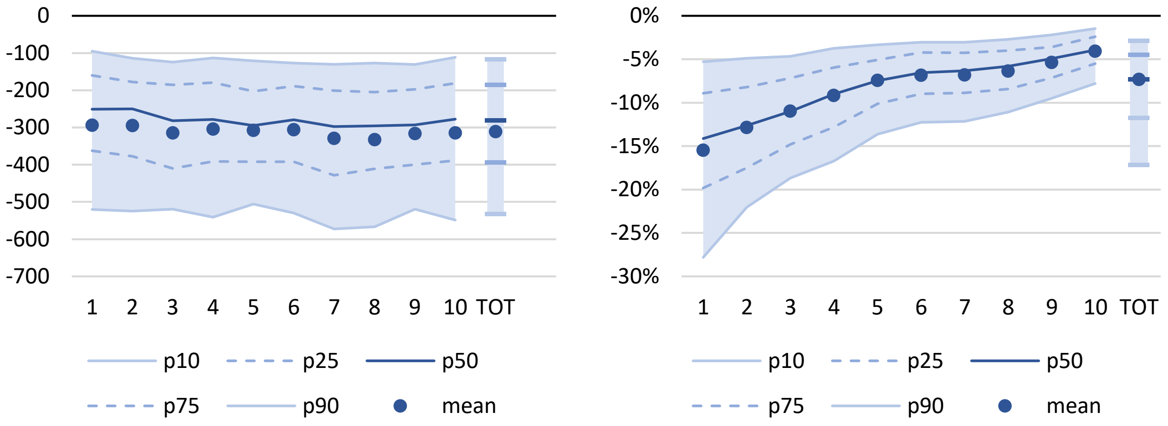
Source: Own calculations based on SILC 2019 and HBS 2018 provided by Statbel.

There is however a larger variation of energy expenditure within income groups compared to between income groups. This is due to household (member) characteristics (size, number of children, age, …), type of dwelling, heating technology, isolation of the dwelling, and finally preference heterogeneity. This implies that the impact of the energy price hike in euro will vary within income deciles, and not as much between income deciles.

The panel on the left-hand side of Figure 1 shows this picture. For each household we calculate the amount of money extra needed in order be able to afford the same energy consumption as before the price shock (the figure represents the negatives of that amount, so that an amount lower than zero corresponds to a welfare loss). Per income decile of equivalized household disposable income we order individuals based on this measure of the impact of the price shock. We show the average of the increased energy expenditure (dots), the median impact of the shock (blue line), and the spread around the median, with the shaded area representing the middle 80%, and the area between the dashed lines representing the middle 50% of the population. The bar on the right-hand side of the panel gives the same information for the entire population. In the right-hand side panel we express the impact in percentage of baseline income.

Figure 1: The distribution of the impact of the energy price hike on the energy bill without compensation.

(1) absolute *(2) relative*



Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

We find on average a negative impact of 311 euro: households would have to spend 311 euro more per month to keep their consumption constant. Only 10% of individuals live in a household where this is less than 118 euro, and 10% of individuals live in a household that has to spend more than 534 euro extra to keep their consumption constant. The variation in absolute impact is much larger within income groups, than it is between income groups.

That changes if we express the impact in proportion of disposable income. In the first decile households should spend on average an additional 15% of their income to keep consumption constant, while this is only 5% in the 10th decile. In the first income decile there is large heterogeneity with the impact ranging from 5% to 28% of disposable income for the middle 80% individuals. This spread diminishes for the higher income deciles. The relative impact ranges between 1% and 8% for the middle 80 percent of individuals in the 10th decile.[3]

3.2 INTRODUCING THE COMPENSATION MEASURES

The simulated price increase in section 3.1 is a counterfactual price increase in case no compensation measures were introduced to lower the energy bill. However, the federal government has introduced

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[3] The heterogeneity within income groups is even underestimated by our simulations. We assume that all households face the same price increase, whereas in reality some households do not (yet) face the increased energy prices, since they still rely on a contract with fixed energy prices. Moreover, even between households that have a contract with variable prices there can be large heterogeneity given that the (variable) prices also depend on the timing of renewal of the contract. We do not take up this heterogeneity in the prices.

several compensation measures in the course of the energy crisis since January 2021. We can identify three groups of compensation measures: (1) conditional price subsidies, (2) indirect tax reforms, and (3) lump sum reductions.[4]

1. Conditional price subsidies: Some households have a right to a social tariff for electricity and gas consumption. Price increases of such tariffs are capped. In the period January 2021 until December 2022 it implies a double price subsidy towards those households that were eligible. First, the initial energy price was lower than without the social tariff and the price increase was much less stark. Before February 2021 eligibility was based on one person in the household receiving one of several specific social benefits, such as social assistance, social assistance for the elderly, or disability benefits. Since February 2021, as part of the COVID-measures, the eligibility was extended towards households with low incomes. The extension stayed in place after the pandemic to alleviate the impact of the energy price crisis The extended eligibility is based on a means-test at the household level. The income benchmarks used depend on household composition, including a less stringent means-test for vulnerable households, such as pensioners.
2. Change in indirect taxation: The federal government lowered the VAT rate from 21% to 6% from March 2022 onwards for electricity, and from April 2022 onwards for gas.
3. Lump sum reductions: The federal government introduced several reductions of the energy bill in two stages. In the spring of 2022 all households buying heating oil are granted a reduction of 225 euro. Households with an electricity contract for the main dwelling received a one-off reduction of 100 euro. Assuming that these premiums cover a year of high energy prices, they correspond to a reduction of 18.75 euro per month for heating oil, and a reduction of 8.30 euro per month for electricity. In the fall of 2022 the heating oil reduction was increased with 75 euro, or 6.25 euro per month. Additionally, a base allowance for electricity and gas was introduced, corresponding to a reduction of the electricity bill with 61 euro, and a reduction of the gas bill with 135 euro. Both reductions are granted monthly from November to March. Analogously to the one-off reduction, we spread the impact out over 12 months, so that the monthly impact is 25.42 euro for the electricity bill and 56.25 euro for the gas bill. To target the base allowance to those who need it most, it is not granted to households that enjoy the social tariff, and the reduction is taxable for very high incomes. The reduction is taxed by 1.5 the average tax rate of the household if the yearly net taxable income exceed 62 000 euro for singles, or 125 000 for couples.

Figure 2 shows for each decile and for the total population, the mean impact on purchasing power of each of these measures. To make a comparison with the impact of the price shock easy, we retake the information on the average additional cost to maintain consumption after the price hike at its pre-shock level (the blue dots of Figure 1) and represent it by the orange bars. The light blue bars represent the average reduction of the energy bill at pre-shock quantities, that stems from the existing social tariff, the dark blue bars represent the average impact of the extension of the social tariff. The red bars represent the impact of the VAT reduction. The light yellow bars show the impact of the first package of energy reductions (on heating oil and electricity) and the dark yellow bars represent the introduction of the base allowance for gas and electricity, and the increase of the reduction for heating oil. Note that there is also an additional negative impact in the high income deciles (dark yellow). This represents

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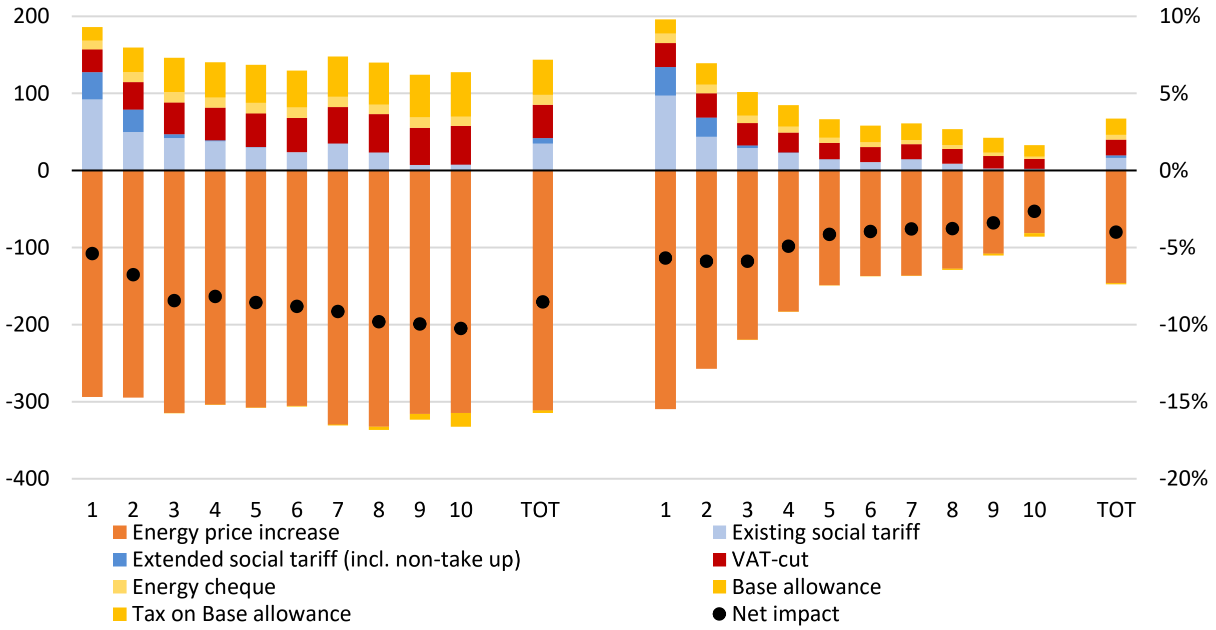
[4] See Appendix I for details on the compensation measures and how they were implemented in the simulations.

the tax on the base allowance for high income households.[5] The panel on the left-hand side shows the impact in euro, in the right-hand side panel the impact is expressed in percentage of disposable income.

Figure 2: The average impact of the energy price hike and compensation on the energy bill.


(1) absolute *(2) relative*

Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

The compensation for the price shock is considerable. Households had to pay on average only 171 euro more to keep their consumption constant, while this was 311 without the compensation. The social tariff, both existing and the extension, was most important for households in the lowest income deciles. The impact of the VAT-reduction and the lump sum reductions (energy cheques and base allowance) is spread out over the income distribution, and mitigates 30% of the impact of the price increase for the middle and high income deciles. The reason that they had less of an impact in the first two deciles is because of the social tariff. The VAT-reduction is less advantageous, given that expenditures are already lowered considerably due to the existing and extended social tariff. Moreover, the base allowance was not granted to households enjoying the social tariff.

However, the impact of these compensatory measures goes beyond the energy bill. Since each of the measures lowers the price of energy, and thus lowers the index which is used in the indexation mechanism, the (indexation of) incomes of households will be lower in a situation with compensatory measures compared to a situation without these measures. In what follows, we evaluate the measures while taking into account this interaction between compensation and indexation.

