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INFLATION IS NOT EQUAL FOR ALL: THE HETEROGENEOUS EFFECTS OF ENERGY SHOCKS

by Francesco Corsello* and Marianna Riggi*

Abstract

Energy price shocks broaden inflation inequality, measured by the gap between consumer prices for households at the bottom and top of the expenditure distribution, which is due to different consumption baskets. We provide a VAR-based quantification of the impact of energy shocks on inflation inequality. We then develop and estimate a general equilibrium two-agent model with imported energy to rationalize the empirical results and show why this effect becomes stronger when monetary policy responds aggressively to inflation. Indeed, though less affluent consumers too benefit from the containment of inflation resulting from monetary policy action, they do so to a lesser extent than more affluent ones, given the relatively lower share of consumption spent on items whose prices are sensitive to cyclical conditions. Our results call for the need to complement the monetary policy response with targeted fiscal measures.

JEL Classification: E31, E32, E50, E52.
Keywords: energy shocks, inflation inequality, VAR, dynamic general equilibrium, two-agent model.
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Contents

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1 Introduction[1]

The dramatic soaring of energy prices in 2021 and 2022 has woken inflation after a long era of subdued consumer price growth, forcing central banks to undertake a process of monetary policy normalization that rapidly evolved in a tightening. An unprecedented sequence of policy rate hikes was necessary to avoid second-round effects passing through wages and inflation expectations and to get inflation down to target. In this context, our research leaves aside the aggregate developments and explores the uneven impact of inflation on different consumers, unveiling the role played by monetary policy.

Inflation per se is typically considered a regressive tax, as it erodes more the purchasing power of vulnerable households (Erosa and Ventura, 2002). Nevertheless, the inflationary wave that started in mid-2021, largely driven by skyrocketing energy and food prices, has exacerbated the regressive nature of inflation. Indeed, the most vulnerable households consume a much larger share of these primary goods compared to the more affluent households. This phenomenon makes inflation inequality a key feature of the 2021-2022 inflation surge and a matter of concern for policy makers, as it calls for a fiscal remedy.

Our main results are that energy shocks are the main drivers behind inflation inequality and that the monetary policy response can contribute to its widening. The rationale relies upon the fact that rising interest rates mostly affect *core* prices rather than energy prices, since the latter are more exogenously determined while the former are more elastic to domestic demand. This distinction is particularly pronounced in the post pandemic period, as the energy shock was clearly determined by global factors and amplified by the war in Ukraine, especially in the euro area. Since households in the right tail of the expenditure distribution consume relatively more of the *core goods,* they also reap more benefits from a stronger monetary policy response in terms of preserving their purchasing power compared to more vulnerable consumers. It is important to stress that, when an inflationary shock hits the economy, in the presence of a weaker monetary policy response, inflation would be much higher for all consumers, including the less affluent; thus, the latter also benefit from the containment of core inflation, albeit relatively less than wealthier consumers.

We study the impact of energy shocks on the inflation gap and assess the role of monetary policy using Italian data on consumer prices by expenditure quintiles produced

[1] We are especially grateful to Valerio Nispi Landi for his valuable contribution. We also thank Michele Caivano, Stefano Neri, Massimiliano Pisani, Tiziano Ropele, Alex Tagliabracci, Fabrizio Venditti, Giordano Zevi and Roberta Zizza for their helpful insights. The views expressed here do not necessarily reflect those of Banca d'Italia.

by the Italian National Statistical Institute (Istat). The data point to a record inflation gap across the households' distribution at the end of 2022.

As a first assessment, after having shown stylized facts regarding heterogeneity in the consumption baskets and the associated disparities in inflation across households, we use a VAR model for the Italian economy to quantify the impact of energy price shocks on the inflation gap. We show that a 1% increase in energy inflation leads to an increase in the price gap between quintiles of around 0.2 p.p.

We then set up a dynamic stochastic general equilibrium two-agent model with imported energy shocks to rationalize the VAR findings and highlight the role played by monetary policy in the transmission of the energy shocks and its redistributional impact. Households are heterogeneous in many dimensions. They have different working efficiency and different income levels and, most importantly, they differ in the relative share of energy in their consumption baskets: the share of expenditure for energy is higher for low-efficiency households than for high-efficiency households. They also have different marginal propensities to consume, since low-efficiency households consume all their income in every period (hand-to-mouth) as they are excluded from the asset market, whereas high-efficiency households smooth consumption over the business cycle. We show that the stronger the monetary policy response to energy-driven inflation, the larger the widening of inflation and consumption inequality.

We estimate the model using Bayesian methods and Italian data to confirm the VAR findings and to explore the drivers of inflation inequality over time. We find that while the shocks of energy prices constitute the main driver of inflation inequality, monetary policy also plays a significant role. In the periods in which the ECB's monetary policy was accommodative, it provided a negative contribution to the price gap and, conversely, it exerted upward pressures on inflation inequality during tightening phases. We use the estimated model to compute counterfactuals aimed at assessing the role played by the ECB's monetary policy. During the 2021-2022 high inflation, the bulk of the increase in inflation inequality is due to the imported energy shock, even though there is also a significant role played by monetary policy in explaining this development.

The analysis is subject to an important caveat. The distributional effects of monetary policy pass through a multifaceted set of real and financial channels, related to the impact on income, wealth and credit capacity. Our paper does not aim to reach a verdict: the broad consensus is that the overall losses and gains, when these channels are considered altogether, may appear more or less evenly distributed across households (Panetta 2015). Instead our goal is to stress that the monetary policy implications on inflation disparities via the heterogenous consumption basket, which so far has been neglected, should be considered an important piece of the story. In addition, these results call for the need to complement the monetary policy tightening required to counter the impact of the energy shock with targeted fiscal measures.[2]

The paper is organized as follows. In Section 2, we present some descriptive evidence motivating our analysis. Section 3 presents the empirical evidence based on a VAR model estimated with Italian data. Section 4 lays out the theoretical model and derives its predictions on the relationship between energy shocks, inflation inequality and monetary policy. Section 5 provides the results from the estimation of the theoretical model and presents the counterfactual analysis. Section 6 provides a brief review of related literature in order to put our paper into perspective. Finally, Section 7 offers concluding remarks.

2 Motivating evidence

This paper is motivated by two main features of the inflationary wave in place since 2021. First, from the point of view of many advanced countries, the shock has an unambiguously imported nature, since it originated abroad from turmoil in global energy and food markets. Second, these economies are also characterized by a multifaceted degree of household heterogeneity: households are not only different in their spending levels and financial capabilities but also in the composition of their consumption baskets. Less affluent consumers spend a higher share of their income on food and energy, and are therefore more vulnerable to increases in the prices of these primary goods. The combined effect of these two features exacerbates the macroeconomic repercussions of energy price increases and poses relevant implications for monetary policy conduct.

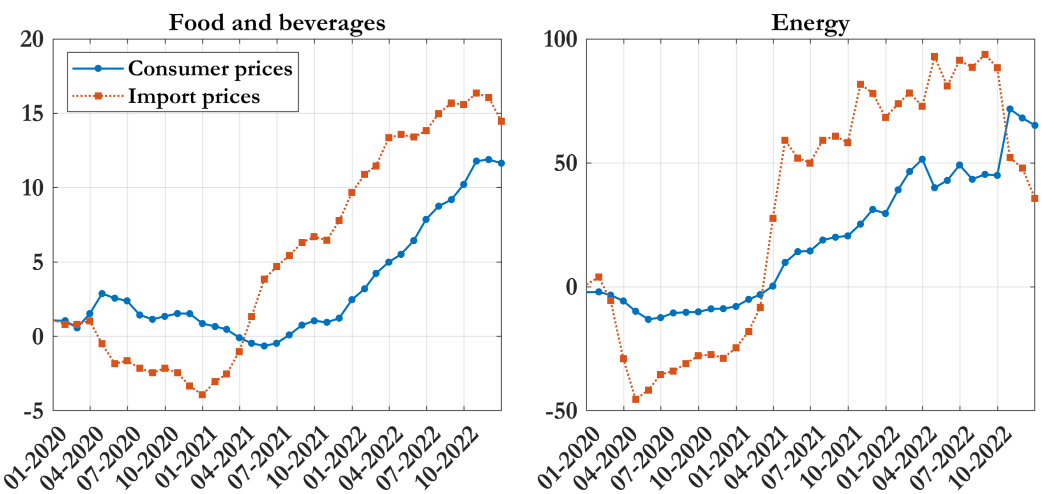
In this section, we provide evidence about these two aspects and their importance for the Italian economy. Figure 1 shows year-on-year (y-o-y) growth rates of import and consumer prices. Food and energy import prices rose markedly in the second quarter of 2021 with a gradual transmission to consumer prices, especially starting in the last quarter of 2021. These upward trends have been exacerbated and prolonged by the outbreak of the conflict between Ukraine and Russia that severely affected global supply chains in these sectors.

[2] On this respect Bartocci et al. (2023) study the policy response to fossil fuel shocks, focusing on reductions in excise taxes on fossil fuels and targeted transfers to the most affected households. They conclude that a reduction of excise taxes disincentives the substitution of renewable sources for fossil fuels and transfers to hand-to-mouth households can stabilize their consumption with limited inflationary effects.

