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Limiting Prices or Transferring Money? An ex ante assessment of alternative measures to cope with the hike in energy prices*

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Abstract

The hike in energy prices across Europe in 2022 and 2023 led to significant government interventions. Several governments introduced 'energy price cap' measures to alleviate the increased burden on households' expenditures. This paper presents an ex ante assessment of the expected distributional impact of the inflation surge and the cushioning effect of these price cap policies introduced in 2023 in Germany, the Netherlands and Austria. Our analysis combines macroforecasting techniques with microsimulation methods and shows that the inflationary shock of 2023 will more severely affect those households at the bottom of the income distribution. Our results also highlight that the price cap measures will only partly absorb the negative distributional consequences of the inflationary shock while it would completely offset the increase in energy poverty. Additionally, we show that simpler measures, such as lump-sum cash transfers, are more efficient (considering government's budgetary costs) in cushioning the inequality-increasing effects of inflation, especially when such measures are targeted. Price caps, on the other hand, are more efficient in reducing energy poverty, given the non-negligible incidence of energy poverty in middle-income groups.

JEL classification: H31, C81, Q48
Keywords: Energy, price cap, microsimulation, inequality, Europe

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Executive Summary

- After many years of enjoying rather moderate inflation, from 2021 Europe saw consumer prices sharply rising across the board. According to Eurostat, in 2022, the average EU consumer prices for basic services such as housing, water, electricity and fuels increased by 18%. This hike in energy prices across Europe in 2022 and 2023 led to significant government interventions. Among these, several governments introduced 'energy price cap' measures to alleviate the increased burden on households' expenditures.

- These caps work on the demand side to ensure energy affordability, but they do not limit the market price of energy for producers. While this policy can help to contain inflation in the short term, it will not be effective in fighting the underlying causes of inflation (instability and shortages in energy supply) and it could put a substantial financial burden on governments.

- We assess the distributional impact of price cap policies introduced in 2023 in Germany, the Netherlands and Austria. We combine macroforecasting with microsimulation techniques to estimate the heterogeneous welfare effects of the inflationary shock across households and the cushioning effect of the price cap measures. The microsimulations are carried out using EUROMOD, the tax–benefit microsimulation model for the EU, with its recently developed Indirect Tax Tool.

- Our results suggest that the inflationary shock is expected to hit all households, but disproportionately more those at the bottom of the income distribution. This is because the poorest households spend the highest shares of their income on consumption (a pattern that is even more pronounced for necessary products such as energy and food, which were the categories mainly affected by the recent inflation surge).

- Our estimates show that price cap policies partly absorb the negative distributional consequences of the inflationary shock and counteract the increase in energy poverty. However, even after the implementation of price caps, the poorest households are still the most severely affected. Price caps are far from enough to offset their welfare losses.

- To shed more light on these policy challenges, we extended the analysis to assess the efficiency (considering governments' budgetary cost involved) of the price caps in comparison with alternative hypothetical policies (targeted price caps and targeted and untargeted lump-sum benefits). We find that simpler measures, such as targeted lump-sum cash transfers, are more efficient in cushioning the inequality-increasing effects of inflation. Price caps, on the other hand, are more efficient in reducing energy poverty, measured by the so-called 2M indicator (high income shares of expenditures), given the non-negligible incidence of energy poverty in middle-income groups.

1. Introduction

After many years of enjoying rather moderate inflation, from 2021 Europe saw consumer prices sharply rising across the board. At the EU level, the inflation rate had reached 10.5% by October 2022.[1] While part of this increase had been expected following the post-pandemic recovery – with the pandemic having disrupted global value chains, slowed supply and delayed the consumption of several types of products (Auray and Eyquem, 2020) – the inflation rate increase was exacerbated by the significant reduction in the gas supply from Russia following the invasion of Ukraine and the uncertainty concerning energy security. Energy prices, especially those for gas and electricity, skyrocketed for both companies and households. According to Eurostat, in 2022, the average EU consumer prices for basic services such as housing, water, electricity and fuels increased by 18%. Many countries attempted to compensate households for their higher energy spending using one-off cash transfers. On 30 September 2022, the Council of the European Union agreed on an emergency regulation[2] to address high energy prices. In addition, several governments introduced (or announced for 2023) 'price cap'-like measures for households to ensure affordable energy prices and alleviate the additional expenditures burden imposed by the rising energy bills.

This paper assesses the distributional impact of such policies and their cost-efficiency (considering the involved budgetary cost for governments) in terms of offsetting the effects of the hike in energy prices compared with some alternative (hypothetical) policy measures (cash benefits). Price control measures such as price caps are usually introduced to improve the affordability of goods that are experiencing strong price increases. In its standard form, a price cap represents a ceiling to the market price, which influences the market signals for both sellers and buyers. A price cap allows rising prices to be controlled, while ensuring an affordable price for consumers, sustaining demand. However, in their current form, 2022–2023 energy price caps introduced are more government subsidies alike. This policy approach reduces prices for consumers by paying part of the energy price charged by the producers. Consequently, the household affordability of energy is maintained only through a consumer price ceiling, while the market signal (high selling price) remains for producers, avoiding further reductions in energy supply. Although the literature on the effects of the current energy price caps is still limited, price control measures have been widely studied and began with Galbraith (1952) and his lessons from wartime. More recent examples of price regulations are rent control in the housing market (Dolls et al., 2020; Sagner and Voigtländer, 2022), ceiling prices for necessary goods such as some types of foods in developing countries (Pinstrup-Anderson, 2015), maximum prices for medicines (Nonell and Borrell, 2001; Atella et al., 2012; Philipson and Durie, 2021) and the minimum wage in the labour market, that is, a price floor (Card and Krueger, 1993; Neumark and Wascher, 2000).

Price control measures have traditionally spurred controversy. They have been praised

[1] Eurostat data code PRC HICP AIND, HICP - annual data (average index and rate of change).

[2] See EU Parliament Briefing.

for helping to stop firms from profiting from supply shortages while keeping prices affordable for all consumers in the short term. Another advantage of price caps, as opposed to standard household subsidies or cash transfers, is that they have a direct impact on the harmonised index of consumer prices (HICP) and, through this index, they can help contain inertial inflationary pressures (e.g. through income indexation). On the other hand, price caps have been criticised because they usually rely on a costly system to enforce and control the newly set prices, because they put a substantial financial burden on the government budget (the subsidy-like caps) and because of other undesired long-term effects on the price of substitute, non-capped, goods, as well as because of the difficulties to phase them out (e.g. New York and Germany rent controls). Moreover, price caps may not be effective in fighting the underlying causes of inflation, as price signals are muted. For instance, if inflation is caused by excess demand, price caps will make goods and services more attractive because prices are lower; by contrast, if inflation is caused by a shortage of goods and cost-push factors, the subsidy to consumers embedded in the price cap will not reactivate supply.

In the current context, the energy price caps introduced in 2022–2023 in the EU Member States work on the demand side to ensure energy affordability, but they do not limit the market price of energy for producers. While this policy can help to contain inflation in the short term, it will not be effective in fighting the underlying causes of inflation (instability and shortages in energy supply), it could put a substantial financial burden on governments and it may become difficult to phase out in the longer term. Furthermore, temporary energy price reductions may work against other EU policies, such as those related to the Green Deal (e.g. the proposed revision of the Energy Taxation Directive[3]). For these reasons, some countries introduced mixed price caps, which do not cap prices completely and so maintain price signals, at least partially.

This paper estimates the distributional impacts of the inflationary shock and the cushioning effect of the price cap policies introduced in 2023 in Germany, the Netherlands and Austria. To achieve so, it uses nowcasting and forecasting microsimulation techniques. By simultaneously assessing both the budgetary cost and the welfare impact of the current and alternative (hypothetical) policy measures aimed at offsetting the effects of the hike in energy prices, we shed new light on the cost-efficiency of these measures in terms of containing inequality and energy poverty.

The analysis covers three western central European countries with similar levels of gross domestic product (GDP) per capita at purchasing power parity and similar characteristics that affect energy consumption (e.g. climate, technology and energy taxation). Cross-country differences in the welfare effects of the inflationary shock and in the cushioning role of the policy measures assessed are expected to depend on the magnitudes of the inflationary shock and the characteristics of the policies in place. Austria's price cap

[3]Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity (OJ L 283, 31.10.2003, p. 51). This proposal was launched with other legislative initiatives within the Fit-for-55 package in 2021, such as the Carbon Border Adjustment Mechanism, that imposes a price on carbon emissions of imported goods.

concerns only electricity, whereas Germany and the Netherlands have implemented price caps on both electricity and gas. Households with lower incomes tend to allocate a higher proportion of their income to the consumption of essential goods such as food and energy, which are demand inelastic (Amores et al., 2023). It is, a priori, uncertain whether price caps would benefit mostly energy- and/or income-poor households. Understanding the redistributive effects, alongside the budgetary cost, of each of these measures is important for policymakers to make informed decisions on budget allocation and to evaluate the adequacy of the support provided to households during the energy crisis.

This paper presents an ex ante assessment of how price caps will partially offset the increase in inflation and its expected distributional effect in 2023. Our approach involves several steps. First, we forecast[4] the increase in consumer prices (by category of goods) using information about future prices for the energy components for 2023. For gas and electricity, we forecast a counterfactual increase in consumer prices assuming that price cap measures are not in place. Second, following a standard compensating variation welfare approach,[5] we estimate the additional expenditures required to maintain the same level of goods and services purchased in 2023 given the price increases. Third, we use EUROMOD – the tax–benefit microsimulation model for the EU (Sutherland and Figari, 2013) – and its indirect tax tool extension (Akoğuz et al., 2020) to compare the current (untargeted) price cap with a set of hypothetical alternative measures, such as targeted price caps and targeted and untargeted lump-sum benefits. We estimate household welfare losses on inequality (Gini index variation) and the prevalence of energy poverty. In a fourth step, we assess the cost-effectiveness of each anti-inflation measure and draw some conclusions.