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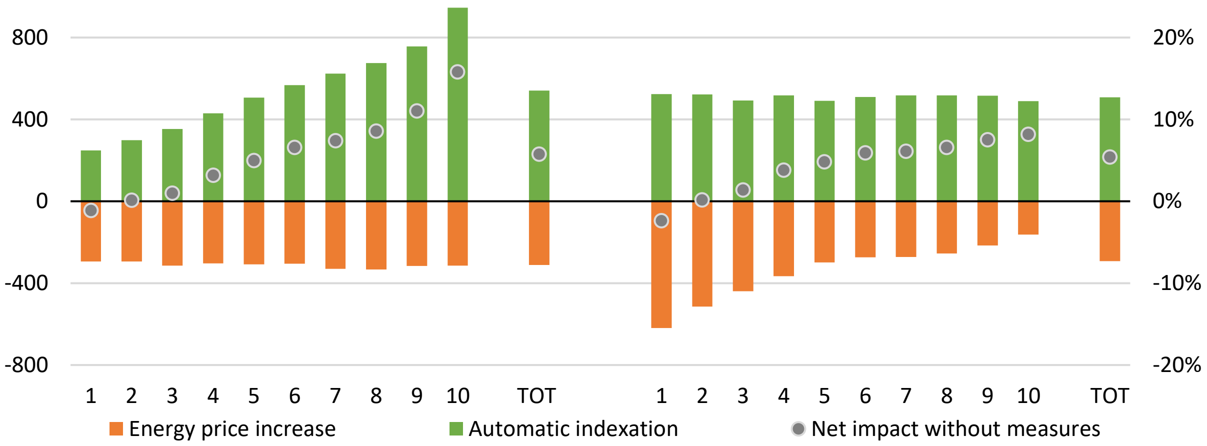
[5] Note that only a small number of households pay this tax on the base allowance for gas and electricity. In our simulation 10% of households have a net taxable income above the income thresholds of 62 000 (125 000) for singles (couples).

3.3 INDEXATION OF INCOMES

Belgian households are protected against a shock in (energy) prices by the automatic indexation of wages and benefits.[6] Nevertheless, the government decided to implement compensatory measures since the impact of indexation is not immediately felt and some incomes are not indexed.[7] To understand the distributional picture of the compensatory measures, including their interaction with indexation, it is useful to first discuss the distributional impact of indexation in the absence of price compensation. Figure 3 shows the impact of indexation of wages and benefits (green bars) after the energy price shock (orange bars retaken from Figure 2) without compensatory measures. The grey dots show the net impact after the price shock and indexation. The average impact of indexation exceeds the average impact of the price increase on expenditures. However, the indexation mechanism does not succeed in compensating the first decile fully for the energy price hike, while households in the middle and high income deciles are on average overcompensated.

Figure 3: The average impact of the energy price hike and indexation, without compensation.



Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact on expenditures and income is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

The explanation for this distributional picture is threefold and follows from the indexation of *income* based on *average* expenditure shares. First, we discuss the impact of using *average* expenditure shares. The indexation in Belgium is based on the health index, which is comparable to a consumer price index but excludes unhealthy goods, such as alcohol, tobacco, diesel and gasoline used for transport. The health index captures price changes of all other goods, and weights them with a reference consumption basket. The basket is more or less calibrated on average consumption of households in Belgium. This means that in the case of an energy price increase, those households that relative to total expenditures spend more on energy than the average household, will not be fully

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[6] Throughout the entire paper we only account for the indexation following from the isolated price shock of energy. We do not account for other commodity price changes, which would also influence the indexation of wages and benefits. That is because we want to isolate the effect of the energy price evolution from any other events.

[7] The modalities of the automatic indexation in Belgium depend on sector and occupation. Benefits and many wages are indexed once the moving average of the health index over four months increases with 2%. Another often-used scheme is an indexation with that moving average of the health index on a fixed moment during the year (in most cases January). That means that the delay between price change and indexation is maximum 16 months. Moreover, a small group of employees don't see their wages indexed; self-employment income and capital income and capital gains are also not (automatically) indexed.

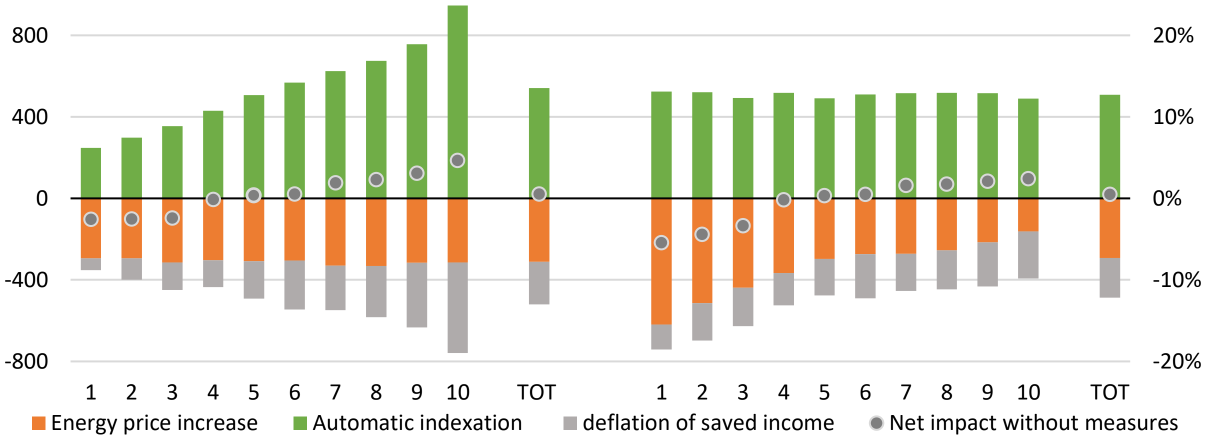
compensated. On the other hand, households that spend less than the average household will be overcompensated. Second, all *income* is indexed even though not all income is spent in the current period with high energy prices. Part of the income is saved, and will be consumed in the next period, when prices will – by assumption – be again lower. This results in an overcompensation of households that save, and only a partial compensation for households that spend more than their income. Third, there is a distributional impact from the fact that not all income is indexed. The income of self-employed, capital gains and income, are not (automatically) indexed after the rise in energy prices.

In Appendix III we discuss the impact in more detail, and decompose the green bars of Figure 3 in (1) the effect of indexing with average expenditure shares, (2) the effect of indexing income with expenditure shares and (3) the effect of leaving out some income components from the indexation mechanism.

Households that save are on average overcompensated by the indexation of income. The increase in their income due to indexation is higher than the increase of their energy bill. However that difference is not for sure a clear gain for those households. That will depend on prices in the future. Up until now we have implicitly assumed that the price increase is only temporary, and that saved income will be spent in an environment with baseline energy prices. It is of course possible that energy prices will stay high in the future, and that the saved income will be spent at high energy prices. In that case, the saved income is worth less than is implicitly assumed in Figure 3. To account for that depreciation of saved income, we deflate saved income with the new price index, based on household-specific expenditures. For more details, see Appendix II.

The grey bars in Figure 4 show this negative impact due to the deflation of saved income. The total impact of the energy price shock and indexation is now much less positive for the middle and high income deciles. The persons belonging to these deciles are still somewhat overcompensated, whereas those in the first three income deciles are now on average undercompensated for the rise in their present and the part of their future higher energy bills covered by current saving.[8]

Figure 4: The average impact of the energy price hike and indexation, without compensation.



Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact on expenditures and income is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

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[8] Appendix III provides a discussion on the heterogeneity behind these average total impacts of the energy shock and indexation across deciles.

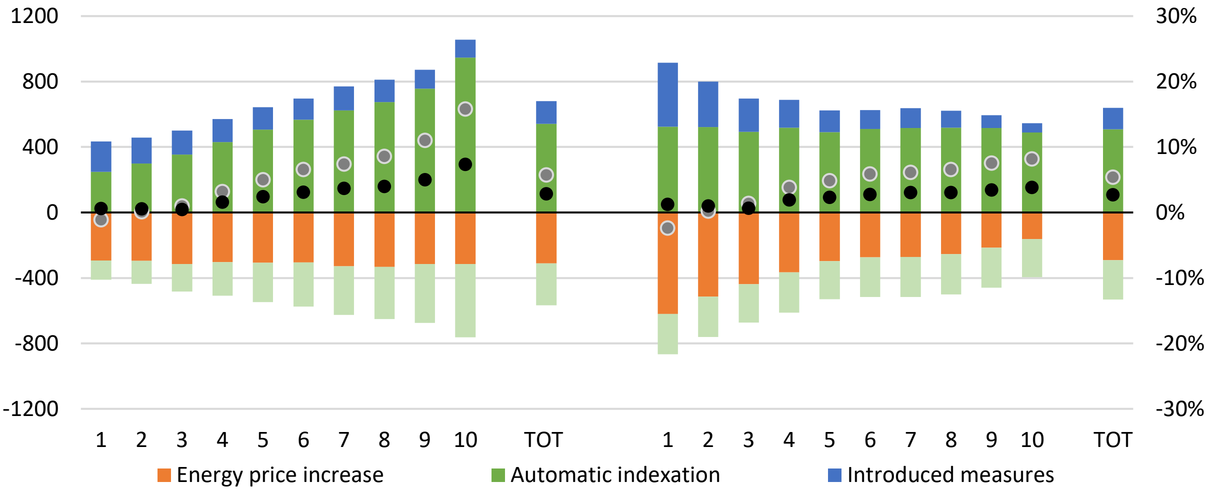
3.4 THE COMPENSATING MEASURES DAMPEN THE IMPACT OF INDEXATION

Up until now we discussed how on the one hand the compensation measures provided some timely alleviation of the energy price crisis, and on the other hand how the indexation of income provides a very substantive protection against the price shock in the medium term. However, the compensation measures also influence the indexation of incomes, as they dampen the rise of the energy price, and thus the price index determining the indexation of incomes. The distributional impact of the compensation measures on the energy bill is different from the impact on incomes due to the dampening effect on indexation. In this section we discuss the total effect of the price shock, the indexation, the compensatory measures, including this important interaction effect.

We show the interaction in Figure 5 where we summarize the impact of the measures in the blue bars.[9] They are the sum of the separate impacts of the measures from Figure 2. We add the automatic indexation that would have happened without the measures (the green bars), as in Figure 3, and the negative impact on the automatic indexation due to the introduction of the measures (light green bars). The average total impact is shown by the black dots. They grey dots show the total impact in the case of no compensatory measures and thus including a full indexation of wages and benefits (they correspond to the grey dots of Figure 2).

On average, people are fully compensated for the price shock through both the compensation and indexation. But high income deciles lose from the introduction of the measures, since the blue bars, which is what they gain from compensatory measures, are smaller than the light green bars, which is what they lose from the interaction with the automatic indexation. In the two lowest income deciles, households win on average from the introduction of the compensation measures. On average, over all income deciles, households lose from the interaction with the automatic indexation.

Figure 5: The average impact of the energy price hike, indexation and compensation.



Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact on expenditures and income is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

We show the resulting heterogeneity of the net impact without government measures and with government measures within each decile in Figure 6. The panels on the left-hand side show the absolute impact, the ones on the right-hand side express the impact relative to baseline disposable

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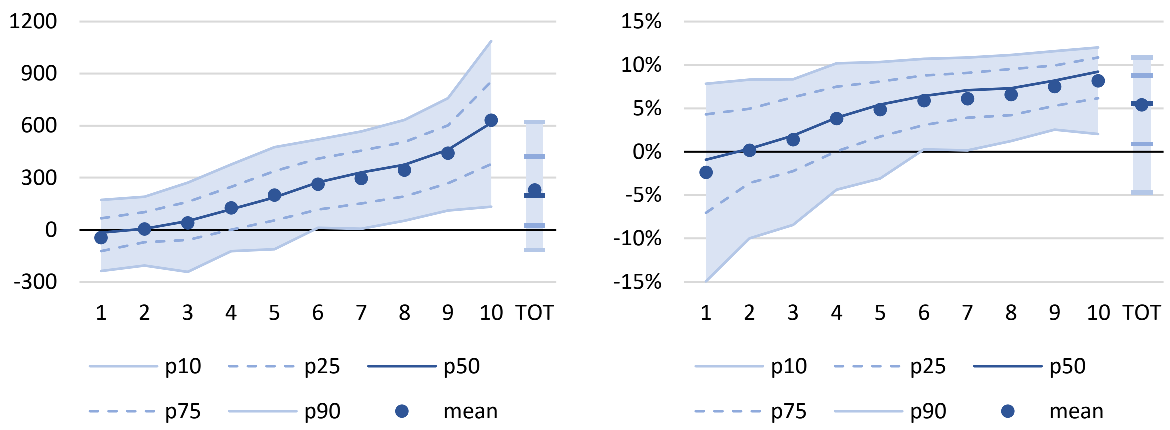
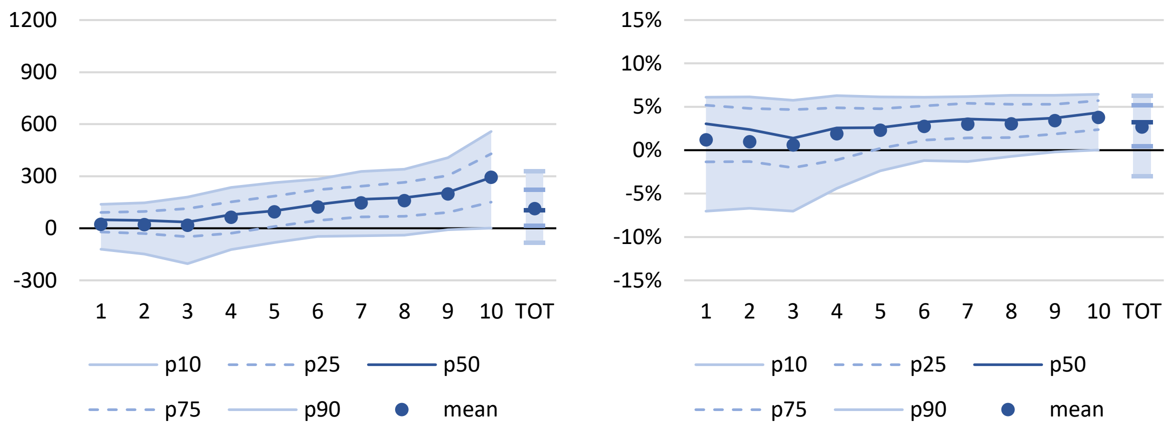
[9] The interaction of each of the specific measures separately is shown in Figure 13 in Appendix IV.

income. The two panels at the top correspond to the scenario without government measures, and the two panels at the bottom correspond to the scenario with the compensation measures included. In each panel we show for each decile the average impact, the median, and the spread around the median. The shaded area covers the middle 80% of the population within one decile ranked on their impact, and the area between the dashed lines covers the middle 50% of that population. The bar on the right-hand side of each panel, gives the same information for the entire population.

Figure 6: The distribution of the impact of the energy price hike, indexation and compensation.



(1) without government measures (absolute) *(2) without government measures (relative)*



(3) with government measures (absolute) *(4) with government measures (relative)*

Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

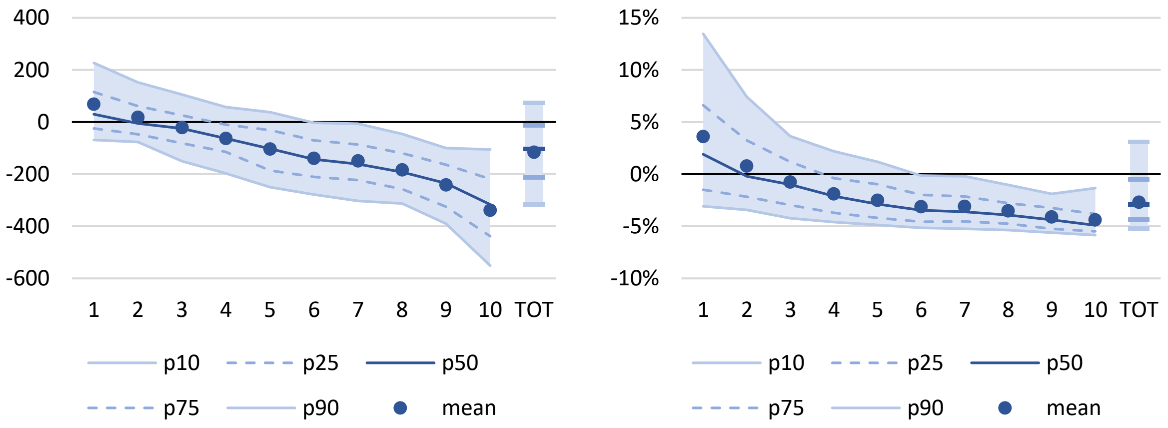
Without the introduction of compensation measures we have the situation that was discussed in the previous section on the indexation mechanism. As shown in that section, the automatic indexation causes an overcompensation for most households in the upper half of the distribution, and a loss for low-income households. There is a clear regressive effect. High income deciles are on average better off than low income deciles after the energy price increase. The households that are faced with a loss due to the energy price increase are concentrated in the first two deciles. More than half of the persons in these deciles face losses.

The introduction of the government measures (bottom two panels), changes the picture. In the first two income deciles there are less households faced with a loss. Expressed in relative terms, as a proportion of disposable income, such small losses in euro can still represent a significant percentage of baseline income. Panel (4) represents this relative impact after the introduction of government measures. In each of the bottom three deciles there are still 10% of individuals that are faced with a household loss larger than 7% of baseline income. But, the income gradient is far less outspoken after the introduction of compensatory measures (compare panel 3 with panel 4). When taking into account the compensation measures, less than 10% of the persons belonging to the 10th decile gain more than 10% of household income from the price increase. Without government measures this was more than 50%.

From Figure 6 we can conclude that the compensatory measures protected a substantial part of the low-income households against large losses, and mitigated the overcompensation of high-income households. But, also the impact of the compensatory measures themselves (that is when filtering out the impact of the price shock) is not uniform within one income decile. To show the pure impact of the measures, we present in Figure 7 the difference in the overall impact of the price shock in a case with government measures and in a situation without government measures (that is the difference in the top and the bottom panels of Figure 6). Within a decile, we rank individuals according to the magnitude of that difference. For each decile we show then the average of that difference, the median of that difference, and the spread around the median, in a similar way as for previous figures.

Figure 7 makes the redistributive impact of the measures, already uncovered in the discussion of Figure 6, transparent. Low income households gain from the introduction of compensation, while high income households lose from the compensation. From the 6th decile onwards more than 90% of individuals undergo a negative impact after the introduction of the measures. This *does not* mean that these individuals lose from the price shock itself. On the contrary, we already highlight previously that an overwhelming majority of these persons where overcompensated through the indexation mechanism. However, their gains are less than what they would have been without government compensation.

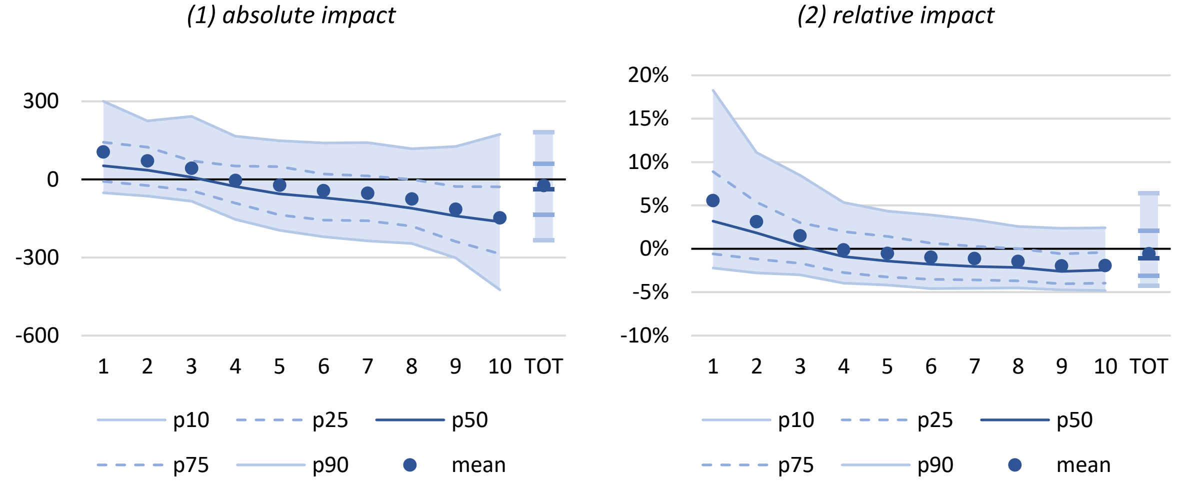
Figure 7: The distribution of the impact of the compensation measures.


(1) absolute impact *(2) relative impact*

Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a ‘smoothed average’, i.e. the ratio of the average impact over the average disposable income.

Up to now in our discussion of the compensation measures, we assumed that the energy price shock was only temporary. If prices stay high in the future, we need to adjust our measure of households’ welfare, to take into account that income saved in the current period will be spent at high prices in the future. We therefore adjust the additional amount of euros necessary to keep energy consumption constant with the ratio of baseline income over baseline total expenditures.[10] We assume that the current prices are also the future prices, i.e. that the compensation measures have lowered prices permanently. This implicitly assumes that the compensation measures will stay in place as long as the prices are high. Under that assumption, the impact of the energy price shock is larger for high income households. Conversely, the income gradient caused by the automatic indexation is less outspoken. Appendix V shows the overall impact of the energy price shock, the compensation, and the indexation when saved income is deflated due to high prices in the future. Here we focus on the overall impact of solely the compensation. In Figure 8 we show the average impact, as well as the heterogeneity within income groups (similarly as in Figure 7, but now with deflated saving).

Figure 8: The distribution of the impact of the compensation measures.



Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

Even with the deflation of saved income, there is still a clear redistributive effect of the introduction of the compensation. The positive impact of the compensation is concentrated at the bottom two income deciles, where around 75% of individuals are experiencing gains from the compensation measures. Of course, these individuals might still lose overall, but they will lose less compared to a situation without government measures.

There is mainly a negative impact of the government measures from the 4th decile onwards, with more than 50% of individuals losing from the introduction of the compensation. In the top three deciles this is more than 75% of individuals. Contrary to what we saw without the deflation of saved income (Figure 7), there are still around 25% of individuals in the top three deciles who gain from the introduction of the compensatory measures. This is due to our assumption that prices will stay constant in the future, and thus include the impact of the measures on consumer prices. For households that save a lot, there is a positive impact because saved income will be spent at lower prices in the future due to the introduction of the compensation measures. If we assume that compensation was temporary, even though prices would stay high, there would not be such a large group with a positive impact at the top of the income distribution.

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[10] See Appendix II for a justification of this approach.

4 DISCUSSION

In this paper we have shown that the interaction between compensation and indexation changes the distributional impact of the price shock. While the compensation measures are on average not beneficial for households, they had an important effect on the energy bill.

Behind that average we find that low-income households with high energy expenditures are compensated through both compensation and indexation for the rising energy bill, but that middle and high income households, which, without any compensation measures, would have been overcompensated by the indexation mechanism, are losing part of that overcompensation. If we take into account the deflation of saved income due to high prices in the future, the overcompensation for high income households becomes much smaller, and the introduction of compensation measures has a mixed effect on high income households, as is the effect for low income households. Those that spend less than average on energy, relative to their total expenditures, will lose from the introduction of the compensation, those that spend more than average on energy, will gain from the introduction of compensation.

The fact that the compensation measures dampens the indexation of wages, means that they can also be viewed as indirect support to employers. Indeed, the compensation lowers average prices, which lowers the health index. As a consequence, the labor costs of employers (including the government) are lower than what they would have been compared to a situation with high energy prices and no compensation of households.