In 2021, Russia was the largest supplier of energy commodities to the euro area, not only for natural gas but also for oil and coal. In 2022, the tension in the European gas market due to the conflict in Ukraine reinforced the upward dynamics of energy prices. On top of the spillover of energy inflation to the food industry, which is highly energy intensive[3], Russia and Ukraine are also major suppliers of some crucial food commodities, including wheat, maize, vegetable oils and fertilizers.

These patterns illustrate the imported nature of the shock and that in Italy domestic conditions were not playing the leading role in determining the inflationary wave.

Figure 1. Import and consumer prices in Italy



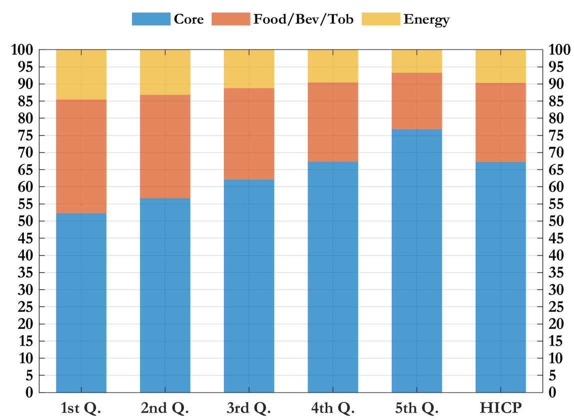
Note. The figure reports the y-o-y rate of change of the Italian index for import prices in industry for food, beverages and tobacco products (left panel) and energy (right panel) and the y-o-y rate of change of the Italian harmonized index of consumer prices for food including alcohol and tobacco (left panel) and energy (right panel).

These shocks affected Italian households with different intensity across the distribution of expenditure. The Italian national statistical institute (ISTAT) produces the Harmonized index of consumer prices (HICP) not only for the entire sample of Italian households but also for five subgroups classified by their expenditure levels. ISTAT collects the information on household expenditure from the Household Budget Survey (HBS), which is

[3] Agricultural production and food processing are strongly dependent on energy inputs, not only via fuels that affect the utilization cost of agricultural machinery and transportation costs, but also by electricity and gas that heavily affect the production of important inputs (chemicals and fertilizers) and the cost of storage, irrigation and livestock breeding.

the survey also used to determine HICP weights for the entire population[4]. These five indexes by expenditure levels have been calculated since 2005 and are released twice a year (while the overall HICP is published monthly). The driver of inflation heterogeneity across households is the different composition of their consumption baskets, with less affluent households spending a much larger share in primary goods. Figure 2 shows that the share of expenditure for food (including alcohol and tobacco) and energy is inversely related to the level of total expenditure. In 2022, the weight of energy in the HICP was 14.6% for households in the first quintile against 6.7% for those in the fifth; the weight of food was 33.2% and 16.5%, respectively. Conversely, core components (services and non energy industrial goods) represent the bulk of expenditure for more affluent households (76.8%) and only about half of total expenditure (52.2%) for more vulnerable households.

Figure 2. Consumption basket in 2022 by spending quintiles



Note. The figure shows the composition of items included in the HICP, for the different quintiles of households by expenditures and for the entire population in Italy (source ISTAT).

Given that the episodes of high inflation in Italy observed since 2006 (the first y-o-y observation available for the different quintiles) have been mainly driven by a surge in the most volatile components, households with lower expenditure levels have been hit

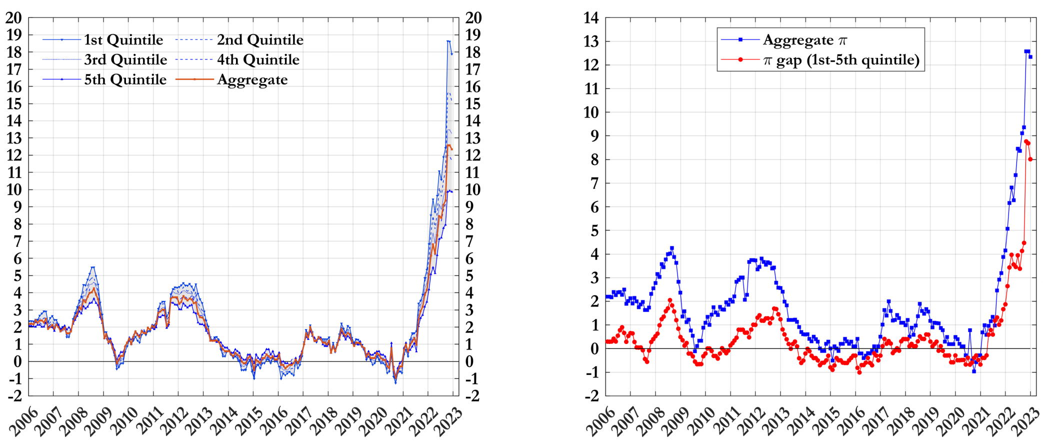
[4]The subgroups are obtained in the following way: (i) all households are sorted by their amount of expenditure and then divided into 5 subgroups of the same size (quintiles); (ii) the HBS and the HIPC elementary items are linked together, in order to obtain the weights of expenditure for each item in each quintile; (iii) a representative basket for each quintile is produced, along with its associated set of weights; (iv) the class-specific weights are used to compile an HICP index using the same prices of elementary items that are collected for the HICP of the entire population.

harder in terms of their cost of living relatively to those with the highest expenditure levels, as shown in Figure 3 (panel a). The exceptional magnitude of the energy price shock since mid-2021 has caused a record inflation gap between the bottom and top tails of the expenditure distribution (see Figure 3 panel b). The inflation gap that was close to zero at the beginning of 2021 has risen sharply since then, reaching 8.5 p.p. on average in the last quarter of 2022. Such remarkable rise of inflation inequality has occurred in the context of government interventions aimed at contrasting the effects of surging energy prices and in part targeted to less affluent households (see Curci, Savegnago, Zevi, Zizza 2022).

Figure 3: Inflation inequality in Italy

Panel a. Headline y-o-y inflation rates by consumption expenditure

Panel b. Inflation gap

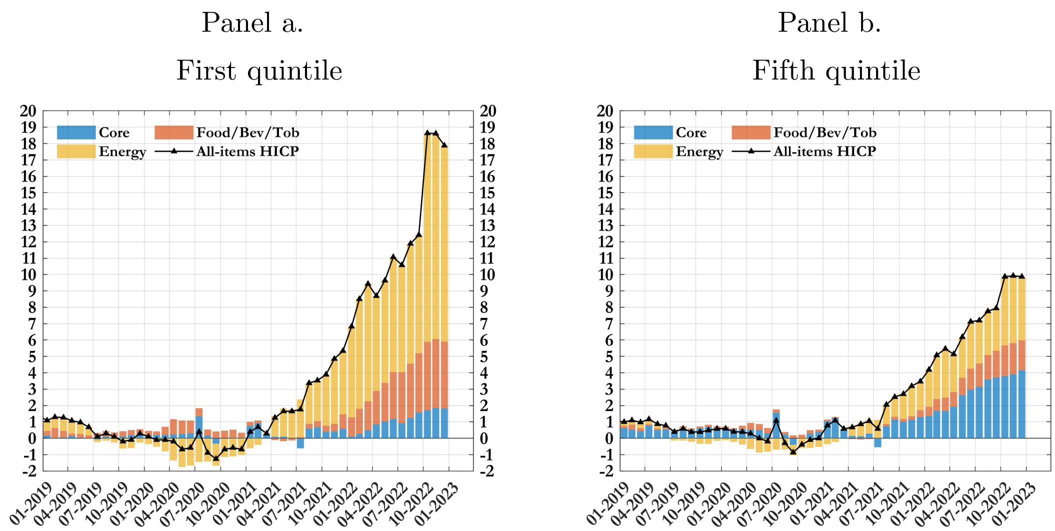


Note. The figure shows (panel a) the headline y-o-y inflation rates across households in the different quintiles of consumption expenditure and (panel b) the comparison between aggregate headline y-o-y inflation rate and the inflation gap between households in the first and the last quintile (source ISTAT).

Figure 4 breaks headline inflation - for the first (panel A) and the fifth (panel B) expenditure quintiles - into the contributions of its main components. For both groups, the contribution of the energy component became positive in April 2021 and has continued to rise since then. In December 2022, the contribution of the energy component to headline inflation for households in the first quintile was 12 p.p., against 3.9 p.p. for households in the fifth quintile. As to the food component, in the same month it contributed to the inflation rate for households in the first quintile by 4.1 p.p., against a contribution of 1.8 p.p. for the fifth quintile.

As is evident in Figures 2 and 3a, aggregate headline HICP inflation closely tracks the price dynamics faced by more affluent households and in particular it is almost coincident to that of the fourth quintile.