Our results suggest that the current (untargeted) price cap measures will help to contain the negative distributional effects driven by the increase in energy prices and to reduce energy poverty substantially, while tackling the inflationary shock through a direct effect on the HICP. Still, these measures are far from compensating the disproportionately large inflation-driven welfare losses experienced by the poorest households. Due to their untargeted design, more than 20% of governments' budgets involved in these price cap measures go directly as a subsidy to the richest 20% of the population. We also show that targeted measures, both price caps and lump-sum benefits, would be substantially more efficient than untargeted measures in reducing inequality and energy poverty. In fact, lump-sum benefits, both targeted and untargeted, are more cost-efficient than price caps in redistributive terms and have the advantage of preserving market signals and not contradicting the European Green Deal (EGD) policies pushed forward to reduce energy consumption.[6]

[4] At the time of writing, there are no official statistics for inflation for the whole of 2023.

[5] Compensating variation and the concept of equivalent income (income after the price shock) to assess the welfare effects of changes in prices were first defined by King (1983) and since then have been widely used in the literature. Similar approaches have been followed by more recent studies on the welfare effects of price shocks (see, for example, Loughrey and O'Donoghue (2012) for a general discussion; Vandyck et al. (2021), for the application of compensating variation in the context of climate policies; and Capeau et al. (2022) for a recent assessment of the effect of the energy shock in Belgium).

[6] Although the proposed revision of the Energy Taxation Directive does not involve an increase of

The rest of the paper is organised as follows. Section 2 discusses the price cap measures currently in place in Germany, the Netherlands and Austria. Section 3 presents the methodology and data used and describes the scenarios analysed. Section 4 contains the results. Section 5 provides some concluding remarks.

2. Price cap measures

In 2023, energy price caps had already been introduced in the EU, but they were set at a generally high price level. For example, the EU energy ministers agreed on establishing a price cap on natural gas to protect European businesses and households from excessively high gas prices in the EU. This cap is seen as a market correction mechanism that kicks in if the price of gas exceeds a price of EUR 180/MWh for at least 3 days on the Dutch Title Transfer Facility (TTF) gas hub's front-month contract.[7] Additionally, in December 2022, the European Commission introduced an oil price cap to stabilise global energy prices at USD 60 per barrel of crude oil or petroleum oil originating or exported from Russia. These measures set a maximum selling price for energy producers.

National governments, however, decided to introduce additional price caps to protect consumers directly from high energy prices. National measures differ widely across EU Member States in both their level and target population. They are typically constructed as a subsidy (the opposite approach to those at the EU level mentioned above) for energy consumers, meaning that the state pays the costs exceeding the price cap to the energy distributor. Therefore, consumer prices are influenced directly by these measures, even though the price itself that is charged by the energy seller is not affected. The price signal is therefore only partially altered (directly on the demand side, while, on the supply side, oligopolistic operators have incentives to set the price, at least, close to the cap, and even higher). There are several positive aspects of price caps. Philibert (2009) argues that price caps could significantly reduce the economic uncertainty caused by unpredictable economic growth and energy prices. On the other hand, Earle et al. (2007), for example, show that, if firms are facing a demand uncertainty, imposing or lowering a price cap can result in reduced production and, therefore, a loss in welfare. Price caps could even lead to an increase in average prices and a decrease in consumer welfare.

However, the recently introduced price caps are different from standard price caps, as they only influence the consumer price, not the producer price. Weber et al. (2023) argue that the German gas price cap not only provides relief for households, but also reduces the cost pressure on firms. In its current design, this price cap also retains the incentives for consumers and businesses to save gas. In clear contrast, Gros (2023) argues that 'any national price cap that subsidises the prices paid by consumers diminishes the

minimum tax rates in electricity due to the intended electrification of energy demand, a core principle of this and other EGD policies is the reduction of energy consumption through demand reduction and efficiency gains. Energy price interventions could then be seen as counterproductive, as they can soften the incentives for achieving these objectives.

[7] The Dutch TTF is used as the European benchmark.

incentives to save on gas'. Similarly, Rüdinger (2023) argues that the electricity price cap in France, introduced in 2021, led to positive macroeconomic effects: France has since reported considerably lower inflation rates and therefore also lower macroeconomic costs. However, this French price cap was not able to achieve the political goal of social justice and environmental sustainability.

Given the lack of data and the uncertainty of future price developments, modelling the social consequences of such measures is overly complex. There are some research item on the distributional implications of the energy crisis like Kalkuhl et al. (2022) and Guan et al. (2023) or the or the generalised inflation like Menyhert (2022) or Caisl et al. (2023), but to the best of our knowledge, there are no specific studies on the fiscal and distributional impacts of the energy price caps that were recently introduced in European Member States. In this paper, we make a first attempt at analysing this for three EU countries, namely Germany, the Netherlands and Austria. In the following subsections, we describe the characteristics of the national price cap measures implemented in these three countries. The parameters are also summarised in Table 1. The energy price forecast for electricity, oil and gas can be found in Appendix Appendix A.

Table 1: Summary of price caps in Germany, the Netherlands and Austria for 2023

Component	Unit	Germany		Netherlands		Austria	
		Electricity	**Gas**	**Electricity**	**Gas**	**Electricity**	**Gas**
Price cap variable rate (including value added tax)	EUR/kWh	0.40	Gross 0.12	0.25	0.081	0.10(b)	n/a
Volume limit (annual)	kWh	80%(a)	80%(a)	2900	12667.68	2900	n/a
Energy tax (not affected by price cap/volume limit)	EUR/kWh	n/a	n/a	0.15	0.057	n/a	n/a

Note: (a) This represents the percentage of the projected consumption. (b) The subsidy is capped at EUR 0.30/kWh.

The prevalence of the different energy carriers (see B.1 for the different consumption levels of fuels in the different countries) depends on countries. This made that Germany and the Netherlands implemented the cap in electricity and gas while Austria did only for electricity being gas a much less relevant energy source in that country.

2.1. Germany

The German government approved a price cap on electricity and gas that became effective from 1 March 2023, but it has also been retroactively applied for January and February 2023. The electricity price for private consumers and small businesses with an electricity consumption of up to 30 000 kWh per year will be capped at EUR 0.40/kWh gross (i.e. including all taxes, levies, surcharges and grid fees). This applies to the basic demand of 80% of the projected consumption. For private households, the gas price is capped at EUR 0.12/kWh gross for 80% of the annual consumption from the previous year.

2.2. Netherlands

The price caps on electricity and gas in the Netherlands apply from January 2023. The final gas and electricity price paid by consumers consists of a variable rate topped up by value added tax (VAT) and an energy tax. The variable rates including VAT have been fixed at the price levels shown in Table 1. For energy use under the volume limit, the purchasing price paid by consumers in 2023 will amount to EUR 0.138/kWh (including the tax of EUR 0.057/kWh) for gas and EUR 0.40/kWh for electricity (including the tax of EUR 0.15/kWh). Given the volume limits, the Dutch authorities estimate that the price cap applies to around 80% of total energy use by households.

2.3. Austria

In Austria, households are subsidised for basic electricity needs, defined as up to 80% of the average annual consumption of a two-person household in 2021 (i.e. 2 900 kWh per year). Further subsidised kWh may be granted to households where at least three people are registered in the Central Register of Residents (Zentrales Melderegister). The electricity costs brake is based on two reference values that define a price corridor. The level of subsidy per kWh is capped at the difference between the lower and upper reference values. Households pay a reduced price for 2 900 kWh per year but no less than EUR 0.10/kWh (lower reference value). In fact, the public finances compensate the difference between EUR 0.10/kWh and the contractually agreed price between the consumer and supplier (net of all the discounts and rebates of private market participants, as well as price components based on laws, that is, taxes, levies, public rebates, etc.). The upper reference value is set at EUR 0.40/kWh; therefore, the subsidy is capped at EUR 0.30/kWh.[8] For example, if the price per kWh is EUR 0.30, the government pays EUR 0.20 and consumers pay EUR 0.10, while, if the price per kWh is EUR 0.45, the government deducts the full EUR 0.30 and consumers pay EUR 0.15.

3. Methodology

3.1. Microsimulation model

The simulations carried out in this analysis use EUROMOD, the static open-source tax–benefit microsimulation model for the EU (Sutherland and Figari, 2013), version I5.0+. The tax–benefit system simulated in the baseline scenario refers to the one in force on 30 June 2022, as coded in EUROMOD.