In the argumentation for the compensation measures, and the public discussion regarding the evaluation of these measures, the interaction with indexation has not yet been addressed. Moreover, the policy objectives of the compensation that have been put forward, namely supporting households for the rising energy prices, are no longer reached by the compensation, given that they interact with wage formation.

Nevertheless, the compensation can – also after taking into account the interaction with the indexation and the overall negative effect – be motivated. First, low income household are better protected than without the compensation. Second, high income households would have been overcompensated by the indexation of wages and benefits. This overcompensation is alleviated by the compensation. If we account for high prices in the future, and deflate the saved income, there is on average no longer any overcompensation after introduction of the compensation measures for the high income deciles. Third, the compensation measures support better those households that have high energy expenditure due to dwelling type, isolation, heating source, etc. Indexation does not account for these differences in energy use. Finally, the compensation can also be seen as a transfer to employers. Employers were already confronted with high energy prices, but also face high labor costs due to the indexation of gross wages. Supporting these firms is a legitimate motivation for introducing compensation measures that reduces the price level, and thus dampens the price index with which wages are adapted.

However, there might be other policy options that reach the same objectives, but do not share some of the disadvantages of the current compensation measures. One main disadvantage of compensating through lower energy bills, is that it might affect energy demand. By lowering the price of energy, households will consume more energy (Peersman & Wauters, 2022). A second main disadvantage is that it has important spillovers on other applications of “automatic indexation.” Not only wage and benefit growth is linked to the evolution of the CPI (or a variation of such an index, such as the health index), also other financial flows are adjusted with such indices. For example, in Belgium the transfers from the federal government towards the regions and communities is determined by changes in the CPI.

Direct income support could also support low-income households, and when financed by a crisis tax on high income households, it would result in a redistributive effect that might be equivalent to that of the current compensation measures, without being targeted towards households that consume a lot of energy. Moreover, if the crisis tax would be high enough to raise a budget to support firms, such a support could also be targeted towards the most vulnerable firms, or towards sectors in which the spillover of labor costs on commodity prices is largest. Now, the support is targeted towards firms with labor-intensive production.

In any case, the evaluation of the compensation measures, and the policy recommendations, depend on the policy objectives that one wanted to attain by introducing them. Even though the interaction between compensation and indexation is not recognized in the motivation of introducing the compensation, any evaluation of the compensation should take this interaction into account. We have shown that the impact of compensation on indexation erodes the positive impact of indexation for middle and high income households. On the other hand, the compensation after interaction with indexation, is still targeted towards low income households.

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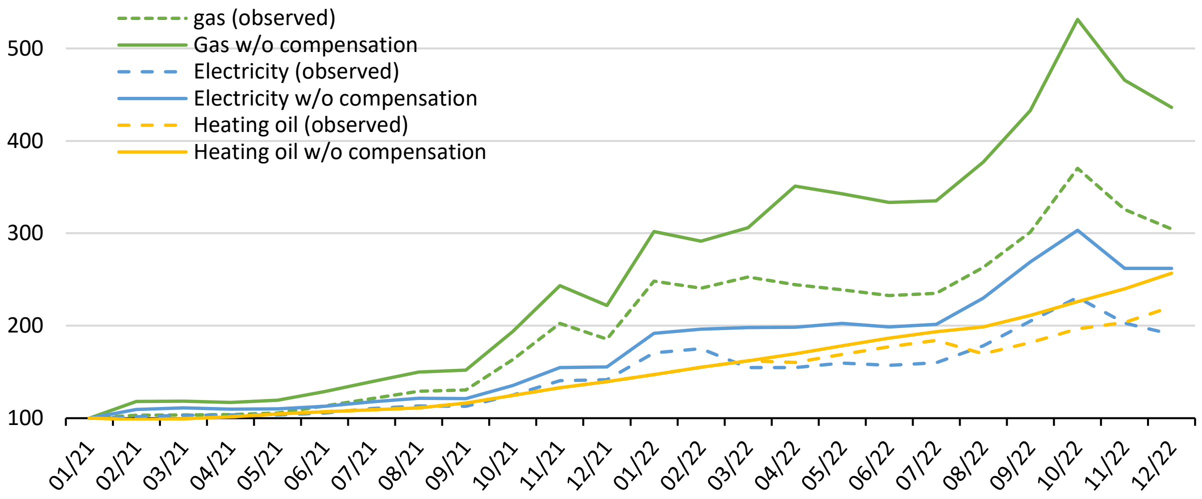
APPENDIX I: THE IMPLEMENTATION OF THE PRICE SHOCK, INDEXATION, AND COMPENSATION

The implemented energy price increase is calibrated on real price evolutions. We start from the price changes for electricity, gas and heating oil between January 1st, 2021 and the most recent predictions for December 31st, 2022. For our baseline scenario (the price rise in case no compensations were introduced) we need the evolution of energy prices as it would have been if there were no compensatory measures. We calculate such a counterfactual evolution, based on detailed projections provided by the Federal Planning Bureau, and show it in Figure 9. We use the evolution of prices for our implemented price change in the simulations. we arrive at a 150% increase of the price of electricity and heating oil, and a 350% increase of the price of gas.

Figure 9: The evolution of energy prices.



These price changes reflect the changes in prices of new contracts. We thus assume that in our simulation every household has to renew its contract with the new prices. This is another reason to not misread our simulations as the welfare impact of today. This would be much more driven by heterogeneity in the consumer prices, which we cannot observe in our simulation.[11] Our simulations should be seen as an assessment of the joint impact of an external price change, indexation and compensation on the household income distribution, keeping all other factors constant. The qualitative conclusions we draw from these simulations, would stay the same with a higher or a lower simulated energy shock.

We assume that the indexation of wages and expenditures is only affected by the (simulated) increase of energy prices. All other commodity prices stay constant throughout the analysis. We implement the indexation of income by calculating for each simulation the change in health index, compared to the baseline. This index is calculated by multiplying the respective weights of gas, electricity and heating oil consumption that are used in the health index in 2022, with the average price change resulting from our simulations. Table 3 shows for each simulated scenario the health index, normalized to 100 in the baseline. The table should be read from top to bottom, where in each line an element is added to the

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[11] For electricity and gas, private customers in Belgium conclude a contract with an energy provider. Energy providers offer different types of contracts. The contract stipulates a term (usually one year, but sometimes two or three years) and a price. This price can be fixed for the term of the contract, or flexible. Flexible prices adapt monthly or three monthly to a forward looking or spot price index stipulated in the contract. Customers can change provider before the end of their contract. Fixed price contracts are rarely offered since the end of 2021.

simulation. For example the last line shows that the normalized health index is equal to 107.51 after the energy price shock and after the introduction of all compensation measures. The normalized health index would be equal to 114.25 if no compensation measures were introduced.

Table 3: Change in health index after the energy price shock and compensation measures

	Normalized Health index
Baseline	100.00
After energy price shock	114.25
+ social tariff (existing + extended)	112.38
+ decrease in VAT-rate	110.45
+ reduction from spring 2022	109.79
+ reductions from fall 2022	107.51

For calculating the disposable income after indexation, we index all gross incomes that are automatically indexed, i.e. wages, pensions, social benefits. We also index the simulated social security contributions related to each one of those incomes. Finally, to calculate the personal income tax after indexation, we split out the by EUROMOD simulated tax bill of a household in proportion to the different components of the net taxable income, i.e. gross wages, pensions, social benefits, self-employment income, and so on. Then the taxes ascribed to the income components that are indexed, are increased by the same factor as the indexation. We deliberately do not account for any fiscal drag due to a lagged indexation of taxation parameters, as we want to make abstraction of any timing issues in our analysis. This fiscal draft effect is anyway negligible in the medium term.

There are five compensation measure-packages that can be distinguished. They are simulated in a specific order. First, we implement the existing social tariff, for which eligibility depends on receiving specific benefits. Second, we implement the extension of the social tariff to a group that receives increased reimbursement in the sickness insurance. Since we know there is large non-take-up for that benefit, we also simulate the non-take-up for the social tariff, so that the extended number of households to whom the social tariff is granted, is comparable to what is observed in reality. The social tariff essentially limits the price increase over time. In our reference period, from January 2021 until December 2022, this implies two advantages for the eligible households. First, they pay a lower initial price (for electricity 185.90 euro per MWh compared to 270.2 euro without the social tariff; for gas 5.86 euro per Gj instead of 13 euro). Second, the price increase is much less stark. The price shock in the social tariff is also calibrated on the true evolution of the social tariff prices between January 2021 and December 2022. The social tariff for electricity increases with 65%, the social tariff for gas increases with 82%.[12] Third, the VAT-rate on gas and electricity is lowered from 21% to 6%. Fourth, there have been two packages of reductions on the energy bill. A first was introduced in the spring of 2022. It entails a reduction of the energy bill with 100 euro, and a premium of 225 euro to cover heating oil expenses. We simulate these as if they were spread out over 12 months. That is, we assume the one-off reductions were used to cover rising expenditure in an entire year. Only those with positive expenditures for respectively electricity and heating oil, receive the reduction and premium. Finally, the second package of energy bill reductions was announced in the autumn of 2022. The government introduced an additional premium for heating oil expenditure of 75 euro. Additionally, households that do not enjoy the social tariff, and do not have a fixed contract from before October 1st 2021, have the right on a "base allowance" of electricity and gas. The base allowance is equivalent to a reduction of 61 euro per month for electricity and 135 euro per month for gas. Every month between November

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[12] See https://www.creg.be/nl/professionals/marktwerking-en-monitoring/boordtabel

2022 and March 2023 the base allowance is settled on the energy bill. In the simulation we only exclude the households that have a social tariff (since we assume every household has to renew its contract). Analogously to the other reductions, we spread this allowance, received over the course of 5 months, over a full year, to arrive at a monthly amount of the reduction. An additional characteristic of the base allowance is that it is taxable for households with high incomes. If the net taxable income of a single (couple) exceeds 62 000 euro (125 000 euro), the allowance is taxed at 1.5 times the average tax rate of the fiscal household. We also implement this additional tax in our simulation, but only 10% of the households are faced with such an additional tax.

The order of implementation of the measures matters for the impact of each simulation. Indeed, the impact of the VAT-reduction is lower for households that have a social tariff, given that expenditures are lower.

APPENDIX II: DERIVATION OF THE WELFARE MEASURE

To measure the welfare impact on households of the combined change in prices and disposable income of households, we utilize the compensating gain-concept of King (1983). It is defined as:

$$\begin{aligned} WG(\mathbf{p}_1,\mathbf{p}_0,y_1,y_0) &= e(\mathbf{p}_1,v(\mathbf{p}_1,y_1)) - e(\mathbf{p}_1,v(\mathbf{p}_0,y_0)) \\ &= e(\mathbf{p}_1,v(\mathbf{p}_1,y_1)) - e(\mathbf{p}_0,v(\mathbf{p}_0,y_0)) + e(\mathbf{p}_0,v(\mathbf{p}_0,y_0)) - e(\mathbf{p}_1,v(\mathbf{p}_0,y_0)) \\ &= y_1 - y_0 - CV(\mathbf{p}_1,\mathbf{p}_0,v(\mathbf{p}_0,y_0)), \end{aligned} \tag{3}$$

with $v(\mathbf{p},y)$ the indirect utility function, reflecting the maximal utility level someone faced with prices $\mathbf{p}$ and disposable income y, can obtain; $e(\mathbf{p},u)$ denotes the expenditure function (that is, the minimal expenditures necessary to reach utility level u when confronted with prices $\mathbf{p}$); y_0 is the baseline disposable income and y_1 the disposable income after the shock (including indexation); $\mathbf{p}_0$ is the old price vector and $\mathbf{p}_1$ the new price vector, with high energy prices, and possible price reduction, depending on the case at hand. $CV(\mathbf{p}_1,\mathbf{p}_0,u_0) \equiv e(\mathbf{p}_1,u_0) - e(\mathbf{p}_0,u_0)$ is the compensating variation, i.e. the monetary compensation one should receive to be as well of after the price shock as before, keeping the baseline disposable income constant. The compensating gain is intuitively straightforward, in that it is equal to the extra income received minus the compensation one should get to be as well off after the price change. To operationalize the compensating variation, we need to make assumptions on the structure of preferences.