Figure 4: Contributions to Italian headline inflation by consumption expenditure class

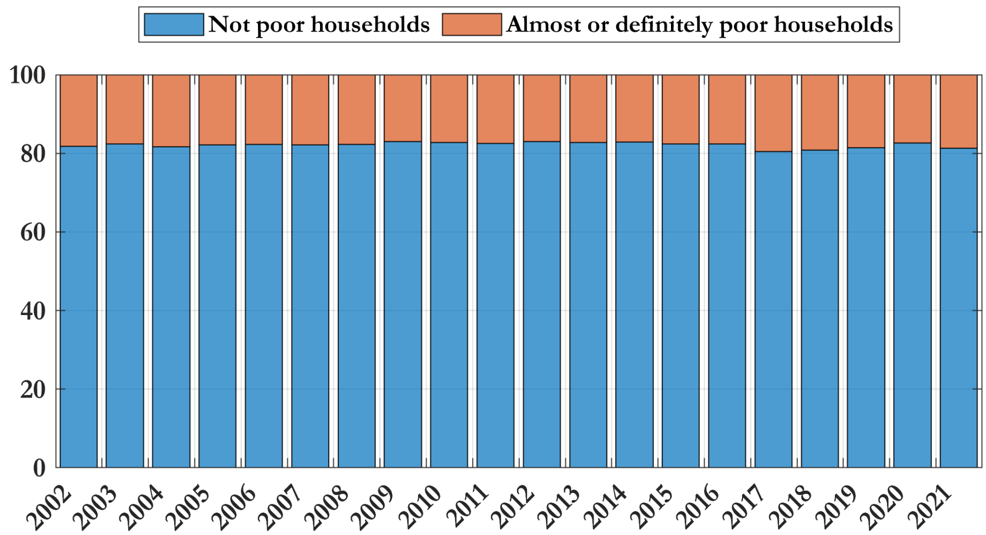


Note. The figure shows the decomposition of headline inflation rates into the contributions of its main aggregates for the first (panel a) and the fifth (panel b) quintile of households' expenditure distributions.

How sizeable is this inequality numerically? Every year ISTAT produces absolute and relative poverty measures. Figure 5 shows that since the late 1990s about 20% of Italian families are defined as almost or definitely poor.[5] These households behave very likely as families in the first expenditure quintile, being less affluent in terms of income. Moreover their status limits the possibility for them to be provided credit and thus their ability to smooth consumption: as it is widely documented in the literature they are characterized by a higher marginal propensity to consume (Kaplan and Violante 2022).

[5]Relative poverty is defined as households that have consumption expenditure below a conventional relative poverty line (poverty line). For a two-member household it is equal to the average expenditure per person in the country (i.e. per capita expenditure and is obtained by dividing the total expenditure per household consumption by the total number of members). Households of two persons having a monthly expenditure equal to or less than this value are classified as poor. For households of different sizes, the line value is obtained by applying an appropriate equivalence scale, which takes into account the economies of scale that can be achieved as the members number increases.

Figure 5. Relative poverty in Italy



Note. The figure shows the proportion of households classified as definitely not poor and almost or definitely poor using the relative poverty measure provided by Istat, which is based on the poverty line (International Standard of Poverty Line - ISPL) defining as poor a household of two components with a consumption expenditure level lower or equal to the mean per-capita consumption expenditure.

3 Empirical evidence

In order to evaluate empirically the macroeconomic effects of an energy shock, especially concerning inflation inequality, we estimate a VAR model using data for the Italian economy. In particular, we use a parsimonious specification with the following five variables: i) energy inflation, ii) inflation gap, iii) core inflation, iv) industrial production and v) the policy rate.

For this exercise, our sample runs at monthly frequency from 2005 to 2022, due to limitations in the historical depth of data for the inflation gap. Time series for inflation and industrial production used in estimation are log-differences of the underlying indexes, while a shadow rate in levels is used to avoid the issues related to the zero lower bound.[6]

[6] Data on the inflation gap between households with different levels of expenditure has been described in Section 2. Energy and core consumer price indexes (HICP), along with the industrial production index, are downloaded from ECB SDW. We use seasonally adjusted core index and industrial production, before calculating the monthly differences. As policy rate, we use an estimated shadow rate for the euro area made publicly available by *LJK macrofinance analysis by Leo Krippner.*

The chosen empirical model is a constant parameters VAR specified as :

$$y_t = \sum_{l=1}^{p} B_l \cdot y_{t-l} + u_t$$

where B_l are $n \times n$ matrices of coefficients and $u_t \sim N(0, \Omega)$ is a vector of i.i.d. multivariate normal disturbances. The model is estimated using $p = 6$ lags via Bayesian techniques. Prior distributions for the coefficients are set using a Minnesota scheme implemented in a conjugate fashion via dummy observations (as in Sims and Zha, 1998), where some hyper-parameters are optimized by maximizing the marginal data density as in Giannone et al (2015).

Given the purpose of our analysis, we aim at identifying an exogenous energy shock from the reduced-form residuals in u_t. To this end, we use a set of sign restrictions in order to characterize the shock as a contractionary energy shock. The latter passes through the gap and core inflation on impact and depresses the economic activity (proxied by industrial production). The policy rate response is restricted to be muted on impact, reacting only with some delay. A summary of the restrictions is reported in Table 1. The sign and zero restrictions are implemented using the algorithm by Binning (2013).

Table 1: Impact sign restrictions for the energy shock

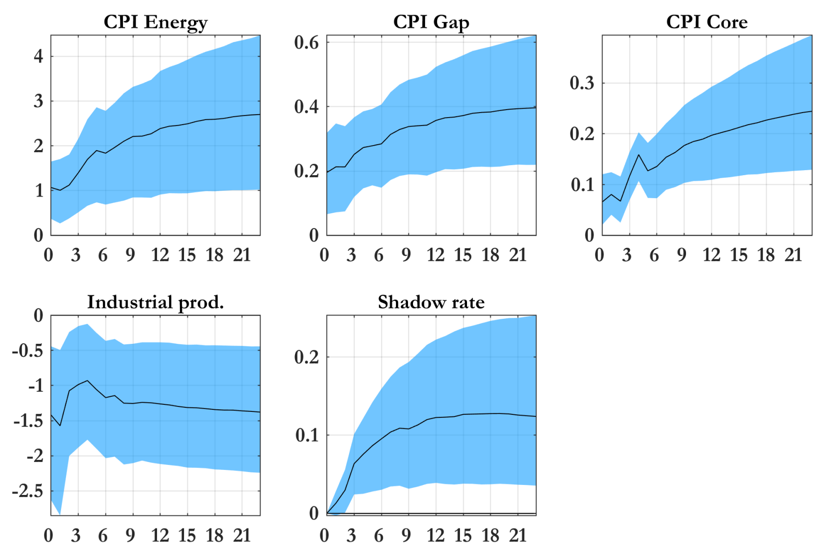
Energy inflation	Inflation gap	Core inflation	Industrial production	Policy rate
+	+	+	-	0

Notes: +, - or 0 indicates that the response of the variable of interest to the structural shock is restricted to be positive, negative or null on impact.

The estimation and identification of the VAR model allows us to analyze the variables' responses to the energy shock (Figure 6). A persistent shock to energy prices is reflected directly and positively by an increase in the price gap, and passes through, even though to a lesser extent, also to core consumer prices. The contractionary energy shock persistently depresses economic activity and induces a restrictive monetary policy response already in the first three quarters.

These results highlight a significant widening of inflation inequality across households driven by the energy shock. This empirical evidence further motivates our analysis, calling for a deeper understanding of the channels through which shocks to imported energy prices transmit heterogeneously to households and of the role played in this context by the monetary policy response. This is the goal of the next section, which will build a fully fledged theoretical framework and perform several simulation and estimation exercises.

Figure 6. Impulse Response Functions



Notes: Blue shaded areas correspond to the 68% credible regions of the posterior distribution. IRF to an energy shock are normalised to yield a 1% impact increase. Responses of CPI and industrial productions are computed as cumulative IRFs.

We conduct a number of robustness exercises[7]. Among them, we have relaxed some of the restrictions used as identifying assumptions. In particular, we have estimated the VAR without imposing the zero restriction at impact on the shadow rate or the positive restriction to the price gap; the results remain similar both on a qualitative and quantitative ground. As a next step, we have used a specification based on euro-area data, estimating a VAR using euro-area HICP energy and core prices and industrial production, instead of the Italian ones, together with Italian price gap. Also in this case, results remain similar, entailing a positive reaction of the price gap of a similar magnitude, even though the energy shock at the euro area level shows a smaller degree of persistence.

[7] All the robustness checks are available upon request.

4 Theoretical model

We lay out a tractable and intuitive theoretical model able to capture the nexus between energy shocks and inflation inequality. It builds on Blanchard and Gali (2009) and Blanchard and Riggi (2013) but, given our purposes, it is modified along different dimensions. As in their models, the country is an energy importer where energy is used as an input in both production and consumption. Yet, rather than assuming a representative consumer, in order to have cross-households differences in consumption expenditure, households are heterogeneous with respect to their time-invariant working efficiency and hence earn different income levels. To maximize the model's tractability, we consider only two types of households, in the spirit of Bilbiie (2018, 2020)[8], whose shares are invariant through time[9], with a high or low level of efficiency.