The analysis of the price cap was performed with the recently developed Indirect Tax Tool (version 4) extension of EUROMOD. The Indirect Tax Tool is designed to estimate the effect of current or hypothetical VAT rates and excise duties on household budgets and government revenues, but can also be manipulated to simulate changes in consumer prices. To simulate these changes in either consumption tax liabilities or prices at the household level for the EU27 countries, the underlying microdata of EUROMOD (primarily based on Eurostat's EU statistics on income and living conditions (EU-SILC)) were complemented

[8] The quantity (i.e. 2 900 kWh per year) and the two reference values (i.e. EUR 0.10/kWh and EUR 0.40/kWh) can be changed by way of ministerial directive (i.e. without adoption by the ministerial council or parliament). However, when changing parameters concerning quantity, incentives to reduce electricity consumption must be conserved and the upper reference value has to remain in line with market prices.

with consumption-level data for about 200 commodity categories[9] from household budget surveys (HBSs; primarily based on Eurostat's harmonised EU HBSs). The procedure used to impute EU HBS data into the EU-SILC is explained in Section 3.2.2. More information on how this tool works, as well as on the semi-parametric imputation method used for combining these data sources, is publicly available from the EUROMOD website.[10]

3.2. Data and Parameters

3.2.1. Inflation forecast

Most of the energy measures of EU Member States were introduced because of the tremendous increase in energy prices, especially of gas and electricity, from early 2022. However, price caps have generally been introduced later, in most EU countries in 2023. To estimate the impact of price caps on households' income and to assess the related costs, we would need detailed prices for these commodities in 2023. Given that they are not yet available (at the time of writing), we follow a twofold approach to derive accurate price forecasts. First, we use the standard inflation forecast of the European Commission, namely the spring 2023 economic forecast for all commodity classes, except for energy. The inflation forecast has four subcategories, namely non-energy industrial goods, processed food (including alcohol and tobacco), unprocessed food and services.

For several reasons, we do not use the energy forecast of the European Commission in our paper. First, this forecast does not contain a breakdown of energy inflation into different energy products, which is key for our analysis. The development in oil, gas and electricity prices differs substantially by energy class and, for the price caps on electricity and gas, such a breakdown is essential, given that the energy mix of households is very country specific. Second, the European Commission forecast includes the effect of the policy measures. Given that these price caps have a direct impact on energy inflation, the energy inflation forecast of the European Commission is not useful for our purpose because we would not have a counterfactual scenario (without policy measures) against which to compare the actual scenario and assess the policy effect.

For these reasons, we made use of future prices for all energy components. Energy futures have traditionally been relied upon by forecasters and institutions for predicting future trends.[11] As also argued by the European Commission (2022), recent research such as that by Reeve and Reeve and Vigfusson (2011), Reichsfeld and Roache (2011) and

[9] This was done for the Netherlands and Austria. Germany releases only a restricted level of granularity of consumption categories in household budget survey microdata.

[10] See https://euromod-web.jrc.ec.europa.eu/.

[11] Their poor performance in accurately anticipating the price surge during 2003–2008, coupled with concerns about increased volatility in futures markets, prompted a critical re-evaluation of this approach. Bernanke (2008) warned against disregarding the valuable information on supply and demand conditions that futures markets aggregate. However, he acknowledged that forecasts of commodity prices derived from futures markets should be regarded as highly uncertain. Considering the heightened volatility and significant structural shifts in energy markets, it is justified to employ scenario analysis that primarily focuses on the development of futures prices.

Polanco-Martínez and Abadie (2016) has provided noteworthy evidence regarding the significance of futures markets in forecasting commodity prices. Research has shown that futures markets effectively communicate valuable information concerning anticipated supply and demand conditions, namely that deviations between spot prices and futures prices primarily result from evolving assessments of demand and supply circumstances, rather than from a fundamental breakdown in the role of futures in price discovery. Additionally, predictions derived from futures markets generally outperform alternative methods. Nevertheless, recent studies have also issued a word of caution, indicating that financial speculation has the potential to impede the price discovery function of futures, as highlighted by Beckmann et al. (2014).

The energy market is typically characterised by a strong delayed pass-through of prices, especially when it comes to electricity and gas. This is because of several reasons, but mainly it is caused by contractual arrangements with households that adjust to higher prices with a certain delay. Given these two empirical regularities, we set up a simple model that estimates the relation between the HICP by energy type and the wholesale price. We chose the lag in pass-through by choosing the model with the lowest root mean squared error (RMSE) and the highest explained variation (R^2). The model choice differs across countries, but overall, we can see that the pass-through is typically shortest for oil and longest for electricity. The detailed model description used to forecast energy inflation can be found in Annex A.

3.2.2. Imputation of household budget survey consumption data into statistics on income and living conditions

To impute consumption expenditure data from EU-HBS (i.e. the source dataset) to EU-SILC for the same year (i.e. the recipient dataset), we use a semi-parametric procedure developed by Akoğuz et al. (2020). This methodology combines the estimation of Engel curves (Decoster et al., 2010) with matching techniques. There are mainly three steps involved. First, a common set of potential variables that could explain differences in income shares of expenditure consumption across households is identified in the source and recipient datasets. Second, consumption categories are aggregated into 20 groups, expressed in terms of consumption shares of income. These are then regressed against the covariates identified in the first step. Third, we use the estimated coefficients to estimate fitted income shares of consumption in both datasets. A Mahalanobis distance metric is used to find the closest match between households in the two datasets. Once households from recipient and source (I.e. EU-SILC and EU HBS) datasets are matched, the income shares of expenditures (the full consumption basket) from the source dataset are imputed to the recipient. When undertaking an analysis for policy years that do not coincide with the survey years, appropriate uprating factors are used to update income information.[12]

Our imputation method has two main advantages with respect to other imputations used by the literature, mainly based on Engel curves. First, by matching observed in-

[12] Information on uprating factors in EUROMOD can be found online at: EUROMOD Country Reports.

come shares of consumption rather than estimating them based on a regression (as in the standard Engel curve approach), we impute expenditures at the highest available level of disaggregation. In our case this is the Classification of Individual Consumption by Purpose (COICOP) level 4, which classifies expenditures into about 200 types of consumption categories. Second, the regression model exploits the information on the relation between household characteristics and expenditures in the dataset, which is neglected in other widely used imputation methods, such as hot deck matching. Therefore, the "distance" between households in both datasets (i.e. our metric of how different or alike households at one and the other side are) is measured based on household characteristics (e.g. age, gender and education of the head of the household, income, ...). These characteristics are implicitly weighted in the distance function according to their statistical relevance to explain household consumption.

Still, our imputation method has also some limitations. First, fitted values (I.e. projected income shares of expenditures in the recipient dataset, based on the estimated regression coefficients) are obtained by means of a regression model that takes the logarithm of income as input. Therefore, this approach makes sense only for households with a sufficiently high and positive income. Second, it makes only make reasonable predictions about expenditures on broad categories, such that only those enter in the distance function. For a more detailed discussion on the scope and limits of this imputation method see Amores et al. (2023) and Akoğuz et al. (2020). For this analysis, households' consumption expenditures from the 2010 EU HBS for Germany, the 2015 EU HBS for the Netherlands and the 2010 national HBS for Austria were imputed in the EUROMOD micro-dataset based on the 2010 EU-SILC. Uprating factors (the average increase in gross wages, pensions and other sources of incomes) were used to update the income values from the income reference period (2009) to the policy year (2022). Prices for goods subject to excise duties were updated based on the forecasts.

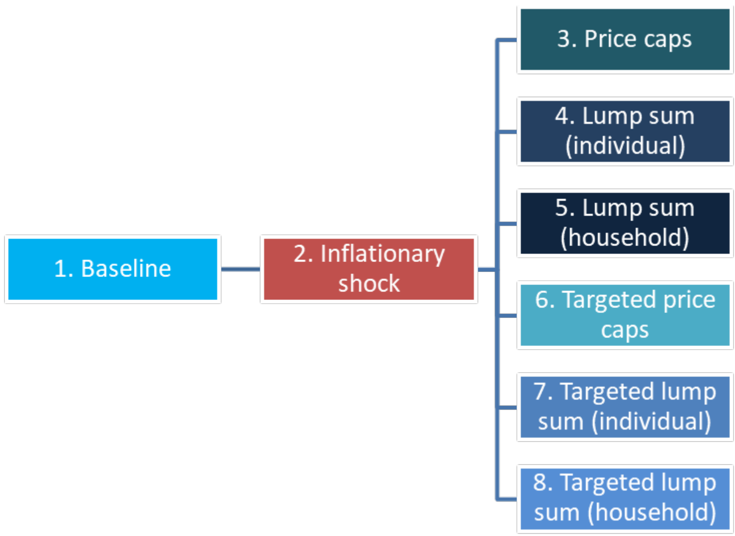
3.3. Scenarios

The inflationary shock simulation in our analysis is based on the consumer price increase forecasts from 2022 to 2023. in general, we consider the following eight scenarios (Figure 1):

1. **Baseline.** Our benchmark was the situation in 2022 (the tax–benefit system and prices).
2. **Inflationary shock.** This was simulated based on the forecasted increase in consumer prices in 2023, assuming households maintained their 2022 consumed quantities.
3. **Price caps.** This scenario builds on the inflationary shock scenario (2) and in addition simulates the electricity and gas price caps that are in place in 2023.
4. **Lump sum (individual).** This scenario builds on the inflationary shock scenario (2) and redistributes the same budget as in the price caps scenario (3) in the form of a lump-sum benefit for each individual.

5. **Lump sum (household).** This scenario builds on the inflationary shock scenario (2) and redistributes the same budget as in the price caps scenario (3) in form of a lump-sum benefit for each household.
6. **Targeted price caps.** This scenario builds on the inflationary shock scenario (2) and simulates the current electricity and gas price caps only for low-income households (the first and second quintiles of the baseline equivalised household disposable income distribution).
7. **Targeted lump sum (individual).** This scenario builds on the inflationary shock scenario (2) and redistributes the same budget as in the targeted price caps scenario (6) in the form of a lump-sum benefit to low-income individuals (the first and second quintiles of the baseline equivalised household disposable income distribution).
8. **Targeted lump sum (household).** This scenario builds on the inflationary shock scenario (2) and redistributes the same budget as in the targeted price caps scenario (6) in the form of a lump-sum benefit to low-income households (the first and second quintiles of the baseline equivalised household disposable income distribution).