We assume that preferences over consumption are Leontief. The household thus maximizes following problem:

$$\max_{\mathbf{x}} u = \min\{a_i x_i\} \qquad i \in G \qquad\qquad s.t. \qquad \mathbf{p}'\mathbf{x} \le y, \tag{4}$$

with a_i the preference parameters, x_i the quantities consumed for each good i, element of G, the set of all goods. Expenditures cannot exceed disposable income y. The solution to this maximization problem leads to the Marshallian demand for good i:

$$D_i(\mathbf{p},y) = \left(a_i \sum_j \frac{p_j}{a_j}\right)^{-1} y. \tag{5}$$

The corresponding expenditure function is equal to:

$$e(\mathbf{p},u) = \left(\sum_j \frac{p_j}{a_j}\right) u. \tag{6}$$

The corresponding indirect utility function is equal to:

$$v(\mathbf{p},y) = \left(\sum_j \frac{p_j}{a_j}\right)^{-1} y. \tag{7}$$

The compensating variation for the case of Leontief preferences thus corresponds to:

$$\begin{aligned} CV(\mathbf{p}_1,\mathbf{p}_0,y_0) &= e\big(\mathbf{p}_1,v(\mathbf{p}_0,y_0)\big)-e\big(\mathbf{p}_0,v(\mathbf{p}_0,y_0)\big)\\ &=\left(\sum\nolimits_k \frac{p_{k,1}}{a_k}\right)\left(\sum\nolimits_j \frac{p_{j,0}}{a_j}\right)^{-1} y_0-\left(\sum\nolimits_k \frac{p_{k,0}}{a_k}\right)\left(\sum\nolimits_j \frac{p_{j,0}}{a_j}\right)^{-1} y_0 \\ &=\sum\nolimits_k \left(p_{k,1}-p_{k,0}\right)D_k(\mathbf{p}_0,y_0). \end{aligned} \tag{8}$$

Thus, in this case, the compensating variation is the extra amount of euros needed at the new prices, in order to be able to buy the same bundle of goods as at original prices.

So far we have assumed that there was only one period, and all income was spent during that same period. In our application we however deal with saved income that will be spent in the future, possibly at different prices. We thus want to make a difference between consumption in the current period, and consumption in the following period. Assume the household's intertemporal preferences are represented by the following utility function:

$$U=\min\left\{\beta_p \min_i \left\{a_i x_{i,p}\right\}, \beta_f \min_i \left\{a_i x_{i,f}\right\}\right\}, \tag{9}$$

with $x_{i,p}$ the consumed quantity of a good i in the current period, and $x_{i,f}$ the consumed quantity in the future. The within period preference parameters for each good i, denoted by a_i, are identical across periods. The parameters β_p and β_f determine the optimal amount of current expenditure and saving.

As the utility function (9) is weakly separable between current and future consumption, a two-stage budgeting approach can be used to maximize (9) subject to the intertemporal budget constraint:

$$\sum_{j\in G} p_{j,p}x_{j,p}+\sum_{j\in G} p_{j,f}x_{j,f}\le y, \tag{10}$$

where $p_{j,p}$ and $p_{j,f}$ denote respectively the current and future price of commodity j.

Let E be the total expenditures in the current period, that is $E=\sum_{j\in G} p_{j,p}x_{j,p}$, and S the income saved for future consumption, so that $S=\sum_{j\in G} p_{j,f}x_{j,f}$. The within period Marshallian demand functions then equal:

$$\tilde{D}_{i,p}\left(\mathbf{p}_p,E\right)=\left(a_i\sum_{j\in G}\frac{p_{j,p}}{a_j}\right)^{-1}E \qquad \text{and} \qquad \tilde{D}_{i,f}\left(\mathbf{p}_f,S\right)=\left(a_i\sum_{j\in G}\frac{p_{j,f}}{a_j}\right)^{-1}S. \tag{11}$$

To determine the optimal amount of current and future spending, E and S, the household maximizes

$$\max_{E,S}\ \min\left\{\frac{\beta_p E}{L_{\mathbf{a}}\left(\mathbf{p}_p\right)},\frac{\beta_f S}{L_{\mathbf{a}}\left(\mathbf{p}_f\right)}\right\} \text{ s.t. } E+S\le y, \text{ with } L_{\mathbf{a}}(\mathbf{p})\equiv\sum_{j\in G}\frac{p_j}{a_j} \tag{12}$$

The solution to this maximization problem is equal to:

$$\begin{aligned} E^* &= \frac{L_{\mathbf{a}}\left(\mathbf{p}_p\right)/\beta_p}{L_{\mathbf{a}}\left(\mathbf{p}_p\right)/\beta_p + L_{\mathbf{a}}\left(\mathbf{p}_f\right)/\beta_f} y, \\ S^* &= \frac{L_{\mathbf{a}}\left(\mathbf{p}_f\right)/\beta_f}{L_{\mathbf{a}}\left(\mathbf{p}_p\right)/\beta_p + L_{\mathbf{a}}\left(\mathbf{p}_f\right)/\beta_f} y. \end{aligned} \tag{13}$$

The indirect utility function corresponding to the maximization of the two-period utility function (9) subject to the intertemporal budget constraint (10), denoted by $V\left(\mathbf{p}_p, \mathbf{p}_f, y\right)$, equals:

$$V\left(\mathbf{p}_p, \mathbf{p}_f, y\right) = \frac{y}{L_{\mathbf{a}}\left(\mathbf{p}_p\right)/\beta_p + L_{\mathbf{a}}\left(\mathbf{p}_f\right)/\beta_f}, \tag{14}$$

and the corresponding expenditure function denoted by $m\left(\mathbf{p}_p, \mathbf{p}_f, U\right)$, equals:

$$m\left(\mathbf{p}_p, \mathbf{p}_f, U\right) = \left(\frac{L_{\mathbf{a}}\left(\mathbf{p}_p\right)}{\beta_p} + \frac{L_{\mathbf{a}}\left(\mathbf{p}_f\right)}{\beta_f}\right) U. \tag{15}$$

The Marshallian demand functions resulting from the two-period utility maximization problem are equal to:

$$\begin{aligned} D_{i,p}\left(\mathbf{p}_p, \mathbf{p}_f, y\right) &= \left(\frac{L_{\mathbf{a}}\left(\mathbf{p}_p\right)}{\beta_p} + \frac{L_{\mathbf{a}}\left(\mathbf{p}_f\right)}{\beta_f}\right)^{-1} \frac{y}{\beta_p a_i}, \\ D_{i,f}\left(\mathbf{p}_p, \mathbf{p}_f, y\right) &= \left(\frac{L_{\mathbf{a}}\left(\mathbf{p}_p\right)}{\beta_p} + \frac{L_{\mathbf{a}}\left(\mathbf{p}_f\right)}{\beta_f}\right)^{-1} \frac{y}{\beta_f a_i}. \end{aligned} \tag{16}$$

We can now compute the compensating variation corresponding to the maximized two-period utility function. Recall that the compensating variation is defined as:

$$CV_U\left(\mathbf{p}_{p,1}, \mathbf{p}_{f,1}, \mathbf{p}_{p,0}, \mathbf{p}_{f,0}\right) = m\left(\mathbf{p}_{p,1}, \mathbf{p}_{f,1}, U_0\right) - m\left(\mathbf{p}_{p,0}, \mathbf{p}_{f,0}, U_0\right), \tag{17}$$

which after replacing U_0 with the indirect utility function (14) and using the Marshallian demand functions (16), can be transformed into:

$$\begin{aligned} CV\left(\mathbf{p}_{p,1}, \mathbf{p}_{f,1}, \mathbf{p}_{p,0}, \mathbf{p}_{f,0}, y\right) &= m\left(\mathbf{p}_{p,1}, \mathbf{p}_{f,1}, V\left(\mathbf{p}_{p,0}, \mathbf{p}_{f,0}, y\right)\right) - m\left(\mathbf{p}_{p,0}, \mathbf{p}_{f,0}, V\left(\mathbf{p}_{p,0}, \mathbf{p}_{f,0}, y\right)\right) \\ &= \frac{L_{\mathbf{a}}\left(\mathbf{p}_{p,1}\right)/\beta_p + L_{\mathbf{a}}\left(\mathbf{p}_{f,1}\right)/\beta_f}{L_{\mathbf{a}}\left(\mathbf{p}_{p,0}\right)/\beta_p + L_{\mathbf{a}}\left(\mathbf{p}_{f,0}\right)/\beta_f} y - \frac{L_{\mathbf{a}}\left(\mathbf{p}_{p,0}\right)/\beta_p + L_{\mathbf{a}}\left(\mathbf{p}_{f,0}\right)/\beta_f}{L_{\mathbf{a}}\left(\mathbf{p}_{p,0}\right)/\beta_p + L_{\mathbf{a}}\left(\mathbf{p}_{f,0}\right)/\beta_f} y \\ &= \sum_{i \in G}\left(p_{i,p,1} - p_{i,p,0}\right) D_{i,p}\left(\mathbf{p}_{p,0}, \mathbf{p}_{f,0}, y\right) + \sum_{i \in G}\left(p_{i,f,1} - p_{i,f,0}\right) D_{i,f}\left(\mathbf{p}_{p,0}, \mathbf{p}_{f,0}, y\right). \end{aligned} \tag{18}$$

So we obtain again that the cost of a price change from $\left(\mathbf{p}_{p,0}, \mathbf{p}_{f,0}\right)$ to $\left(\mathbf{p}_{p,1}, \mathbf{p}_{f,1}\right)$ can be assessed as the difference in expenditures needed to buy the same baseline bundle at the new prices $\left(\mathbf{p}_{p,1}, \mathbf{p}_{f,1}\right)$. Of course, we do not observe next period baseline consumption, $D_{i,f}\left(\mathbf{p}_{p,0}, \mathbf{p}_{f,0}, y\right)$, and therefore need to simulate it. To do so, notice that within period Marshallian demands (Equation (11)) and the two period Marshallian demands (Equation (16)) are, through the expression for optimal current expenditures and saving (Equation (13)), connected as follows:

$$\begin{aligned} D_{i,p}\left(\mathbf{p}_p,\mathbf{p}_f,y\right) &= \left(\frac{L_{\mathbf{a}}\left(\mathbf{p}_p\right)}{\beta_p}+\frac{L_{\mathbf{a}}\left(\mathbf{p}_f\right)}{\beta_f}\right)^{-1}\frac{y}{\beta_p a_i} = \frac{E^*}{a_i L_{\mathbf{a}}\left(\mathbf{p}_p\right)} = \tilde{D}_{i,p}\left(\mathbf{p}_p,E^*\right), \\ D_{i,f}\left(\mathbf{p}_p,\mathbf{p}_f,y\right) &= \left(\frac{L_{\mathbf{a}}\left(\mathbf{p}_p\right)}{\beta_p}+\frac{L_{\mathbf{a}}\left(\mathbf{p}_f\right)}{\beta_f}\right)^{-1}\frac{y}{\beta_f a_i} = \frac{S^*}{a_i L_{\mathbf{a}}\left(\mathbf{p}_f\right)} = \tilde{D}_{i,f}\left(\mathbf{p}_f,S^*\right). \end{aligned} \tag{19}$$