Most importantly, we assume that the two types of households consume different baskets of goods. Each family obtains utility from the consumption of a bundle of goods that is made up by a household-specific combination of (imported) energy and *core* goods, where only the latter ones are domestically produced. Crucially, motivated by the data explored in Section 2, we also assume that the share of expenditure for energy is higher for low-efficiency households than for high-efficiency ones, who conversely consume relatively more of the *core* goods.[10]

Finally, we assume that the two classes of consumers have a different marginal propensity to consume: low-efficiency households consume all their income in every period as they are excluded from the asset market, whereas high-efficiency households smooth consumption over the business cycle (as in Galí, Lopez-Salido and Valles 2004 and 2007 and Bilbiie 2008).

[8] The stylized representation of household heterogeneity based on two agents follows on a long tradition of two-agent models (Campbell and Mankiw 1989; Galì et al. 2007, Bilbiie 2008 and Eggertsson and Krugman 2012) and has been more recently revamped and extended by Bilbiie (2018, 2020), as it allows to deepen our comprehension of heterogeneity, preserving the key intuitions without impairing model's tractability.

[9] To maximize model's tractability this model abstracts from the risk of transition across households' types, which instead represents a key feature of models that focus more broadly on inequality and precautionary saving motives (Bilbiie, Primiceri and Tambalotti, 2022).

[10] This modelling strategy recalls the one used in Cravino et al. (2020), where households are heterogeneous with respect to their income levels and consumption baskets. However, within their economy all goods are domestically produced and the heterogeneity across goods derives only from a different degree of price stickiness. They assume that high income households consume more of goods with stickier and less volatile prices relative to middle-income households.

Households

Our economy is populated by a continuum of infinitely-lived households, indexed by $h \in [0,1]$. They are of two types, $h \in \{S, H\}$, whose shares are invariant through time. Households in the λ share, denoted with H, are excluded from the asset market: they do not own any assets nor have any liabilities. Hence, they just consume their current labor income, implying that their marginal propensity to consume is fixed at one (hand-to-mouth). The complementary fraction of households, denoted with S, is instead able to trade in all markets for state contingent securities. These consumers are forward looking and smooth consumption over the business cycle. Non asset holders and asset holders also differ for the level of time-invariant working efficiency, as $A^S > A^H$.

Both types of households get utility from the consumption of a bundle of goods C_t^h, which is made up by a combination of *core* goods that are domestically produced and imported energy. This combination is specific to each household type:

$$C_t^h = \Theta^h C_{m,h,t}^{\chi_h} C_{q,h,t}^{1-\chi_h} \tag{1}$$

with $\Theta^h \equiv \chi_h^{-\chi_h} (1-\chi_h)^{-(1-\chi_h)}$. $C_{m,h,t}$ is household's h consumption of energy, while $C_{q,h,t} \equiv \left(\int_0^1 C_{q,h,t}(i)^{1-\frac{1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}$ is a CES index of domestic goods. In what follows we assume that $\chi_H > \chi_S$, so that in equilibrium the share of energy in the consumption basket of households' H is larger than the share of energy in the consumption basket of households' S.

Each asset holder (household of type S) solves the standard intertemporal problem:

$$\max \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\ln C_t^S - \frac{\left(N_t^S\right)^{1+\varphi}}{1+\varphi} \right] \tag{2}$$

where N_t^S denotes labour supply. We denote with $P_{q,t} \equiv \left(\int_0^1 P_{q,t}(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}$ the price index for domestic goods, while $P_{m,t}$ is the nominal price of energy expressed in domestic currency, which is exogenously determined and follows an AR(1) process $P_{m,t} = P_{m,t-1}^{\rho_\Upsilon} e^{\varepsilon_{mt}}$. We also denote with A^h the working efficiency of household h (with $A^S > A^H$), with W_t the nominal wage per efficiency unit, with Q_t^B the price of a one period nominally riskless bond, paying one unit of domestic currency and, finally, with B_t the quantity of that bond purchased in period t and Π_t are dividends from ownership of firms. For simplicity there is no access to international financial markets. Accordingly, the period budget constraint can be written in the following way:

$$P_{q,t}C_{q,S,t} + P_{m,t}C_{m,S,t} + Q_t^B B_t = W_t A^S N_t^S + \Pi_t + B_{t-1} \tag{3}$$

Conditional on the optimal allocation of expenditures between imported and domestically produced goods, the following relations hold:

$$P_{q,t}C_{q,S,t} = (1-\chi_S)P_{c,S,t}C_t^S \tag{4}$$

$$P_{m,t}C_{m,S,t} = \chi_S P_{c,S,t}C_t^S \tag{5}$$

where $P_{c,S,t} \equiv P_{q,t}^{(1-\chi_S)} P_{m,t}^{\chi_S}$ is the household-type S specific consumer price index. We also denote with $S_t \equiv \frac{P_{m,t}}{P_{q,t}}$ the real price of energy, expressed in terms of domestically produced goods. Substituting (4) and (5) into (3), the budget constraint reads as follows:

$$P_{c,S,t}C_t^S + Q_t^B B_t = W_t A^S N_t^S + \Pi_t + B_{t-1} \tag{6}$$

Maximizing (2) subject to (6), the following intertemporal and intratemporal optimality conditions emerge:

$$Q_t^B = \beta \mathbb{E}_t \left\{ \frac{C_t^S}{C_{t+1}^S} \frac{P_{c,S,t}}{P_{c,S,t+1}} \right\} \tag{7}$$

$$\left(N_t^S\right)^{\varphi} C_t^S = A^S \frac{W_t}{P_{c,S,t}} \tag{8}$$

In each period non asset holders (households of type H) solve a static problem, i.e., they maximize their period utility $U(C_t^H, N_t^H) = \ln C_t^H - \frac{\left(N_t^H\right)^{1+\varphi}}{1+\varphi}$, subject to the constraint that all their income is consumed:

$$P_{q,t}C_{q,H,t} + P_{m,t}C_{m,H,t} = W_t A^H N_t^H \tag{9}$$

or, using the optimal allocation of expenditures between imported and domestically produced goods,

$$P_{c,H,t}C_t^H = W_t A^H N_t^H$$

where $P_{c,H,t} \equiv P_{q,t}^{(1-\chi_H)} P_{m,t}^{\chi_H}$ is the household-type H specific CPI index. As a consequence the price gap can be written as:

$$P_t^{gap} \equiv \frac{P_{c,H,t}}{P_{c,S,t}} = \left(\frac{P_{m,t}}{P_{q,t}}\right)^{\chi_H - \chi_S} \tag{10}$$

The first-order conditions for household-type H are the following, implying a constant employment for households of type H, as well as a consumption level proportional to the real wage.

$$C_t^H = A^H \frac{W_t}{P_{c,H,t}} N_t^H \tag{11}$$

$$\left(N_t^H\right)^{\varphi} C_t^H = A^H \frac{W_t}{P_{c,H,t}} \tag{12}$$

Aggregate consumption is a weighted average of the corresponding variables for each consumer type:

$$C_t \equiv \lambda C_t^H + (1-\lambda) C_t^S \tag{13}$$

Firms

Each firm produces a differentiated good indexed by $i \in [0,1]$ with the following production function

$$Q_t(i) = M_t(i)^{\alpha_m} \overline{N}_t(i)^{\alpha_n}$$

with $\alpha_m + \alpha_n \leq 1$. $\overline{N}_t(i)$ denotes the efficiency units of labor used by producer i and $M_t(i)$ is the amount of energy used as inputs in production. Firms take the price of the two inputs as given. Hence, cost minimization implies that firm i's nominal marginal cost $\Psi_t(i)$ is given by:

$$\Psi_t(i) = \frac{W_t}{\alpha_n \left[Q_t(i)/\overline{N}_t(i)\right]} = \frac{P_{m,t}}{\alpha_m \left[Q_t(i)/M_t(i)\right]}$$

Letting $\mathcal{M}_t^p(i) \equiv P_{q,t}(i)/\Psi_t(i)$ denote firm i's gross markup, the following holds

$$\mathcal{M}_t^p(i) S_t M_t(i) = \alpha_m Q_t(i) \frac{P_{q,t}(i)}{P_{q,t}} \tag{14}$$

Denoting with $Q_t \equiv \left(\int\limits_0^1 Q_t(i)^{1-\frac{1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}$ the aggregate gross output, and considering the demand schedule faced by firm i $Q_t(i) = (\frac{P_{q,t}(i)}{P_{q,t}})^{-\epsilon} Q_t$ we obtain:

$$M_t = \frac{\alpha_m}{\mathcal{M}_t^p} \frac{Q_t}{S_t} \tag{15}$$

where $\mathcal{M}_t^p$ is the average gross markup weighted by firms' input shares, and $S_t = \frac{P_{m,t}}{P_{q,t}}$ the real price of energy.