Figure 1: Inflationary shock and simulated energy measures in 2023



3.4. Distributional analysis

Our analysis rests on assumptions of full tax compliance, full pass-through and constant quantities (overnight effects, no behavioural response). In particular, to analyse the 'welfare losses' from the increase in consumption prices (as well as the 'welfare gains' from price caps), we estimate the change in disposable income that households would need to experience to keep their baseline consumption basket constant (compensating variation). This 'purchasing power' welfare approach resembles the idea of compensating variation and equivalent income (income after the price shock, given the new prices; see, for example, King, 1983), and it has been widely used in the literature when looking at the effect of price shocks on households' welfare (Loughrey and O'Donoghue, 2012). Similar approaches have also been followed in more recent studies on the welfare effects of price shocks (see Vandyck et al. (2021) for the application of this approach in the context of climate policies for a group of EU countries and see Capeau et al. (2022) for a recent assessment of the effect of the energy shock in Belgium).

We use baseline equivalised household disposable income to identify the income deciles. We also use it as the denominator for the indicator used to isolate the effects of inflationary shock and the price cap from the effects of changes in market incomes and the tax–benefit system during 2022–2023.

The baseline income (Y_b) is equivalised household disposable income in 2022. The equivalent income after the inflationary shock (Y_{inf}) is the baseline income minus the change in expenditures needed to keep the pre-inflation consumption basket fixed (ΔX_{inf}; see Equation 1).

$$Y_{inf} = Y_b - \Delta X_{inf} \tag{1}$$

The final income, Y_{final}, is obtained once we subtract the (negative) change in expenditures due to the policy ΔX_{policy}(price cap or alternative measures; see Equation 2).

$$Y_{final} = Y_{inf} - \Delta X_{policy} \tag{2}$$

To assess, in a synthetic way, the distributional effect of the inflationary shock, the price caps and the hypothetical alternative measures, we use the Gini coefficient before and after the inflationary shock and the reform policy (i.e. Gini(Y_{inf})-Gini(Y_b) and Gini(Y_{final})-Gini(Y_b), respectively). Additionally, we focused on the impact on energy poverty.

According to the literature, there are diverse ways to estimate energy poverty (see, for example, Pachauri and Spreng, 2011 and Thomson and Bouzarovski, 2018).[13] In this paper, we use one of the most widespread measures based on shares of expenditures on energy (the so-called 2M, following the notation of the methodology guidebook of Thema and Vondung, 2020), which defines energy-poor households as those with a share of energy expenditure over disposable income above twice the national median.[14] This is one of the four measures

[13] In 2020, the European Commission issued a recommendation (Commission Recommendation (EU) 2020/1563 of 14 October 2020 on energy poverty (OJ L 357, 27.10.2020, p. 35)) in which energy poverty is defined and different measurements are proposed and discussed. Moreover, in 2021, it launched the Energy Poverty Advisory Hub, the successor to the EU Energy Poverty Observatory; this is the leading EU initiative aiming to tackle energy poverty and accelerate the just transition. In the methodological guidebook of Thema and Vondung (2020), there is a comprehensive discussion of the advantages and disadvantages of each of the most common indicators used to measure energy poverty in the EU.

[14] Another standard definition of energy poverty based on expenditures (classified as 'objective' measures in Thema and Vondung (2020)) is to define poor households as those with absolute equivalised energy expenditures below half the national median (the so-called M2). However, in this report, we are analysing the effect of the price shock and price caps under the behavioural assumption of constant quantities (compensating variation welfare metric), which evidently limits the usefulness of this alternative measure

endorsed by the European Commission's recommendation of 2020.[15] Although there is not yet a consensus on which energy poverty indicator presents the best properties to identify these vulnerable groups, the 2M indicator is particularly suitable for the purpose of our analysis, as it is sensitive to changes in consumer prices and income. Nevertheless, our analysis of the impact of inflation and the associated policy measures on energy poverty relies on the assumption of constant quantities. This implies that any change in consumer prices is reflected in higher expenses, proportionally, and that expenditures do not change with income (i.e. we are assuming price and income elasticities of zero, a reasonable assumption to assess overnight effects in the context of a non-behavioural static simulation exercise). Similarly, the budgetary effect is estimated as the difference in total estimated expenditures in each of the simulated scenarios (scenarios 3–7) against the inflationary shock scenario (2), under the constant quantities' behavioural assumption (i.e. households keep their consumption baskets unchanged). For the estimation of the budgetary effect, we calibrate our baseline expenditures with national accounts figures to correct for potential problems of misreporting in the HBSs. Since national accounts figures are not yet available for 2023, or for 2022, we calibrated our results considering the difference between the EUROMOD indirect tax tool simulated expenditures in 2010 (year of the HBS) and the national accounts of 2010 at the three-digit COICOP level (i.e. category 045 – energy consumption).

3.5. Cost-efficiency analysis

EU Member States introduced very generous price cap measures to support households. However, there was a lot of controversy, given their untargeted nature. These measures also support households that are not in need and put pressure on government budgets. As argued by the European Commission (2022), 'a careful targeting of policy interventions would protect vulnerable households and energy-intensive firms, while avoiding unintended side effects. However, the European Commission (2022) and Sgaravatti et al. (2021) highlighted that, in general, EU governments have favoured untargeted price-distorting measures to fight high energy prices over income-support measures.

To assess the efficiency of the measures in targeting vulnerable groups across countries, we follow Bucheli et al. (2014) and introduce a cost-efficiency measure indicating how efficient a policy measure is in reducing inequality (Gini difference) in our welfare measure, which we define as the equivalised disposable household income minus the additional equivalised expenditures caused by the inflationary shock (equivalent income). In addition, we also estimate the cost-efficiency in reducing energy poverty. In principle, if a measure is well targeted to vulnerable (poor) households, inequality and energy poverty should decrease more than if a measure is not targeted. We define the efficiency measure (EM) of

based on absolute expenditures. For a comparison of energy poor rates based on different definitions, see, for example, Drescher and Janzen (2021).

[15] Commission Recommendation (EU) 2020/1563 of 14 October 2020 on energy poverty (OJ L 357, 27.10.2020, p. 35). The recommendation follows the methods proposed by Eurostat and the organisation that was previously known as the European Energy Poverty Observatory.

a specific policy i in country c as the share of the reduction in the Gini coefficient due to the specific policy ($Gini_c^{pre}$-$Gini_{i,c}^{post}$) or the energy poverty ($EPOV$) due to the specific measure ($EPOV_c^{pre}$-$EPOV_{i,c}^{post}$) over the cost of measure i as a percentage of GDP ($\frac{cost_{i,c}}{GDP_c}$), to adjust for distinct size of the economies:

$$EM_{i,c} = \frac{Gini_c(Y_{inf}) - Gini_{i,c}(Y_{final})}{\frac{cost_{i,c}}{GDP_c}} \tag{3}$$

This measure allows us not only to estimate the cost-efficiency in reducing the inequality (cushioning the increase in inequality driven by the inflationary shock) and energy poverty of different price cap measures across countries, but also to estimate the cost-efficiency of different (hypothetical) reform scenarios within each country. The efficiency measure for energy poverty can be analogously calculated by replacing Gini with energy poverty in Equation 3.

4. Results

We start this section with a brief evaluation of the direct (mechanical) effect of the energy price caps on inflation. Then, we move on to the distributional effect of the inflationary shock and the planned price cap measures in Germany, the Netherlands and Austria. We then discuss alternative policy measures to cushion the loss of households' purchasing power and we evaluate the overall impact on energy poverty.

4.1. Direct effect of price cap policies on inflation

As a first step in our analysis, we estimate the impact of the energy price cap measures on 2023 inflation.[16] One of the reasons why governments decided to use these measures was to limit the growth of energy prices for households. Therefore, understanding this impact, besides of other factors that impact inflation,[17] is important from an economic policy point of view.

Our results highlight that the containing effect of price caps is especially strong in the Netherlands (– 2.0 percentage points), mainly driven by the extremely large increase in energy prices. We estimate an inflation cushioning impact of the price cap measures of 0.8 percentage points for Austria and of 0.2 percentage points for Germany. The results for Germany are mainly driven by the high ceilings for both the gas and the electricity price caps. It is worthwhile noting that these results are highly dependent on our energy inflation forecast 1.

[16]Please note that we calculated inflation as the average income share on several products of households, which is similar to, but not the same as, the consumer price index, which uses a specific basket of goods and services.

[17]See, e.g., Jørgensen and Ravn (2022), Jorda and Nechio (2023) or Klein and Linnemann (2023).

4.2. Distributional effect of inflation and price cap policies

In this section, we discuss the impacts of the inflationary shock, the price caps and the alternative policy measures on household welfare, measured as the additional share of baseline household disposable income that would be required to keep the consumption basket fixed under the new prices. We assess these effects across the income distribution (Figure 2) and then we use concentration indices (the Gini coefficient) as a synthetic aggregate indicator to capture the overall effect on income inequality.

The increase in the 'expenditure burden' (or the decrease in purchasing power) due to the inflationary shock is observed across all income deciles, but it is particularly pronounced at the bottom of the income distribution.[18] This regressive pattern is particularly pronounced in Germany, driven by the higher expected price increase of gas. After the change in prices, the first decile experiences a welfare loss (expressed as a percentage of baseline disposable income) of about 8.3% in Germany, 9% in the Netherlands and 7.3% in Austria. This welfare loss is observed across the income distribution, but it monotonically decreases (the richest decile suffers a welfare loss of about 3.1% in Germany, 3.3% in the Netherlands and 4.5% in Austria).