Hence, the compensating variation can further be rewritten as:

$$\begin{aligned} & CV\left(\mathbf{p}_{p,1},\mathbf{p}_{f,1},\mathbf{p}_{p,0},\mathbf{p}_{f,0},y\right) \\ & =\sum_{i\in G}\left(p_{i,p,1}-p_{i,p,0}\right)D_{i,p}\left(\mathbf{p}_{p,0},\mathbf{p}_{f,0},y\right)+\sum_{i\in G}\left(p_{i,f,1}-p_{i,f,0}\right)D_{i,f}\left(\mathbf{p}_{p,0},\mathbf{p}_{f,0},y\right) \\ & =\sum_{i\in G}\left(p_{i,p,1}-p_{i,p,0}\right)\tilde{D}_{i,p}\left(\mathbf{p}_{p,0},E^*\right)+\sum_{i\in G}\left(p_{i,f,1}-p_{i,f,0}\right)\tilde{D}_{i,f}\left(\mathbf{p}_{f,0},S^*\right) \\ & =\sum_{i\in G}\left(p_{i,p,1}-p_{i,p,0}\right)\tilde{D}_{i,p}\left(\mathbf{p}_{p,0},E^*\right)+\sum_{i\in G}\left(p_{i,f,1}-p_{i,f,0}\right)\tilde{D}_{i,p}\left(\mathbf{p}_{p,0},E^*\right)\frac{S^*}{E^*}\frac{L_{\mathbf{a}}\left(\mathbf{p}_{p,0}\right)}{L_{\mathbf{a}}\left(\mathbf{p}_{f,0}\right)}. \end{aligned} \tag{20}$$

When we further assume that the baseline is a period of zero inflation, that is $\mathbf{p}_{p,0}=\mathbf{p}_{f,0}$, this further reduces to:

$$\begin{aligned} & CV\left(\mathbf{p}_{p,1},\mathbf{p}_{f,1},\mathbf{p}_{p,0},\mathbf{p}_{f,0},y\right) \\ & =\sum_{i\in G}\left(p_{i,p,1}-p_{i,p,0}\right)\tilde{D}_{i,p}\left(\mathbf{p}_{p,0},E^*\right)+\sum_{i\in G}\left(p_{i,f,1}-p_{i,f,0}\right)\tilde{D}_{i,p}\left(\mathbf{p}_{p,0},E^*\right)\frac{S^*}{E^*}. \end{aligned} \tag{21}$$

When future price fall back to the low baseline level, the last term drops. Otherwise we can further simplify Equation (21) to:

$$CV\left(\mathbf{p}_{p,1},\mathbf{p}_{f,1},\mathbf{p}_{p,0},\mathbf{p}_{f,0},y\right)=\sum_{i\in G}\left(p_{i,p,1}-p_{i,p,0}\right)\tilde{D}_{i,p}\left(\mathbf{p}_{p,0},E^*\right)\frac{y}{E^*}. \tag{22}$$

The compensating variation then should thus be scaled by a factor of baseline income over baseline expenditures to account for the fact that prices will stay high in the future. The resulting compensating gain is equal to:

$$WG\left(\mathbf{p}_1,\mathbf{p}_0,y_1,y_0\right)=y_1-y_0-\frac{y_0}{E_0}\sum_{i\in G}\left(p_{i,p,1}-p_{i,p,0}\right)\tilde{D}_{j,p}\left(\mathbf{p}_{p,0},E_0\right). \tag{23}$$

Note that the downsizing of the welfare impact when baseline expenditures are larger than baseline income, makes no intuitive sense in our analysis. Therefore, we only apply the scaling when the ratio y_0 / E_0 is larger than one.

APPENDIX III: DECOMPOSITION OF THE DISTRIBUTIONAL IMPACT OF THE AUTOMATIC INDEXATION MECHANISM

An ideal indexation aims to fully mitigate the impact on the utility level of households. A true cost-of-living indexation must offset the compensating variation related to the price change.[13] Given our assumption on preferences, such a true cost-of-living indexation, denoted by $y_1^I - y_0$, is equal to the extra amount of money needed to buy the baseline consumption bundle at new prices.[14] We have:

$$\begin{aligned} y_1^I - y_0 &= \sum\nolimits_i p_{i,1} x_{i,0} - \sum\nolimits_i p_{i,0} x_{i,0} \\ &= \sum\nolimits_i p_{i,0} x_{i,0} \sum\nolimits_i \frac{p_{i,1} - p_{i,0}}{p_i^0} \frac{p_{i,0} \cdot x_{i,0}}{\sum\nolimits_j p_{j,0} \cdot x_{j,0}} \\ &= E_0 \sum\nolimits_k \dot{p}_k w_{k,0} \end{aligned} \tag{24}$$

with $p_{i,1}$ the new prices, $p_{i,0}$ the old prices, and $x_{i,0}$ the baseline consumption for each good i. The second and third line show that this is equivalent to indexing baseline total expenditures, $E_0 \equiv \sum\nolimits_i p_{i,0} x_{i,0}$, with a price-change vector, consisting of the weighted sum of the proportional changes in the price of each good i, denoted by $\dot{p}_i$. The weights are equal to the expenditure share in the baseline $w_{i,0} \equiv p_{i,0} x_{i,0} / E_0$. Note only prices of goods which effectively change, have an impact on this true cost-of-living indexation. In our analysis, this implies that only energy goods (electricity, gas, and heating oil) need to be taken into account.

The indexed income is equal to

$$y_i^I = \left(1 + \frac{E_0}{y_0} \sum\nolimits_k \dot{p}_k w_{k,0}\right) \cdot y_0 = \left(1 + \left(1 - s_0\right) \sum\nolimits_k \dot{p}_k w_{k,0}\right) y_0, \tag{25}$$

with s_0 the household-specific saving rate, S_0 / y_0.

Such an indexation of income with a true cost of living-index is unfeasible for two reasons. First, the weights (i.e. the expenditure pattern) are household specific, and are not known by the government nor by employers. Therefore, the indexation of wages and benefits will be based on an index with reference weights, $\overline{w}_i$, which cannot be household specific.[15] We define an alternative indexation mechanism, based on these reference weights, $\overline{w}_i$, namely the average expenditure shares:

$$y_1^{II} = \left(1 + \left(1 - s_0\right) \sum\nolimits_k \dot{p}_k \overline{w}_k\right) y_0 . \tag{26}$$

Second, also the household-specific total expenditures and thus the saving rate are unknown. The indexation can thus only be applied to income. We thus define a third indexation mechanism

$$y_1^{III} = \left(1 + \sum\nolimits_k \dot{p}_k \overline{w}_k\right) y_0 \tag{27}$$

---

[13] We refer here to the true cost-of-living index (see Deaton & Muellbauer, 1980).

[14] Technically speaking, the true cost-of-living index is equal to the Laspeyres-index when preference are Leontief.

[15] Note that the same holds for a case with household-specific prices and price changes. Here we assume that all households face the same prices, both before and after the shock.

In Belgium, the cost-of-living adjustment is well anchored in the automatic indexation of wages and benefits. Both gross wages, benefits and nominal tax parameters are indexed with the smoothed “health index”, which is an adjusted consumer price index which excludes “unhealthy” goods, such as fuel, alcohol and tobacco. The third indexation mechanism defined in Equation (27), is close, but not equal to this automatic indexation mechanism. We define the automatic indexation in Belgium as

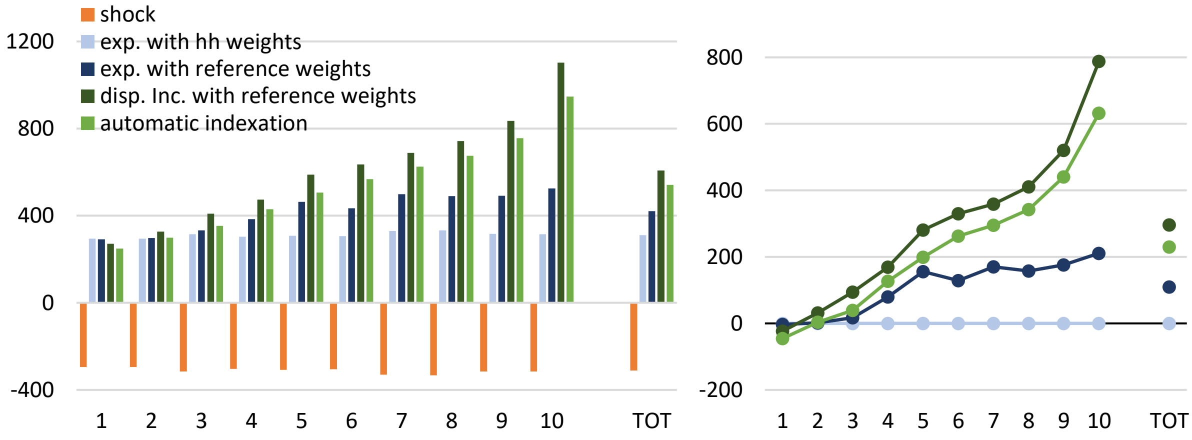
$$y_1^{IV} = \left(1 + z\sum\nolimits_k \dot{p}_k \bar{w}'_k\right) y_0 \tag{28}$$

with $\bar{w}'_i$ the weights as used in the health index (i.e., discarding consumption of unhealthy products, and we have $\bar{w}'_i > \bar{w}_i$ for all other products) and z the ratio of indexed income in total disposable household income. Note that this ratio z also accounts for the issue of indexing gross incomes and taxes, and not directly indexing disposable income.

To disentangle the distributional impact of the automatic indexation, we simulate three conceptual indexations. First, we simulate an ideal indexation based on the true cost-of-living index of total expenditures (Equation (25)). Second, to show the impact of using reference weights instead of household-specific expenditure shares we can compare y_1^{I} with y_1^{II}. Third, the impact of indexing income instead of total expenditures is shown by the difference between y_1^{III} and y_1^{II}. Finally, the impact of applying the real-world automatic indexation mechanism of Belgium, instead of the stylized indexation mechanism, we compare y_1^{IV} with y_1^{III}.

The distributional impact of each of these indexation mechanisms is shown in Figure 10. The orange bars represent the increase of expenditures after the high energy prices (as in Figure 2 of the main text). The light blue bars show the positive impact of an ideal indexation, i.e. an indexation of total expenditures based on household-specific expenditure shares. These are by definition exactly equal to the orange bars. The dark blue bars show the additional income after the indexation of expenditures based on reference expenditure shares. The dark green bars show the additional income after an indexation of total disposable income using on the same reference expenditure shares. Finally, the light green bars show the additional income after the Belgian real-world indexation mechanism (that is with weights from the health index and not all income being indexed). The panel on the right-hand side of Figure 10 shows the net impact of the shock after indexation, with the respective indexation mechanisms.

Figure 10: The impact of different indexation mechanisms.



Note: Deciles are based on equivalized household disposable income and contain 10% of the population.

It is clear from Figure 10 that every indexation has a positive effect on household welfare levels, compared to no indexation. But, whereas the first true cost-of-living index perfectly compensates the shock, both the use of reference weights and adjusting disposable income based on expenditure weights, have a strong distributional impact.