Consumption and gross output

As in Blanchard and Gali (2009), in an equilibrium with balanced trade the following relation must hold:

$$P_{c,t} C_t = P_{q,t} Q_t - P_{m,t} M_t$$

Using (15) we can write:

$$P_{c,t} C_t = P_{q,t} Q_t \left(1 - \frac{\alpha_m}{\mathcal{M}_t^p} \right)$$

where $P_{c,t}$ is the consumer price index of the whole economy.

Price setting and monetary policy

We assume that firms set prices in a staggered fashion, as in Calvo (1983): each firm may reset its price only with probability $(1-\theta)$ in any given period, independently of the time elapsed since the last adjustment. The optimal price setting condition for a firm resetting prices in period t reads as follows:

$$\mathbb{E}_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} Q_{t+k/t} \left\{ P_t^* - \frac{\epsilon}{\epsilon - 1} \Psi_{t+k/t} \right\} = 0 \tag{16}$$

where P_t^* is the optimal price set at time t, $Q_{t+k/t}$ and $\Psi_{t+k/t}$ are the level of output and marginal cost at time $t+k$ for a firm that last set its price in period t. The domestic price level evolves according to:

$$P_{q,t} = \left[\theta \left(P_{q,t-1} \right)^{1-\epsilon} + (1-\theta) \left(P_t^* \right)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \tag{17}$$

Combining the log-linearized version of (17) and (16) around a zero inflation steady state, a standard Phillips curve emerges, where $\pi_{q,t}$ is domestic inflation:

$$\pi_{q,t} = \beta \mathbb{E}_t \pi_{q,t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta} \frac{\alpha_m + \alpha_n}{1 + (1 - \alpha_m - \alpha_n)(\epsilon - 1)} mc_t$$

The monetary authority sets the nominal interest rate according to a standard Taylor rule:

$$\frac{R_t}{\overline{R}} = \left(\frac{R_{t-1}}{\overline{R}}\right)^{\rho_i} \left\{ \left(\frac{P_{q,t}}{P_{q,t-1}}\right)^{\phi_\pi} \right\}^{(1-\rho_i)}$$

where $R_t = \frac{1}{Q_t}$, $\overline{R}$ is the steady state nominal gross rate. As in Blanchard and Gali (2010), we consider $\pi_{q,t}$, which in the model corresponds to core inflation, as the measure of price change that the central bank considers for its interest rate decisions. There are several reasons that make it preferable over headline inflation. On a theoretical ground, $\pi_{q,t}$ is the welfare-relevant measure of inflation, i.e. the one that is associated with price dispersion. Beyond that, this modelling choice appears consistent with the ECB's medium-term orientation of monetary policy, which allows to disregard temporary shocks, such as the exogenous energy shocks, thus avoiding unnecessary volatility in interest rates and economic activity. This is particularly relevant in our setting, as we focus exactly on the effects of exogenous energy shocks: assuming a reaction to headline inflation would produce implausible and abrupt changes in interest rates.

4.1 Energy shock and price heterogeneity. The role of monetary policy

We now use our theoretical framework to explore the effects of the energy shock on the key macroeconomic variables and, in particular, on inflation and consumption heterogeneity. To do that we use a benchmark calibration for the structural parameters, but our results are robust to different sets of calibration.

The discount factor β is fixed at 0.99, a standard calibration for macroeconomic models. We set the Calvo coefficient to 0.5, which implies an average duration of the prices set by firms equal to two quarters. Concerning the fraction of the population that consumes its current income (captured by λ), Gali et al (2007) set it at 0.5. As discussed in Bilbiie (2008), using data until the mid-eighties Campbell and Mankiw (1989) estimate it at around $0.4 - 0.5$ for the US economy. Even though the gradual process of financial inclusion of less affluent families has arguably reduced this share over time, more recent empirical literature (e.g. Johnson et al 2004; Hurst 2004) confirms that a sizeable fraction of the US households still do not behave as prescribed by the permanent income hypothesis. Against this background, our assessment to calibrate λ relies on the following considerations. First, our focus is on the inflation differential between the first quintile of households, in terms of consumption expenditure, and the rest of the economy. In the model, we characterize these households as those having the largest marginal propensity to consume, bringing us to calibrate λ at 0.2. Moreover, considering that since the 1990s about 20% of Italian families are defined as almost or definitively poor, it is very likely that the first quintile of households consumes all their current disposable income. However, it is also plausible that some households in the higher quintiles could have a rule-of-thumb behavior and hence our calibration would represent a lower bound.

In order to calibrate the steady state share of household H in the aggregate consumption expenditure (in nominal terms) we use the Household Budget Survey. Based on these data for 2021, the amount of nominal expenditure of the first quintile of households represents 11% of the total. This share enters in the log-linearized version of the model.

A further step is the calibration of χ_h and χ_s, the shares of imported energy in the consumption basket of the two types of families. In Section 2, we have described the consumer basket allocation for the different quintiles of households according to ISTAT, showing that energy per se accounted for roughly 15 and 7 per cent of the first and last quintile, respectively. Since we model household S as households other than those in the first quintile, we consider as a benchmark for household S the basket of the fourth quintile. In addition, we also consider the imported energy content of other goods, which further increases these shares. For all these reasons, we consider as a central calibration for these shares $\chi_h = 0.3$ and $\chi_S = 0.15$. However, we will also show the sensitivity of our results to different calibrations for this parameter.

In order to compute the share of energy in production α_m, we use a diverse set of information. As a first step, we consider the input-output tables relative to the Italian economy. We refer to the methodology in Blanchard and Gali (2010) and Blanchard and Riggi (2013). More in detail, we split the industries into two large categories: the energy and non-energy producing sectors. Within the former we include: activities related to forestry and logging (wood production), mining and quarrying, manufacture of coke and refined petroleum products, production of electricity, gas, steam and air conditioning supply, water collection, treatment and supply, sewerage and collection, treatment and disposal of waste.[11] Based on our computation on the latest available input-output dataset, which refers to years 2015-2018, we get a value around 0.07.[12] We complement this information with other pieces of evidence. Since 2018 producer energy prices have greatly increased; in the last two years they more than tripled. More recent survey data on Italian firms show that only electricity and gas, which represent around half of total energy inputs, account for around 10% on average of 2022 total cost. All in all, this leads us to calibrate $\alpha_m = 0.2$. For the share of the labour input we assume a standard parameterization borrowed from the literature, setting $\alpha_n = 2/3$. Similarly, we follow the literature to calibrate the elasticity of substitution among differentiated goods and set $\epsilon = 6$, which implies a steady state price markup equal to 20%. Regarding the Frisch elasticity ($1/\varphi$), we assume a value of 1, which is centered in the interval of estimates arising from the micro and macro literature that yield very different values.[13] To capture the high persistence of energy prices, we calibrate the autoregressive parameter of the energy shock $\rho_m = 0.9$.

For what concerns the parameters that capture monetary policy reaction to the energy shock (ρ_i and ϕ_π), we do not take a precise stance as our goal is exactly to investigate how the macroeconomic response depends on the interest rate changes after the shock.

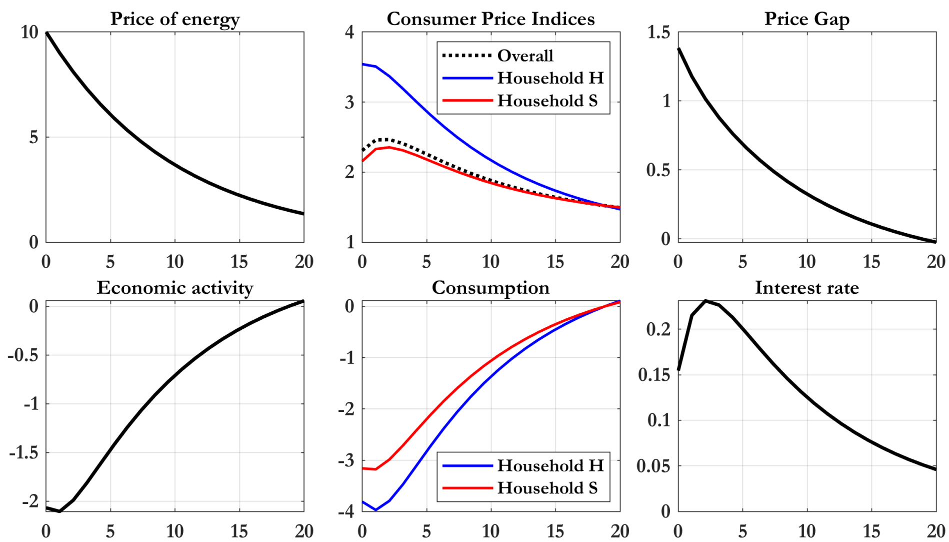
However, as a first step, we calibrate $\phi_\pi = 2$ and $\rho_i = 0.9$ to show (Figure 7) the impulse response functions to a 10% increase in the nominal price of energy (panel a) of consumer price indices of both types of households as well as of the consumer price index for the whole economy (panel b), of the price gap (the wedge between price indices of household H and S; panel C), of output (panel D), of consumption of both types of households (panel E) and of the interest rate. Being a cost push shock, the energy price hike propagates as a supply disturbance, leading to opposite changes of prices and quantities: output and consumption fall while prices rise, inducing a positive increase of interest rate.