The price cap alleviates this situation in all three countries, generating a welfare gain across all income deciles. The offsetting effect of these measures is stronger at the bottom of the income distribution. However, this policy only partly counteracts the regressivity and negative redistributive consequences of the inflationary shock.

Moreover, the effect is heterogeneous across countries. With the cap, the first decile would lose 5.9% (instead of 7.3%) in Austria and 6% (instead of 9%) in the Netherlands. The offsetting price cap effect on welfare decreases along the income distribution (with almost no effect for the richest decile). A different situation is observed in Germany, where price caps have only a minor impact on absorbing the inflationary shock. This is because the price cap in Germany is closer to the forecasted market price than in the Netherlands and Austria.

The estimated change in the Gini of this purchasing-power-adjusted concept of income confirms what we would expect looking at the decile-based figures. Overall, the inflationary shock is inequality increasing. The price cap counteracts this effect, but it is not enough to completely offset it in any of these countries.

Table 2 compares the efficiency (in terms of inequality reduction, based on the Gini coefficient) of the price cap to the six alternative policy measures described in Chapter 3 (see Figure 1). We can observe that the reduction in income inequality would be remarkably similar under the actual price cap and the hypothetical lump sum scenario at household level (scenario 5; see Table 2).

The targeted price cap and targeted lump-sum transfers at household level (i.e. a price cap that applies only to the first two quintiles compared with a lump-sum transfer to the same population and for the same budgetary cost) would lead to very similar results,

[18]This result is attributed to the fact that the poorest households allocate the highest share of their income to consumption (see Figure B.1).

Figure 2: Inflationary shock and simulated energy measures in 2023

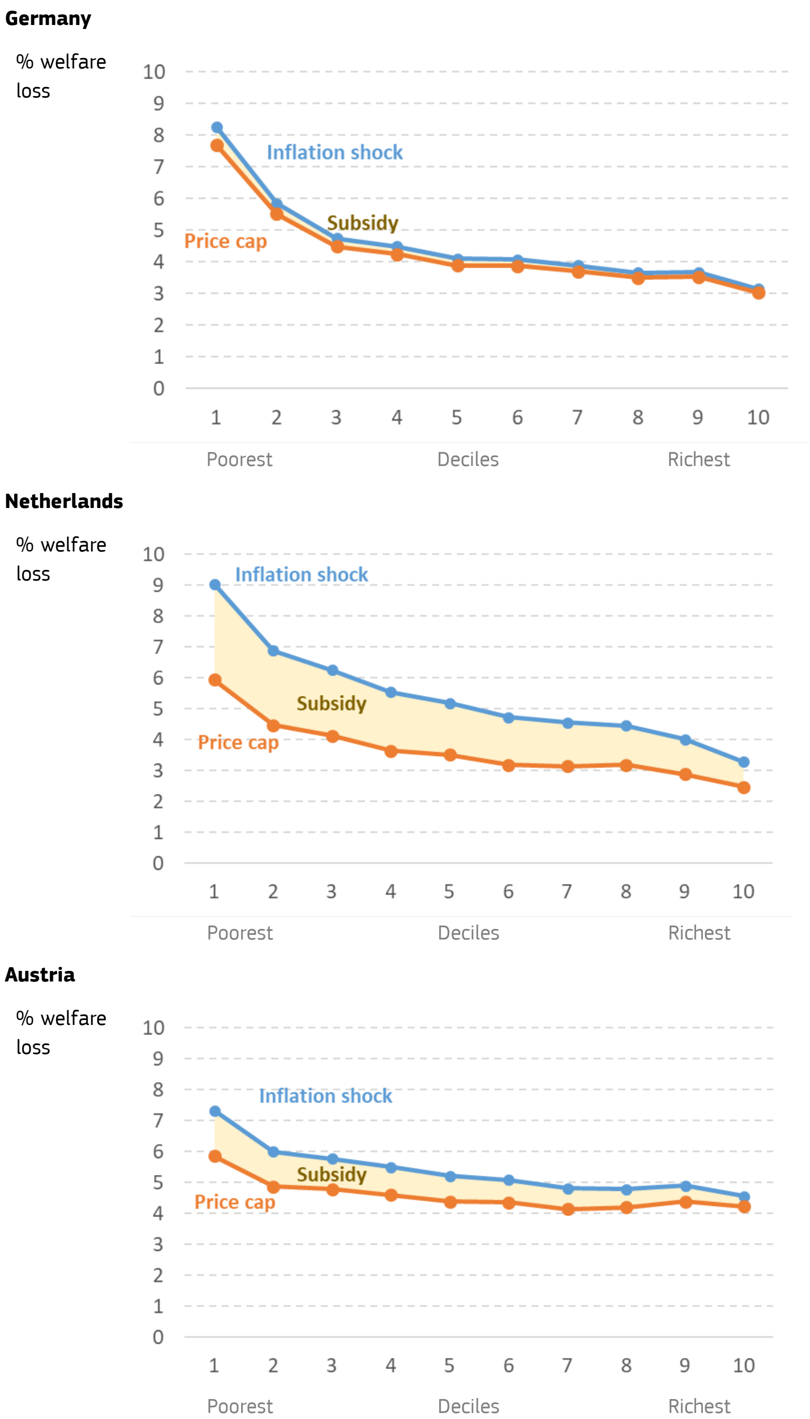


Table 2: Gini coefficient of equivalent income (purchasing power) across scenarios

	Scenario	Germany	Netherlands	Austria
1	Baseline	0.2860	0.2459	0.2384
2	Inflationary shock	0.2913	0.2549	0.2428
3	Price caps	0.2909	0.2511	0.2408
4	Lump sum (individual)	0.2907	0.2494	0.2401
5	Lump sum (household)	0.2907	0.2504	0.2406
6	Targeted price caps	0.2907	0.2505	0.2407
7	Targeted lump sum (individual)	0.2907	0.2487	0.2397
8	Targeted lump sum (household)	0.2907	0.2495	0.2401

Note: The Gini coefficient of the baseline (2022) refers to equivalised household disposable income from the HBS and EU-SILC matched datasets (2010) with incomes updated to 2022.

although with a slightly stronger inequality-offsetting effect (scenarios 3 and 5). However, lump-sum benefits at individual level would further reduce the Gini coefficient, mainly because large households are more likely to be located in the lower part of the income distribution.

4.3. Impact on energy poverty

To complement the assessment of the redistributive effects of the inflationary shock, the price cap and the other hypothetical alternative measures, we simulate the outcomes in terms of energy poverty. Table 3 shows the share of energy-poor households in each scenario compared with the baseline. In the baseline, the share of energy-poor households ranges from 9.2% in the Netherlands to 17.0% in Germany. The inflationary shock increases energy poverty substantially in Germany (1.6 percentage points) and the Netherlands (3.2 percentage points), while in Austria, it slightly decreases energy poverty.[19] In all countries, the introduction of price caps reduces energy poverty rates. The poverty-decreasing impact of the actual price cap measures (scenario 3) is especially high in the Netherlands (8.3 percentage points), followed by Austria (3.9 percentage points) and Germany (1.4 percentage points). The lump-sum benefits for individuals and households (scenarios 4 and 5) would reduce the energy poverty rate slightly less than the price cap measures. Moreover, targeted measures (scenarios 6, 7 and 8) would reduce energy poverty to a smaller extent than untargeted measures. This is because we observe a non-negligible group of energy-poor households in the middle and middle-high parts of the income distribution.

These results across scenarios in terms of inequality-offsetting and energy-poverty-offsetting effects raise the question of what measure is most efficient in protecting households from welfare losses, given the costs of the measure. The next section tries to answer this question.

[19]The decrease in energy poverty in Austria is driven by the forecasted oil price, which is expected to decrease between 2022 and 2023.

Table 3: Percentage of energy-poor households in the baseline, inflationary shock, price cap and lump-sum scenarios

	Scenario	Germany	Netherlands	Austria
1	Baseline	17.0	9.2	13.3
2	Inflationary shock	18.6	12.4	12.5
3	Price caps	17.2	4.1	8.6
4	Lump sum (individual)	17.3	5.3	8.9
5	Lump sum (household)	17.4	4.7	9.0
6	Targeted price caps	17.7	5.1	9.4
7	Targeted lump sum (individual)	17.8	5.9	9.5
8	Targeted lump sum (household)	17.9	5.7	9.7

Note: The poverty line is fixed to 2022 levels (2M energy poverty indicator).