First, the use of reference weights overcompensates high incomes for the extra costs they have. Households with high incomes allocate on average less of their expenditures to energy consumption, which leads to an overcompensation by the indexation. This conclusion clearly depends on the income-gradient of expenditure shares of the goods for which prices have increased.

Second, adjusting incomes instead of total expenditures, moving from the dark blue to the dark green line, results in an even larger overcompensation for high income households. But here, the assumption of the temporary character of the price hike is important. The reason is that the income adjustment also adjusts income that will be spent in future periods, i.e. saved income. If prices will drop next periods to the baseline levels, those who save will gain from the income adjustment much more than those that do not save. Given that households with high incomes save on average much more than households with low incomes, indexing income based on expenditure shares, has a pro-rich impact.

Any implementable indexation will always have distributional effects, due to the information constraint of the government/employer. The welfare loss or gain after the indexation depends on the distance between the household-specific expenditure share and the reference expenditure share, and the amount of income not spend in the current period, the saving rate:

$$\begin{aligned}\Delta u^{III} &= \left(y_1^{III} - y_0\right) - \left(e_1 - e_0\right) \\ &= \left(y_0 \sum\nolimits_k \dot{p}_k \bar{w}_k\right) - \left(\sum\nolimits_i p_{i,1} x_{i,0} - \sum\nolimits_i p_{i,0} x_{i,0}\right) \\ &= \left(y_0 \sum\nolimits_k \dot{p}_k \bar{w}_k\right) - \left(y_0 \left(1 - s_0\right) \sum\nolimits_k \dot{p}_k w_{k,0}\right) \\ &= y_0 \sum\nolimits_k \dot{p}_k \left(\bar{w}_k - w_{k,0}\left(1 - s_0\right)\right)\end{aligned} \tag{29}$$

where $w_{i,0}\left(1-s_0\right)$ is the ratio of expenditures on good i in the baseline over the baseline income, i.e. the income share of good i. If the income share is larger than the reference weight used in the index, the household will lose from the shock and indexation. If the income share is lower, the household will gain from the price change and consequent indexation of income.

Of course, this only holds for the stylized indexation of income with reference weights. Whether one gains or wins from the automatic indexation also depends on which incomes are earned, since only wages and benefits are automatically indexed, and on how large the expenditure is on “unhealthy” goods that are not taken into account.

For the automatic indexation we have the difference in welfare:

$$\begin{aligned}\Delta u^{IV} &= \left(y_1^{IV} - y_0\right) - \left(e_1 - e_0\right) \\ &= y_0 \sum\nolimits_k \dot{p}_k \left(z\, \bar{w}_k - w_{k,0}\left(1 - s_0\right)\right)\end{aligned} \tag{30}$$

with z the share of indexed income over disposable income, which accounts for the impact on taxes, and $\bar{w}_k'$ the reference weights of good k in the health index.

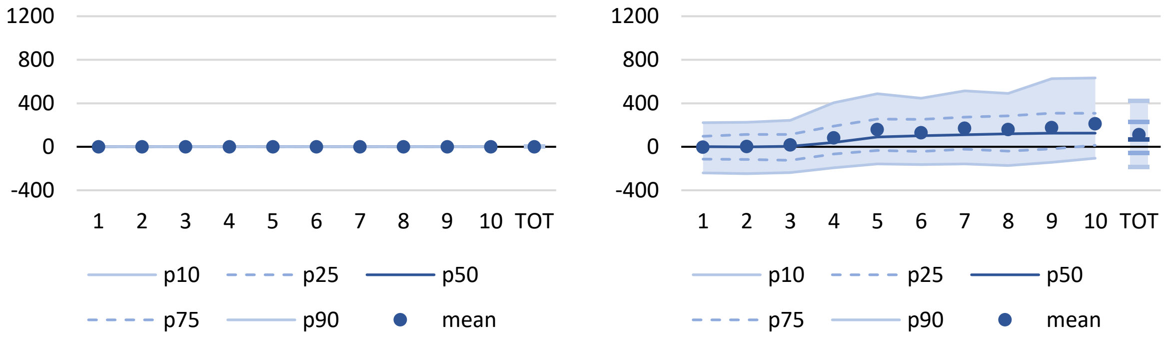
In Figure 10, we see that in all deciles households on average lose by moving from the stylized income indexation with reference weights (dark green) to the automatic indexation (light green). The difference is larger for households in the middle and high-income deciles, than it is in the first two income deciles. The difference is however not nearly as large as the importance of using reference weights, or indexing income instead of expenditures.

There are two important remarks to make with regard to these conclusions. First, averages per decile mask a lot of within-decile heterogeneity. Second, the assumption of transitory price increases is important for the income gradient. We'll discuss these two issues in depth in the next paragraphs.

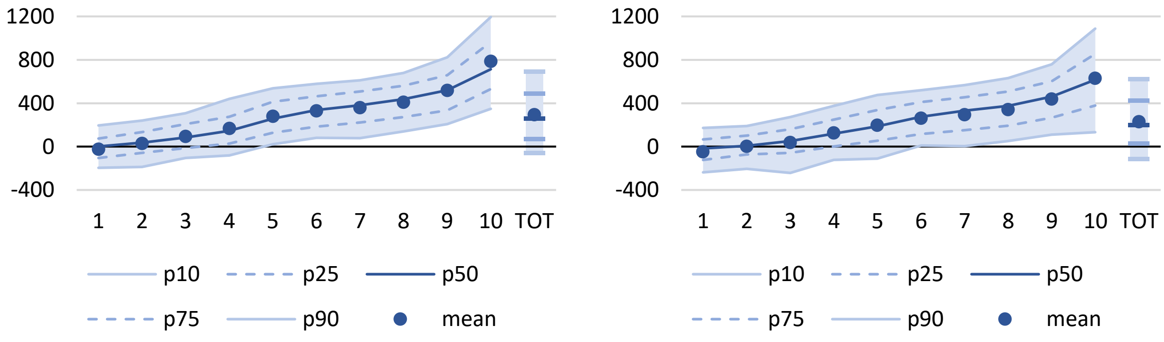
Within one income decile both expenditure patterns and the household-specific saving rate vary greatly. As shown in Equation (29), both will determine whether a household is over- or undercompensated by the indexation. Figure 11 shows the distribution of the net impact of both the price shock, and the simulated indexation mechanisms. From left to right and top to bottom, we show (1) the net impact after the indexation of total expenditures with household-specific expenditure shares, (2) after indexation of total expenditures with reference weights, (3) after indexation of disposable income based on reference expenditure weights, and finally (4) after the indexation of wages and salaries based on the health index, i.e. the automatic indexation mechanism. In each of the panels we show the average loss or gain after the shock and subsequent indexation per decile (dots), and the median (blue line). The blue area covers the middle 80% of the individuals ranked on their loss or gain; the area in between the dashed lines covers 50% of the individuals.

Figure 11: The distribution of the impact of the energy price hike and different indexation mechanisms.

(1) indexation of total expenditures with household-specific expenditure shares *(2) indexation of total expenditures with reference weights*



(3) indexation of disposable income with reference weights *(4) automatic indexation*



Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month. The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

In panel (1) of Figure 11, we see that every household is exactly compensated with the indexation of total expenditures based on household-specific weights (see Equation (24)). Using reference weights in the indexation of total expenditures introduces heterogeneity in the net impact after the price increase and the subsequent indexation. Next to the income gradient, which was already clear in Figure 10, we find that the variation in net impact within deciles is much larger than the variation between deciles, due to large variation of expenditures within deciles. Moving to the indexation of income instead of expenditure, i.e. to panel (3), introduces a more robust income gradient, where the middle 80% of individuals in the 10th decile are all better off than any of the middle 80% of individuals in the first decile. The reason is that the saving rate is much more correlated with income than expenditure shares. The heterogeneity within deciles is largest for high incomes. Finally, the implementation of the automatic indexation in panel (4) reduces somewhat the income gradient, but the heterogeneity within deciles is exacerbated, since now also heterogeneity in income sources contribute to heterogeneity in the net impact after the shock and the indexation.

A second important remark with regards to the income gradient in the net impact after the four indexation mechanisms, relates to the assumption we made on the temporary character of the price increase of energy. Clearly, this assumption is not trivial. If we would assume that that is not the case, and prices will stay high in the future, there is an additional welfare impact for those households that do not spend all of their income, as discussed in the construction of our welfare measure in Appendix II. We take this into account by deflating the saved income by the same price index as total expenditures were deflated. Put differently, the impact on expenditures of the price rise is scaled with a factor baseline income over baseline expenditures.

In that case, a true cost-of-living index would be the indexation of income, instead of total expenditures, based on the household specific expenditure shares (see discussion of deflation of savings in Appendix II). Adjusting (24), we have

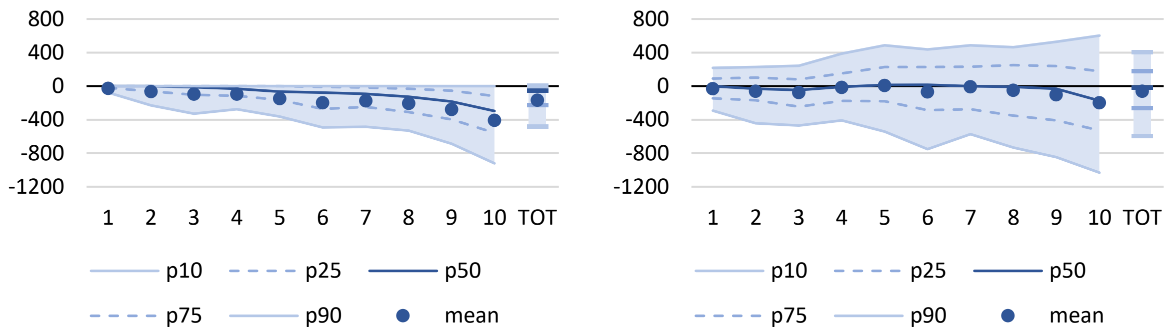
$$y_1^V - y_0 = y_0 \sum_k \dot{p}_k w_{k,0} \tag{31}$$

The net impact of the four previously defined indexation mechanisms is shown in Figure 12, in which we show again the spread of the net impact around the median for each decile (full dark blue line and shaded area), as well as the average net impact in each decile (dots).

After the deflation of saved income, we find that the indexation with the true cost of living index, as we defined it in (24), i.e. the indexation of total expenditure based on household-specific weights (panel (1)) does not compensate the welfare loss of the household for 90% of the individuals. There is a clear income gradient, following from the income gradient in the saving rate, with more high income households not being fully compensated by the indexation, and with the net losses being larger for high income households. From panel (2) it is clear that the income gradient that was introduced by indexing total expenditure with reference weights instead of household-specific weights, is offset by the income gradient in the deflation of saved income. The result is an average impact close to zero, with large variation around it. The net impact after the energy price hike and indexation of income instead of expenditure, with reference weights (panel (3)), is still on average overcompensating high incomes. But now we see that this income gradient is much less steep, and there are individuals in the high income deciles that face the same net impact as households in the first decile. We know from Equation (31) that this heterogeneity, which leads to the income gradient, is a result of only the variation in household-specific expenditure shares. The fact that not all incomes are indexed with the automatic indexation (panel (4)) deteriorates the income gradient even further, although, it is still clearly present. Note that the net impact after the “automatic indexation”, is no longer dependent on the household-specific savings quote when we assume prices stay high indefinitely:

$$\begin{aligned}\Delta u^{IV} &= \left(y_1^{IV} - y_0\right) - \frac{y_0}{e_0}\left(e_1 - e_0\right) \\ &= y_0 \sum\nolimits_k \dot{p}_k \left(z\,\bar{w}_k - w_{k,0}\right)\end{aligned} \tag{32}$$

Figure 12: The distribution of the impact of the energy price hike and different indexation mechanisms.