[11] The sectors we include correspond to the following codes in the NACE classification: A02, B, C19, D, E37, E38, E39.

[12] Say that the energy producing category is made up of two sectors, A and B, and call C the rest of the economy, which is made up of the rest of the industries. The sum of output and imports of sector A (B) can be split between a certain amount x_A (x_B) for domestic final uses, and a certain amount y_A (y_B) for intermediates, of which z_A (z_B) goes to A and/or B and $y_A - z_A$ ($y_B - z_B$) goes to the non-energy category C. Say that the country's value added is v and the value added by A (B) is v_A (v_B). Then the shares of energy in production α_m can be computed as follows: $\alpha_m = \frac{(y_A - z_A) + (y_B - z_B)}{v - (v_A + v_B) + (y_A - z_A) + (y_B - z_B)}$.

[13] Microeconometric estimates of the Frisch elasticity are typically not higher than 0.5. Instead, in order for macroeconomic models to match the observed amount of total volatility in aggregate hours, Frisch elasticity needs to be higher, even around 2.

Figure 7. Macroeconomic responses to an energy price shock



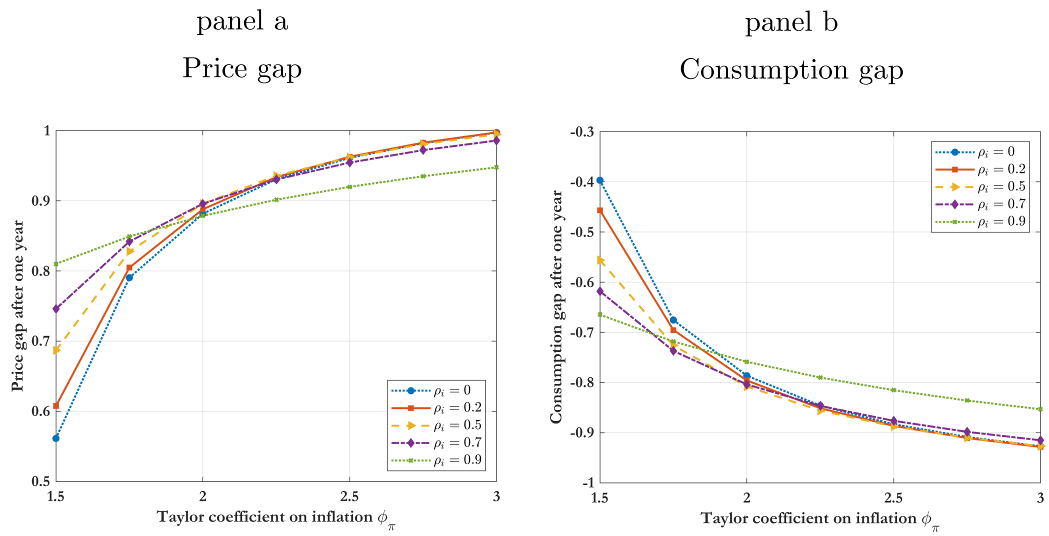
Notes. The y-axis report IRFs to a 10% increase in the nominal price of energy; the x-axis reports the number of quarters after the shock.

Consistently with the empirical results presented in Section 2, the energy shock determines a stronger rise of prices for household H, whose consumption basket is made up by a larger share of energy. This induces a persistent increase in the price differential between different households in the economy, which is associated to a different pattern of changes in consumption: more vulnerable households experience a stronger drop in their consumption expenditure relative to more affluent households. A widening of the price gap exacerbates the recessionary implications of the energy shock. Indeed, households suffering a larger price increase are also those with a higher marginal propensity to consume. In other words, given the size of the shock, the fall in aggregate consumption in an economy with consumption basket heterogeneity is certainly greater than the fall in consumption in an economy with a homogenous basket.

Now we turn to explore the role played by monetary policy in setting distances between families.

On this respect, Figure 8 illustrates what happens to price and consumption gap (defined as $p_t^{gap} \equiv p_{c,H,t} - p_{c,S,t}$ and $c_t^{gap} \equiv c_t^H - c_t^S$, respectively) one year after the shock, for different values of Taylor coefficient ϕ_π and interest rate smoothing ρ_i.

Figure 8. Price (a) and consumption (b) differential after an energy price shock.
The role of the Taylor coefficient on inflation.



Note. The Figure displays on the y-axis the price gap (panel a, defined as $p_t^{gap} \equiv p_{c,H,t} - p_{c,S,t}$) and the consumption gap (panel b, defined as $c_t^{gap} \equiv c_t^H - c_t^S$), one year after a 10% increase in the nominal price of energy, for different values of the Taylor coefficient on inflation (ϕ_π, x-axis). Each line is obtained under a different calibration of interest rate smoothing ρ_i.

Our evidence clearly shows that a stronger monetary policy response (higher ϕ_π) to rising inflation triggers an increase in the price (panel a) and consumption (in absolute terms, panel b) gaps. This result holds true regardless of the degree of monetary policy inertia ρ_i. The intuition is clear. The price gap moves with the real price of energy, as in equilibrium it can be written as:

$$p_t^{gap} = (\chi_H - \chi_S)(p_{m,t} - p_{q,t})$$

The nominal price of energy $p_{m,t}$ is subject only to exogenous changes. On the other hand, by means of the standard demand channel, the rise in interest rate counteracts the increase in domestic prices ($p_{q,t}$): the stronger the response of monetary policy (i.e. the higher ϕ_π), the smaller the rise of domestic prices. In other words, households S reap more benefits from a stronger monetary policy response with respect to households H, given that monetary policy has an effect only on *domestic* price setting combined with the larger share of domestic goods in the consumption basket of type S ($\chi_H > \chi_S$).

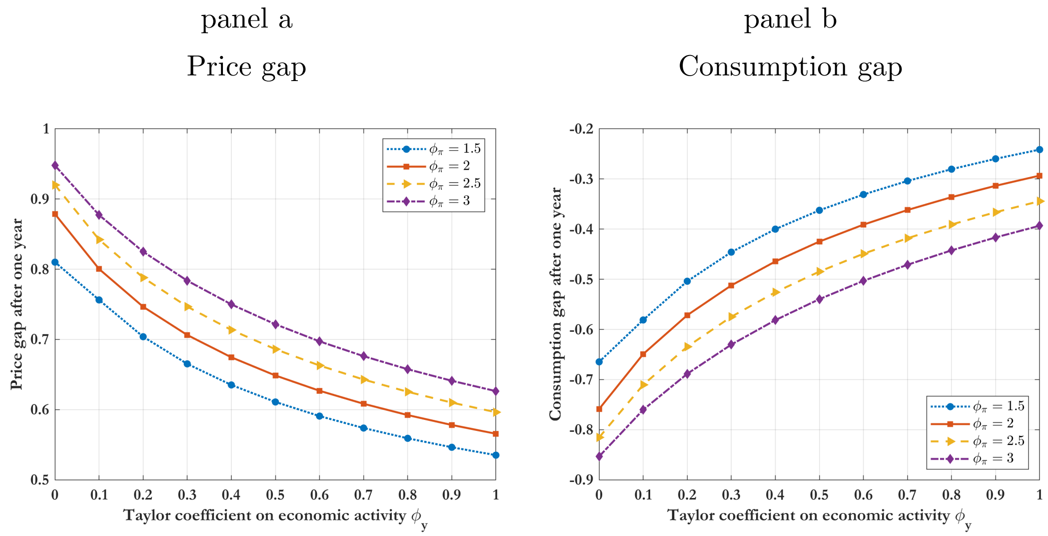
Concerning the consumption gap, regardless of monetary policy coefficients, its reaction to a contractionary shock is always negative. Indeed the drop in consumption of more vulnerable households is always stronger than the one experienced by more affluent households, due to their different marginal propensity to consume. The demand channel of monetary policy works through a change in the intertemporal consumption of asset holders, but the resulting contraction of economic activity leads to a drop in the real wage and consumption also of agents without asset holdings (Households H). A more severe monetary policy tightening causes a larger drop in the real wage and, all else being equal, of the consumption of agents that merely consume their wage income, resulting in a widening of the consumption gap.

We now consider a more general Taylor rule, where the interest rate also reacts to economic activity: $\frac{R_t}{\overline{R}} = \left(\frac{R_{t-1}}{\overline{R}}\right)^{\rho_i} \left\{(P_{q,t}/P_{q,t-1})^{\phi_\pi} Q_t^{\phi_y}\right\}^{(1-\rho_i)}$

Figure 9 illustrates the response of the price (panel a) and consumption (panel b) to a 10% increase in the nominal price of energy, under alternative values of the Taylor coefficient on inflation and the output gap. It turns out that a monetary policy that gives more importance to fluctuations in economic activity dampens the enlargement in the price and consumption gap after the shock. The rationale is in line with the intuition described above: a more restrictive monetary policy stance is able to stabilize inflation more promptly, but at the cost of exacerbating inflation and consumption inequality, as it has an effect only on domestic inflation that matters more for less vulnerable households.