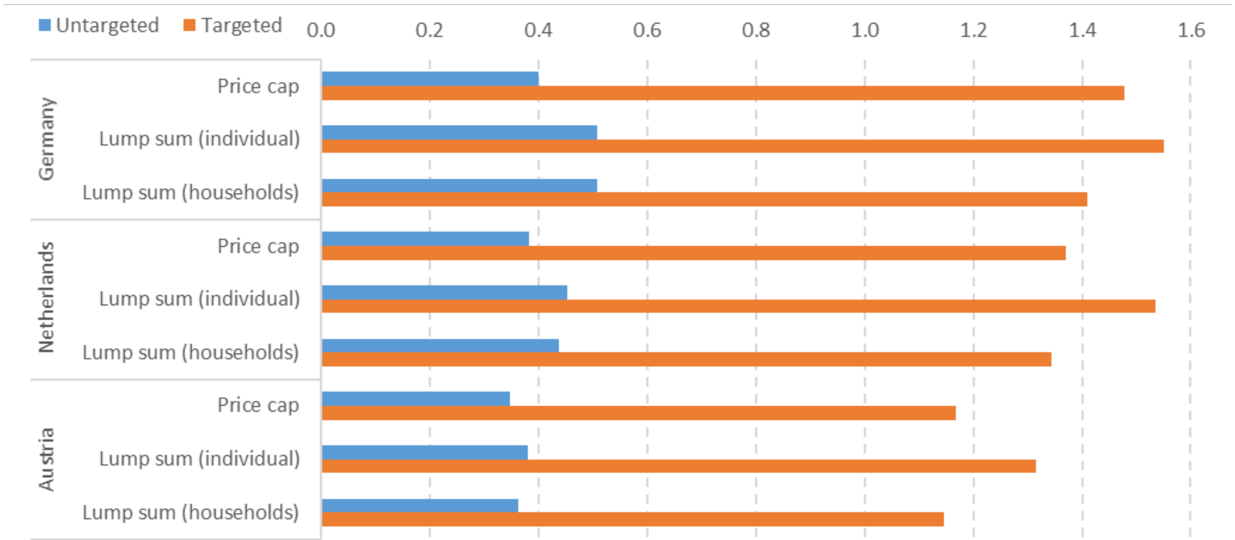
4.4. Cost-efficiency measures

At the economic policy level, there is an ongoing and long-lasting discussion on whether targeted measures are more desirable than untargeted measures (such as the current price caps) to protect households against unexpected price shocks (such as in the current energy crisis). The main argument for targeted measures is that they could protect the poorest households from high energy prices, while limiting government costs and additionally reducing budgetary risks in the future due to unexpected energy price increases. For this reason, we analysed the cost-efficiency of all measures in reducing inequality, as well as in reducing energy poverty.

Figure 3 presents the results from the cost-efficiency analysis of the different policy measures related to reducing inequality. As all three countries introduced untargeted price cap measures, we are able to compare the efficiency measures across them. Our calculations suggest that the German price cap is the most cost-efficient measure in reducing inequality, followed by those in the Netherlands and Austria. This result is driven by the low cost (budget involved) of the price cap measures in Germany, even though, in this country, the result is the worst in terms of inequality reduction. In this sense, if we look at the allocation of total government budget spent on the simulated price caps by quintiles (Figure B.2), we can see that, in Germany, 24% of the budget allocated to price caps goes to the richest 20% of the population, while a smaller share (18%) is spent on the poorest quintile. In the other two countries, the budget allocation is practically uniform across quintiles (i.e. about 20% each). This different pattern can be explained by the design of these policy measures. In the Netherlands and Austria, the energy price is capped up to a volume limit (see Table 1). In Germany, however, the price is capped depending on annual consumption of the previous year, resulting in a higher subsidy (in absolute terms) for households with greater consumption.

Looking at the different characteristics of these measures between countries, we can see that targeted measures (orange bars in Figure 3), whether in form of a price cap or a lump-sum benefit, are always substantially more efficient in reducing inequality than

Figure 3: Cost-efficiency measures related to inequality of different energy price measures



untargeted measures. This is not surprising, as both price caps and lump-sum benefits target poor households (in quintiles 1 and 2) and have a low budgetary impact.

Comparing all untargeted measures (blue bars in Figure 3), our results highlight that lump-sum benefits (and especially those at the individual level) are more efficient than price caps in all three countries. In Austria, the difference is quite small; however, in Germany and the Netherlands, the difference is larger. This has direct implications for policymakers. Given that the current measures (price caps) might be quite complicated to implement and to enforce, our results highlight that a simple lump-sum benefit could be more efficient (provided a proper register of beneficiaries is available) in reducing inequality, even without accounting for the additional administrative cost of price caps compared with lump-sum benefits.

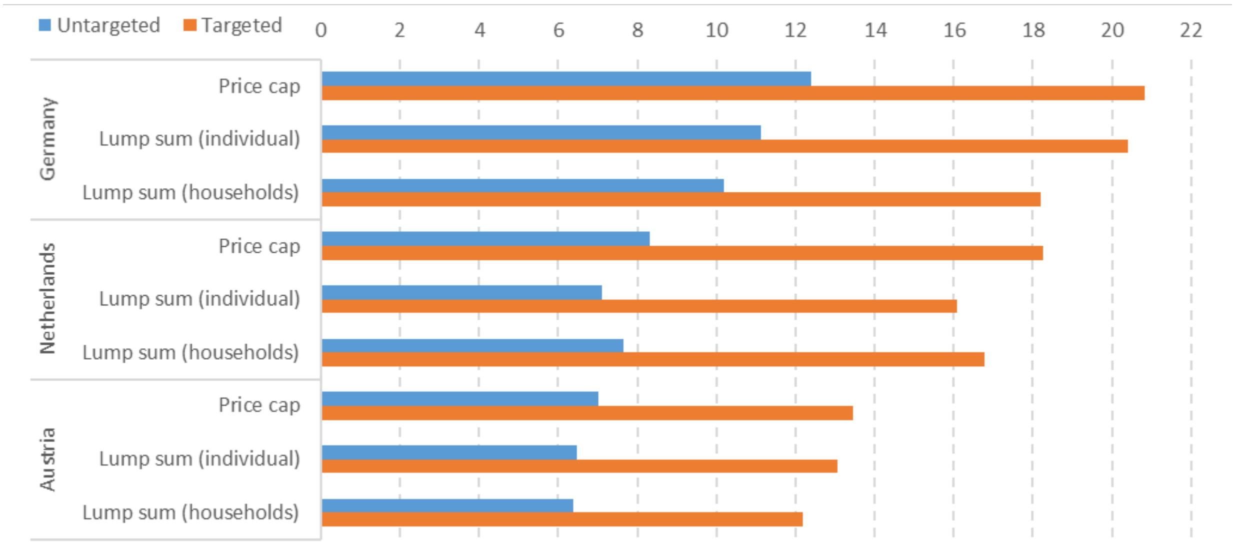
Looking at targeted measures (orange bars), we can see that, again, lump-sum benefits at the individual level are more cost-efficient than price cap measures in all three countries. However, when targeting low-income households, price caps are slightly more cost-efficient than lump-sum benefits at the household level in reducing inequality. This again has important implications for policymakers: according to our analysis, the current price cap measures would be more cost-efficient in decreasing income inequality if they were targeted. Note that the differences are not severe, but are still economically significant.

When analysing the cost-efficiency in reducing energy poverty, the German measures are the most efficient in reducing energy poverty, followed by those of the Netherlands and then Austria (Figure 4).

When comparing different untargeted measures (blue bars), we can see that the price caps are the most cost-efficient measures in terms of reducing energy poverty. This holds true in all three countries and contrasts with our findings on cost-efficiency in reducing income inequality, where lump-sum benefits were more efficient.

Targeted measures (specifically targeted at households in quintiles 1 and 2; orange

Figure 4: Cost-efficiency measures related to energy poverty of different energy price measures



bars) are more efficient in reducing energy poverty than untargeted measures (blue bars), which is driven by the fact that energy-poor households are more concentrated in the lower parts of the income distribution, regardless of the non-negligible incidence of energy poverty in middle-income groups. Comparing different targeted measures, the price caps are also more cost-efficient in reducing energy poverty than lump-sum benefits. Therefore, overall, price caps seem to be the most efficient measure in reducing energy poverty, mainly because their design directly links them to energy consumption and therefore reduces energy expenditures, while, because of the underlying constant quantities assumption, only part of the lump sum is being used for energy consumption.

5. Conclusion

Hikes in energy prices and disruptions to energy supply are among the top concerns in the post-pandemic EU. While the long-term strategy of the EU foresees a gradual increase in energy taxes and prices (e.g. through the new legislation proposed under the Fit for 55 package, such as the revision of the energy taxation directive and, to a lesser extent, the carbon border mechanism adjustment) as a key policy instrument to achieve the ambitious 2030/2050 climate targets, the sudden and unprecedented increase in energy prices that began in 2022 has called for strategic short-term emergency responses. Among others, measures to respond to these unexpected high prices and imbalances in the energy market include price caps, mainly in electricity and gas, as well as lump-sum cash benefits. In this report, we address the ex ante distributional effect of these energy policy measures and evaluate to what extent these could counterbalance the regressivity of the inflationary shock and its effect on energy poverty. We show that the inflationary shock is expected to hit all households, but disproportionately more those at the bottom of the income distribution. This is because the poorest households spend the highest share of their income on consumption (a pattern that is even more pronounced for necessary products such as energy and food, which were the categories mainly affected in the recent price shock).

Our estimates show that price cap policies partly absorb the negative redistributive consequences of the inflationary shock and counteract the increase in energy poverty. However, the impact of these price caps varies across countries. The Netherlands and Austria experience better results (in terms of cushioning the inequality-increasing effects of inflation) due to more generous price caps than Germany. The cushioning effect of price caps is driven by the design of the policy (i.e. a limit on consumed quantities in the Netherlands and Austria) and because of the higher shares of income spent on electricity and gas of households at the bottom of the income distribution. However, the poorest households are still the most severely affected by the inflation shock, and price caps are far from enough to offset their welfare losses. To better support those most affected by this crisis, more targeted policies may be necessary.

To shed more light on these policy challenges, we extended the analysis to assess the efficiency of the price caps in place in Germany, the Netherlands and Austria in comparison with alternative hypothetical policies (targeted price caps and targeted and untargeted lump-sum benefits). We defined efficiency with respect to the performance of each policy in terms of the budget involved and welfare outcomes (with two aggregate welfare indicators: inequality and energy poverty). The results show that targeted measures (to low-income households) are more efficient in cushioning the negative redistributive consequences of the inflationary shock than untargeted measures. Moreover, when implementing untargeted measures, simple fiscal policies such as lump-sum benefits might be more efficient in reducing inequality than complex measures such as price caps, even without accounting for the higher administrative cost of the latter.