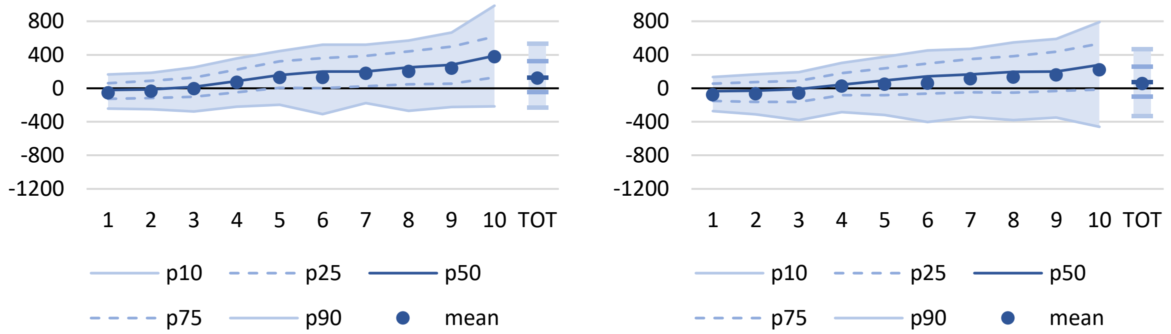


(1) indexation of total expenditures with household-specific expenditure shares

(2) indexation of total expenditures with reference weights

(3) indexation of disposable income with reference weights

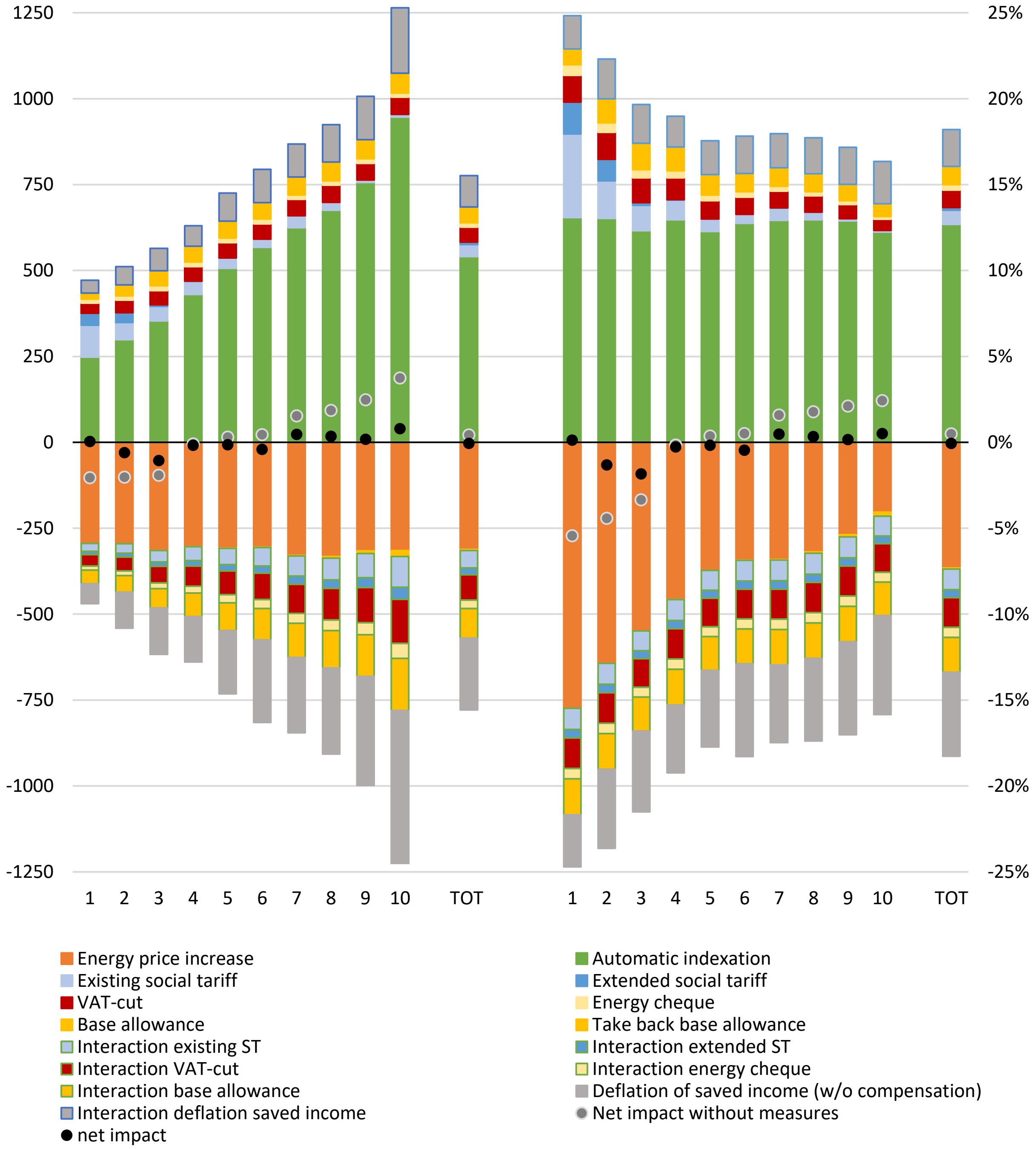
(4) automatic indexation



Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month. The relative average impact is a ‘smoothed average’, i.e. the ratio of the average impact over the average disposable income.

APPENDIX IV: DETAILED GRAPH OF INTERACTION EFFECT OF COMPENSATION AND INDEXATION

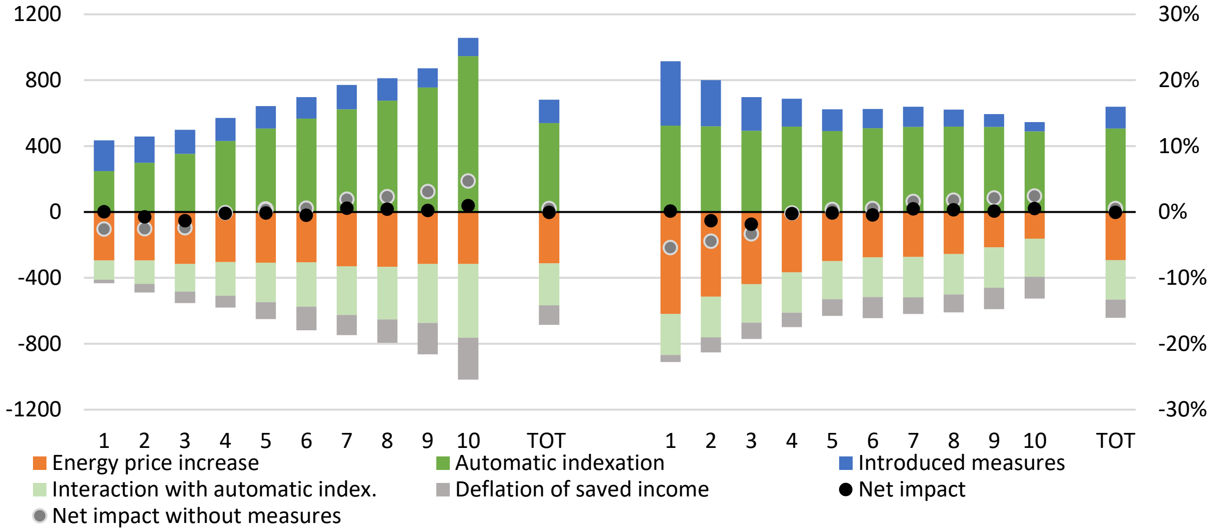
Figure 13: The average impact of the energy price hike, indexation, and the compensation (separately).



Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

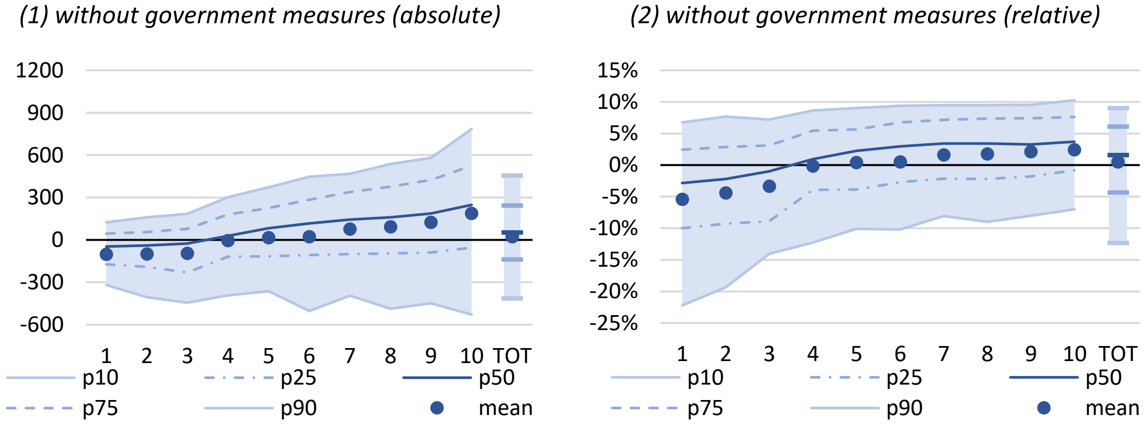
APPENDIX V: RESULTS WITH PERSISTENT HIGH PRICES

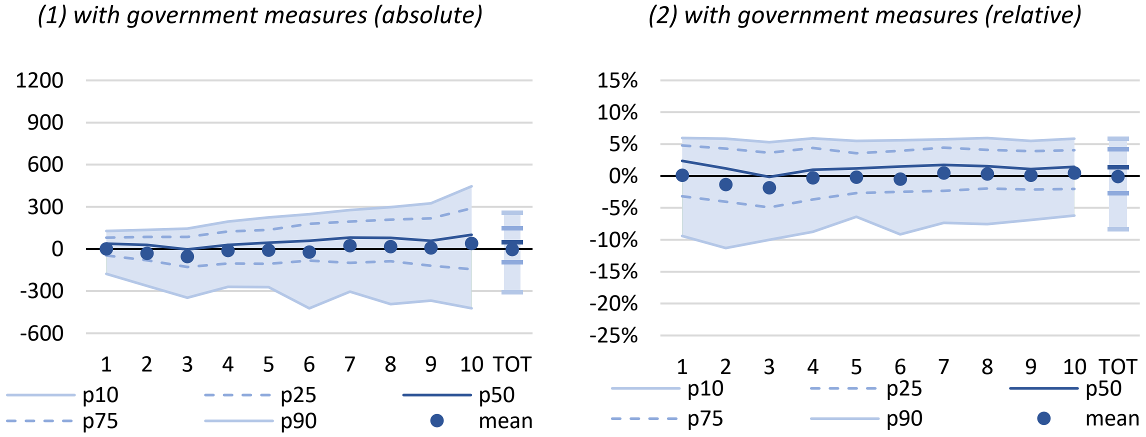
Figure 14: The average impact of the energy price hike, indexation and compensation.



Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.

Figure 15: The distribution of the impact of the energy price hike, indexation and compensation.


(1) without government measures (absolute) *(2) without government measures (relative)*


(1) with government measures (absolute) *(2) with government measures (relative)*

Note: Deciles are based on equivalized household disposable income and contain 10% of the population. The impact is expressed in euro per month (left-hand side) and in percentage of baseline income (right-hand side). The relative average impact is a 'smoothed average', i.e. the ratio of the average impact over the average disposable income.