Note that the positive (negative) relationship between the price gap response and the Taylor coefficient on inflation (economic activity) is stronger the more persistent the energy shock (i.e. the higher ρ_m). For a i.i.d. process our story would be clearly less relevant. Yet, in the literature energy price shocks are typically modelled to be very persistent (see Ghoshray 2018). More crucially in the next Section, this parameter will be estimated, pointing to a very persistent process, as suggested in our calibration.

Figure 9. Price and consumption differential after an energy price shock
The role of Taylor coefficient on economic activity



Note. The Figure displays on the y-axis the price gap (panel a, defined as $p_t^{gap} \equiv p_{c,H,t} - p_{c,S,t}$) and the consumption gap (panel b, defined as $c_t^{gap} \equiv c_t^H - c_t^S$), one year after a 10% increase in the nominal price of energy, for different values of the Taylor coefficient on economic activity (ϕ_y, x-axis). Each line is obtained under a different calibration of the Taylor coefficient on inflation ϕ_π.

5 Digging deeper: the recent spike of the price gap

We now turn to investigate the drivers of changes in the price gap observed since the late Nineties. More in detail, we want to explore whether a part of the increasing inflation inequality observed since 2021 might be attributable to the concomitant monetary policy tightening.

This analysis is subject to a number of issues. Data on inflation by quintile of expenditure have been made available by Istat only since 2005, limiting the possibility of running a VAR analysis able to characterize several inflation cycles. This is particularly troublesome since most of the available sample has been characterized by very low inflation rates along with interest rates stuck at their lower bound. For this reason we prefer to estimate the theoretical model by means of Bayesian techniques using data over a longer period (1997Q1-2022Q4), making it possible to generate a long time series for the price gap, which comes out as a latent variable in our model estimation. We then validate this artificial time series by comparing it with the actual inflation gap available since 2005. Having verified that both time series (the actual and the latent one) are basically overlapping, we assess the drivers using the historical decomposition obtained by the estimated theoretical model.

In order to estimate the model we use Bayesian methods, where the posterior distribution for the model parameters $\xi \in \Xi$ combines the prior distribution and the likelihood of the data. Formally, denoting with $P(\xi, M)$ the prior beliefs on parameters ξ given model M and with $P(Y_T/\xi, M)$, $Y_T = \{y_t\}_{t=1}^{T}$ the conditional distribution (likelihood), according to the Bayes rule the posterior density $P(\xi/Y_T, M)$ can be written as $P(\xi/Y_T, M) = \frac{P(Y_T/\xi,M)P(\xi,M)}{P(Y_T,M)}$. The Bayesian posterior estimates are obtained by using the Kalman filter to form the likelihood function and the Metropolis-Hastings algorithm for Monte Carlo integration (three chains of 1,000,000 draws each) to optimize the posterior density function.

We use quarterly data on Italian harmonized core inflation (i.e. inflation net of food and energy components), energy inflation, industrial production and the euro area shadow rate over the period 1997Q1-2022Q4.[14] In order to avoid stochastic singularity and achieve an exact identification of the model, we enrich the model with three more structural shocks in addition to the energy price shock that is the main focus of our analysis: a monetary policy shock, a TFP shock and a preference shocks, all of which follow an AR(1) process. The monetary policy shock $\Omega_t = \Omega_{t-1}^{\rho_\Omega} e^{\varepsilon_{\Omega,t}}$ enters the Taylor rule $\frac{R_t}{\overline{R}} = \left(\frac{R_{t-1}}{\overline{R}}\right)^{\rho_i} \left\{ \left(P_{q,t}/P_{q,t-1}\right)^{\phi_\pi} Q_t^{\phi_y} \right\}^{(1-\rho_i)} \Omega_t$, the TFP shock $\Gamma_t = \Gamma_{t-1}^{\rho_\Gamma} e^{\varepsilon_{\Gamma,t}}$ moves the frontier of the production function $Q_t(i) = \Gamma_t M_t(i)^{\alpha_m} \overline{N}_t(i)^{\alpha_n}$ and, finally, a demand shock modelled as a preference disturbance $\Psi_t = \Psi_{t-1}^{\rho_\Psi} e^{\varepsilon_{\Psi,t}}$ affects utility $\mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \Psi_t \left[\ln C_t^S - \frac{\left(N_t^S\right)^{1+\varphi}}{1+\varphi} \right]$.

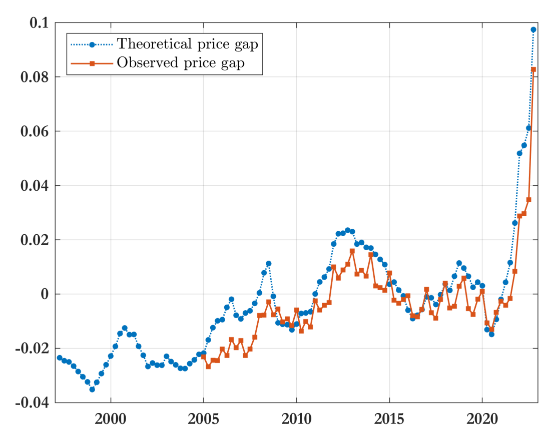
A caveat is in order. Estimating this model with Italian data, adopting a Taylor rule which links the euro-area policy rate movements to Italian inflation and economic activity, might appear naive. However, a number of considerations can justify this approach[15]. First and most importantly, the interest rate is an observable variable: its

[14] As in the VAR presented in Section 3, energy and core consumer price indexes (HICP), along with the industrial production index, are downloaded from ECB SDW. We use seasonally adjusted core index and industrial production, before calculating the quarterly differences. To characterize monetary policy stance we use the euro area shadow short-term rate made public available by LJK macro finance analysis by Leo Krippner.

[15] Note that a similar approach has been already used in the literature. See for instance Riggi and Santoro (2015) that estimate a DSGE model, featuring a Taylor rule to characterize monetary policy, with post 1999 Italian data.

dynamics are not derived from developments in Italian inflation and economic activity but enter in the estimation as data. Hence the estimated coefficients ϕ_π and ϕ_y measure the empirical relationship between the policy rate and the Italian business cycle, giving a "positive" information, without the intention to characterize precisely the euro area monetary policy rule. The estimated shock $\varepsilon_{\Omega,t}$ captures movements in the interest rate that go beyond those explained by Italian data and that, as a consequence, could be attributed to monetary policy innovations or cyclical fluctuations orthogonal to the Italian ones. Furthermore, since 2020 the nominal and real cycles have been generally very synchronous across euro-area countries, being mostly driven by common factors, such as the pandemic, the post-pandemic recovery and the energy shock. The Appendix provides details on the data, the measurement equations, linking the model variables to observables, and the prior and the posterior distributions of the estimated parameters. To validate the model and its estimation, we compare the latent variable for the price gap generated by the estimated model and its empirical counterpart released by Istat since 2005. Figure 10 shows that the dynamics of these two series are very similar, with a correlation of roughly 0.95, even though the theory based series looks somewhat smoother, being less affected by purely statistical and idiosyncratic factors.

Figure 10. Model validation: comparing latent theoretical price gap with the actual one



Note. The Figure displays the gap between the log-level of consumer price index for the first and the fifth quintile of households (in terms of expenditure) according to Istat and the counterpart distance between the log price index for household H and household S ($\log P_{c,H,t} - \log P_{c,S,t}$) generated as a latent variable by estimating the theoretical model.

This result allows us to move to the next step, that is to use the historical decomposition of the latent variable in order to understand the structural drivers of price gap developments. A number of findings emerge.

In line with the intuition given in Section 4, when monetary policy is accommodative it provides a negative contribution to the price gap (Figure 11, panel a), while it pushes up inflation inequality during a tightening. In particular, over the period of low inflation, characterized by a loose monetary policy that reflected both negative monetary policy shocks as well as the endogenous response to negative demand shocks (Figure 11, panel b), the contribution of monetary policy shock to price gap has been negative.

Second, the cycle of energy prices looks to be the main driver of fluctuations in inflation inequality. Focusing on the spike in the price gap observed since 2021, we notice the following facts. The bulk of the recent increase in inflation inequality is due to the imported energy shock, even though a small positive contribution by monetary policy shocks emerges, especially in the latest quarters characterized by a vigorous monetary policy tightening. Yet, in addition to the direct contribution of monetary policy innovations, which appears quite limited, one should also consider that the endogenous reaction of interest rates to rising inflation - that is captured by the contribution of the energy shock to the shadow rate - also affects inflation inequality, for the reasons highlighted in the previous section. This indirect effect is encompassed by the contribution of energy shocks to the price gap.