The Gini coefficient gives us a sense of the expected effect of different policy measures on the distribution of equivalent disposable income (i.e. equivalised household disposable income after the price shock). However, policies implemented in uncertain periods of time may have differing objectives, such as general inflation control or protecting the most vulnerable, which in the current scenario could be the energy poor. Therefore, we complemented our ex ante distributional analysis by looking at the effect of the inflationary shock and the price caps on energy poverty, using the so-called 2M indicator based on income shares of expenditures on energy. Our results suggest that price caps can play a key role in reducing the number of energy-poor households in these three EU countries. When looking at the efficiency of the measures in reducing energy poverty, we found that targeted measures are more efficient than untargeted measures. Across the targeted and untargeted measures, price caps are more efficient than lump-sum benefits in reducing energy poverty, mainly because they are directly linked to energy consumption and therefore to energy expenditures.

From a policy perspective, we have shown that energy price caps are, if at all, only slightly more cost-efficient in reducing energy poverty than simple lump-sum benefits. However, they do not address the shortage in the energy supply and they potentially disturb the price signal. Given the loss in the price signal, price caps are likely to have a lower impact in reducing energy consumption and therefore potentially compromise the achievement of the EU climate targets.

In this context, targeted support policies, even in the simple form of a lump-sum benefit, seem to be a more reliable way of supporting vulnerable households during an energy crisis, keeping in mind other macroeconomic effects, provided that the design considers a quick payment (i.e. specific transfer, not a tax credit in the following year). First, HICP inflation is not affected in any way by these transfers. While a measure that contains the rise in consumer prices might be attractive in a period of high inflation (especially to prevent inertial inflation through indexation mechanisms), the potential phasing out of such a measure could bring back these inflationary pressures. Second, the price setting of firms is not disturbed via a lump-sum transfer (depending on the selling price) that is paid from the government to energy firms directly. Therefore, firms' incentive to set a price close or above the level of the price cap is strongly reduced. Third, households will still pay high energy costs, but are compensated via a lump-sum benefit. Therefore, the incentive for households to reduce energy consumption is stronger (in the case of the price caps, the incentives remain only at the margin when households are above the threshold). Fourth, the targeting of lump-sum benefits to vulnerable, low-income households will ensure that government costs will remain manageable and could also be kept in place for a longer time. Fifth, targeted lump-sum benefits are more cost-efficient in reducing inequality than price caps.

In our analysis, there are at least two decisions we made for simplification purposes, but that deserve some reflections and hopefully will open some avenues for future research. First, at the policy design level, the support for targeted policies may depend on where the threshold is set. Our hypothetical targeted scenarios are based on an arbitrary line set at the second quintile (covering, therefore, the poorest 40% of the population in terms of income). Setting a threshold that would leave out some middle-income groups that could be particularly vulnerable to the rise in energy prices could be a challenge to the political support of such measures. In fact, as our energy poverty measure shows, there is a non-negligible group of energy-poor households (according to the 2M indicator) that are classified in the middle- and middle-top income deciles. Second, when interpreting the results, it is important to remember that the objective of this study was to assess the welfare loss in purchasing power. Therefore, we looked at the welfare effect under a scenario in which households' level of goods and services purchased remained unchanged. This approach allows us to quantify the maximum impact of inflation and policy reforms on households before any reactions. However, the real distributional effects of inflation and price caps might be different if we were to consider that households in the lower part of the income distribution might react to an increase in prices differently from richer households. Future research could focus on analysing whether and how inflation and price caps may affect patterns of consumption.

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Appendix A. Forecasting energy prices

In this paper, we estimate the distributional impact and the budgetary costs of energy price caps on household income. By definition, the energy price caps (on gas and electricity) that were introduced recently all have a direct impact on inflation by lowering energy prices. Therefore, when looking at energy price inflation, the values do not reflect real price developments paid to energy sellers but reflect only the part that is paid by the household, neglecting the part subsidised by the government intervention. However, to estimate the impact of the energy price caps, we compare this new impact to a situation in which a household would pay the full price for energy (the absence of price caps).

To do so, we use information on future prices for oil, electricity and gas. Notwithstanding the drawbacks of using the TTF market as a reference for future developments in the European energy market, our forecast relies on the TTF futures to obtain future retail gas, oil and electricity prices. Our price assumptions of Brent oil are based on the Intercontinental Exchange crude oil daily futures (measured in USD/barrel of crude oil). For gas, we rely on the Intercontinental Exchange Dutch TTF daily gas futures (measured in EUR/MWh) and, for electricity, we rely on an EU weighted average of electricity futures of seven Member States, namely Belgium, Germany, Spain, France, Italy, the Netherlands and Austria. This is mainly because the gas market is not bound by national borders in Europe.

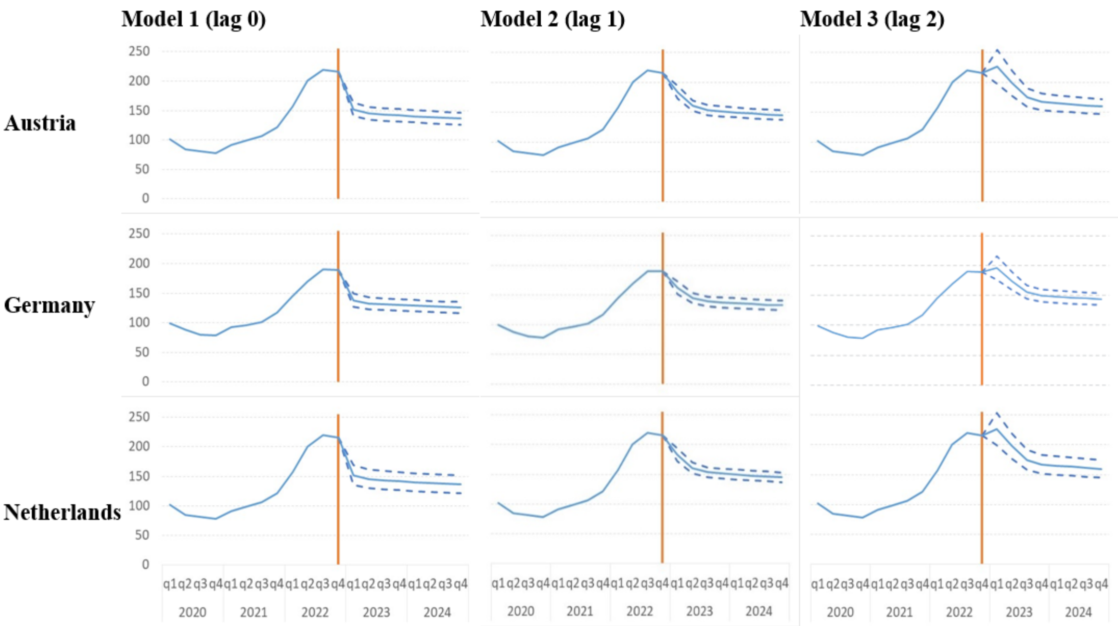
As energy sellers in Europe typically buy energy on the energy market several quarters in advance and contracts of households cannot be adjusted to price increases in the short term, we set up simple econometric models to account for these specificities of the energy market and estimate the past and future developments of energy prices in the absence of the energy price caps. Specifically, we use the strong relation between the energy inflation (measured in the corresponding HICP energy category) and the lagged future prices of the energy type, assuming that the pass-through from retail differs by energy type and by country. We set up several different models and use the model with the lowest RMSE or, in other words, the most accurate in the insample forecast, based on quarterly data for both future prices and the HICP. We estimate a simple time-series model of the following form:

$$HICP_{i,t} = \alpha_i + \beta_i WP_{i,t-n} + \epsilon_{i,t} \tag{A.1}$$

where $HICP_{i,t}$ is the HICP of energy component i, $WP_{i,t-n}$ the wholesale price (including the future prices) of energy component i, and $\epsilon_{i,t}$ the error term.

To forecast the retail price of oil, we use several different assumptions about the pass-through of market prices to retail prices for all three countries. As highlighted in Figure A.1, the price expectations differ substantially across the models. While in the model with an immediate pass-through of oil prices to consumers, we would expect the HICP for oil to fall in Q1 2023, the drop would be substantially smaller if we assumed a pass-through of one or two quarters (models 2 and 3). This highlights the importance of choosing the correct model.

Figure A.1: Model predictions for oil retail prices (Index)



When forecasting the retail price of gas, we again used several different assumptions about the pass-through of market prices to retail prices for all three countries.[20] We use three models based on a pass-through after one, two and three quarters.

As highlighted in Figure A.2, the price expectations for gas also differ substantially across the models. While model 1 forecasts a substantial drop in retail prices in Q1 2023, models 2 and 3, which assume a slower pass-through, suggest a retail price to peak in Q1 2023 and Q2 2023, respectively.

Turning to the forecast for retail electricity prices, we followed the modelling of retail gas prices. We use three models based on a pass-through after one, two and three quarters in each of the countries. Figure A.3 shows the differences in the model-based forecast for retail electricity prices. Depending on the assumption of the pass-through of high electricity prices to consumers, we see different turning points for the retail prices: either an immediate drop in model 1 or a peak in Q2 2022 in model 3. Overall, all of the models forecast a smoothening of the retail electricity prices at the end of 2023 at a very similar level.

[20]For gas, we do not report a direct pass-through model, since as this model has a very weak validation.

Figure A.2: Model predictions for gas retail prices (Index)

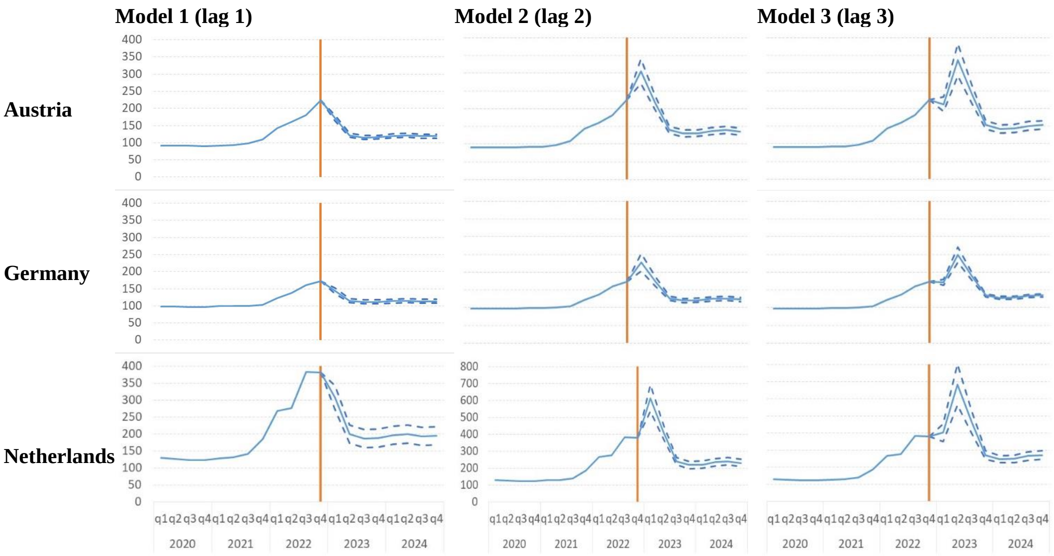
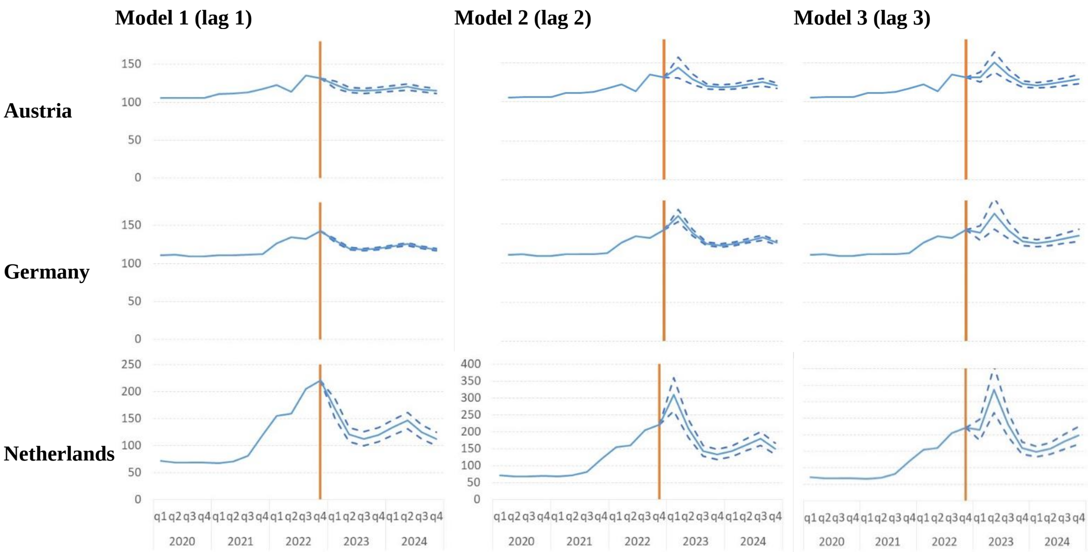


Figure A.3: Model predictions for electricity retail prices (Index)



Appendix A.1. Model selection according to the variation, Akaike information criterion and root mean squared error

The pass-through of high energy prices can potentially differ across countries due to different market structures and contractual agreements of consumers. Therefore, we chose models for each country, allowing for such differences. To choose the best model, we focused on two important statistics: the Akaike information criterion (AIC) and the RMSE.

To choose the best model from those presented, we use two variables that would support our choice. First, we used the R2, that is, the goodness of fit of our model. Second, we used

Table A.1: RMSE, R2 and AIC of energy price models

	RMSE			*R2*			AIC		
	model 1	**model 2**	**model 3**	**model 1**	**model 2**	**model 3**	**model 1**	**model 2**	**model 3**
Oil									
AT	21.69	13.10	21.94	0.85	0.95	0.87	110.7	90.4	92.5
DE	17.48	9.42	16.10	0.84	0.96	0.88	105.5	83.1	86.3
NL	21.69	13.10	21.94	0.85	0.95	0.87	110.7	90.4	92.5
Gas									
AT	10.16	15.39	15.77	0.96	0.90	0.91	84.8	85.4	77.3
DE	9.88	8.28	6.14	0.89	0.92	0.96	84.2	73.0	60.4
NL	41.46	32.44	34.06	0.86	0.92	0.91	115.8	100.3	91.2
Electricity									
AT	5.93	6.37	4.77	0.69	0.65	0.80	73.0	67.8	55.8
DE	2.91	4.09	6.51	0.95	0.91	0.77	57.3	58.9	61.4
NL	18.70	22.14	23.98	0.91	0.88	0.86	98.2	92.7	84.9

the AIC, which measures the explained variance of our model or, in other words, how well our statistical model predicts the outcome AIC, with a trade-off between the goodness of fit of the model and the simplicity of the model. In other words, the AIC deals with both the risk of overfitting and the risk of underfitting. Additionally, we also used the RMSE, which measures how far the predicted values of a model are from the actual values of the data.

Table A.1 sets out the statistics for each of our models, and our model choice is highlighted in grey. To forecast the oil retail price, we used model 2 (lag 1) in all countries, given it had the highest R2 and the lowest RMSE. This suggests a typical pass-through from crude oil prices to consumers within one quarter.[21] Please keep in mind that the estimated HICP for oil does not differ in the scenarios with and without a price cap, as there is no price cap on oil in the countries in this study; however, it is important for our inflation forecast for 2023.

For the gas price, we see no clear pass-through pattern across countries. For Austria, a fairly quick pass-through of one quarter seemed to best fit the data (model 1). For Germany, a pass-through of three quarters fit best (model 3) and, in the Netherlands, a pass-through of two quarters fit best (model 2).

Focusing on the electricity retail price forecast, a slow pass-through of three quarters is suggested by the indicators for Austria (model 3) while, for Germany and the Netherlands, a pass-through of one quarter (model 1) is suggested when comparing the models.[22]

[21] This is in line with the quick adjustment of gasoline prices.

[22] The slower pass-through of electricity prices in Austria compared with other countries has been already reported by Ertl et al. (2023).

Appendix B. Additional figures

Figure B.1: Average share of households' income consumed in gas and electricity, by income deciles

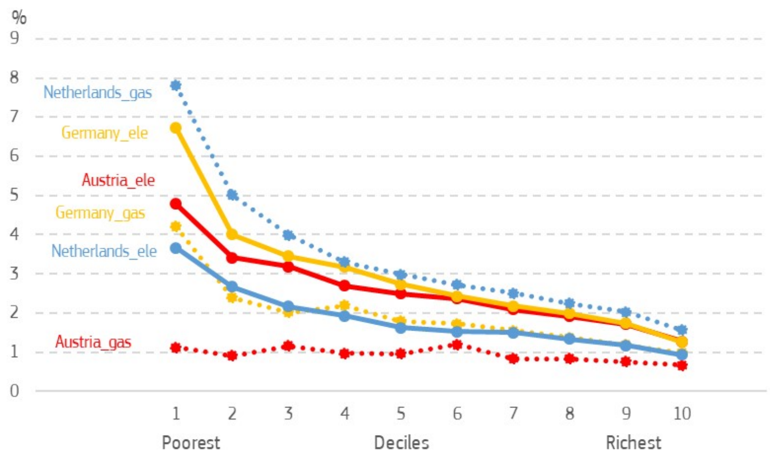
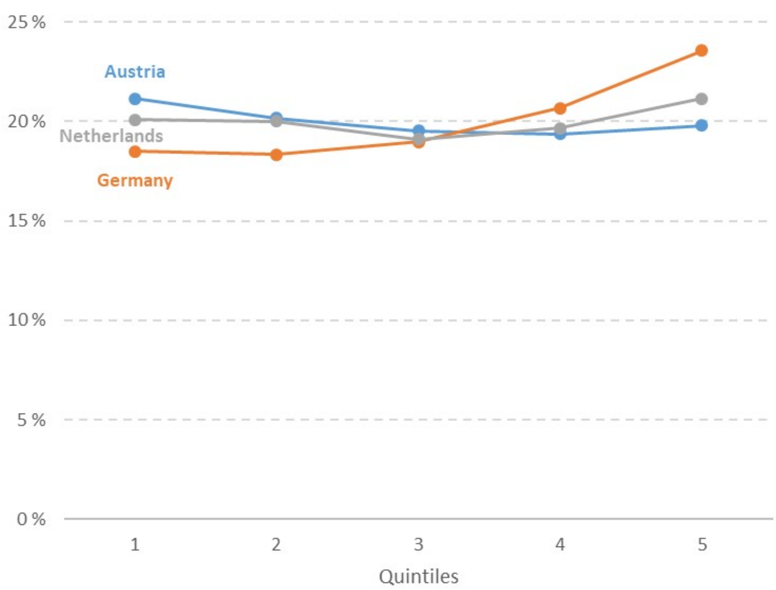


Figure B.2: Allocation of total government budget spent on the simulated price caps by quintiles



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