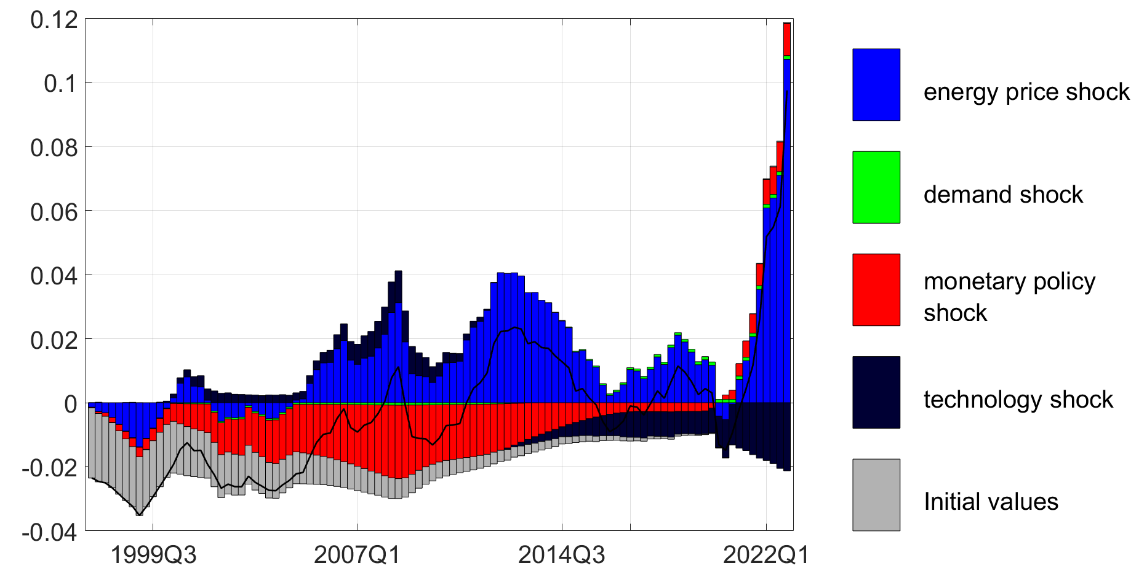
The latter point raises the following question: how much of the recent inflation gap is attributable to the *endogenous* response of monetary policy? In order to answer this question, we run the following exercise: we build a counterfactual path for the interest rate starting from 2021Q2. We choose 2021Q2 as a starting point for this analysis because from that date onwards the interest rate has been boosted by energy price shocks, based on our estimation, as shown in Figure 11. More in detail, the counterfactual path of interest rate, shown in Figure 12 panel a, is built by switching off the contribution of energy prices from the state space solution of the interest rate equation. We then simulate the counterfactual response of the price gap under the assumption that since 2021Q2 onwards the Taylor rule was replaced by this counterfactual interest rate profile. Results, shown in Figure 12 panel b, point to a significant mitigation of the rise in the price gap.

When expressed in terms of the inflation gap measured by the wedge between the y-o-y inflation rate experienced by the first and last household quintile (as shown in Figure 3b), the endogenous response of monetary policy to energy prices would account for around 3 p.p. out of 8.5 p.p. of the Italian inflation gap in 2022Q4.

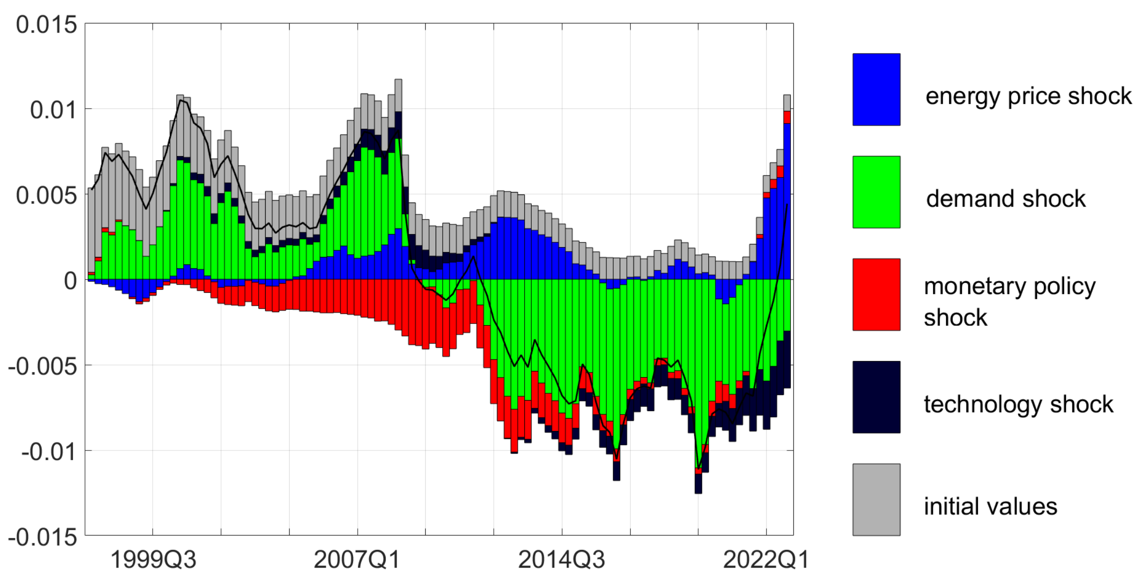
While this exercise provides an indication of the role played by monetary policy for inflation inequality, there are some caveats. In the scenario depicted in this counterfactual analysis the interest rate would not react to both direct and indirect effects of energy shocks on inflation: since 2021Q2 this would have completely precluded the significant monetary tightening actually observed, as the latter was almost completely driven by the energy shock. This explains the strong role attributed to the endogenous response of monetary policy by this exercise. Besides, our analysis does not encompass all the channels through which monetary policy may exert effects on inequality. By contrast, we aim at shedding light on a specific mechanism that has been neglected so far. As we clarify better in the Section on the related literature, monetary policy affects inequality through a multifaceted set of real and financial channels. The broad consensus is that the overall losses and gains, when these channels are considered altogether, may appear more or less evenly distributed across households (Panetta 2015). Our message is that the monetary policy implications related to inflation disparities, via the heterogenous consumption basket, should be considered an important piece of the story.

Figure 11. Historical decomposition

Price gap

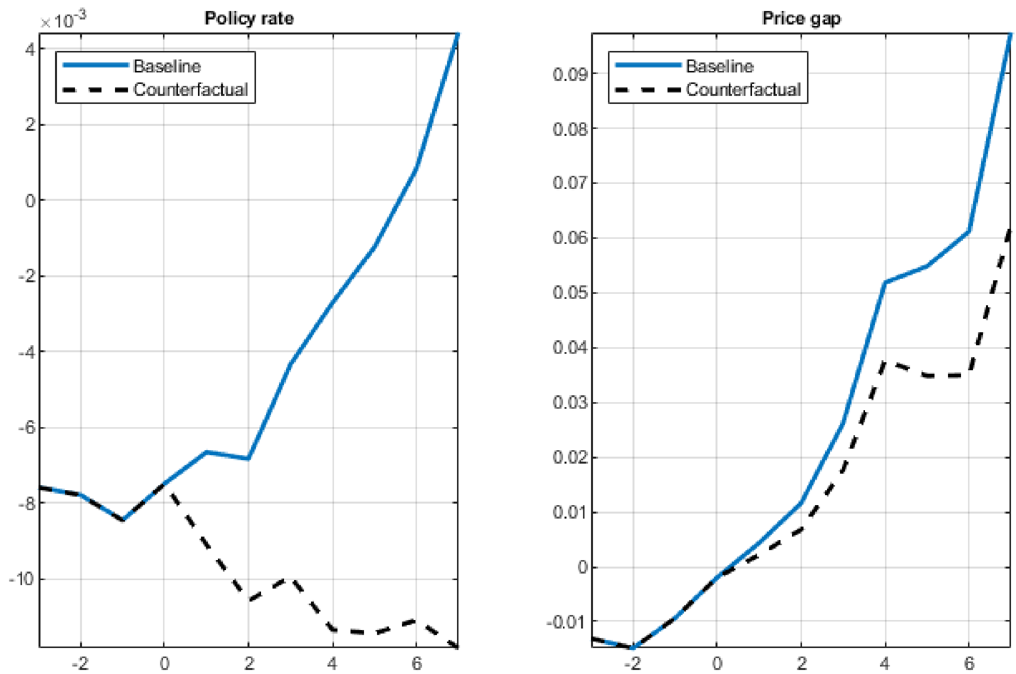


Shadow rate



Note. The Figure displays the historical decomposition of the price gap, measured by the difference between the log price index for household H and household S ($\log P_{c,H,t} - \log P_{c,S,t}$) generated as a latent variable by estimating the theoretical model and the historical decomposition of the shadow rate, which enters as an observable in the model estimation.

Figure 12. A counterfactual exercise



Note. Panel a displays the actual and counterfactual interest rate, where the latter is constructed by switching off the contribution of energy prices from the state space solution of the interest rate equation, since 2021Q2. Interest rates are reported as the deviations from the steady state of the short-term rate evaluated on a quarterly logarithmic basis: $log(1 + R_t/400)$. Panel b shows the associated model-based price gap profile, where the counterfactual path is obtained using a deterministic simulation; the price gap is constructed as the difference between the log price index for household H and household S $(\log P_{c,H,t} - \log P_{c,S,t})$.

6 Related literature

Our paper echoes several themes addressed by different branches of the literature. The first strand to which it relates is that of monetary policy and inequality. The literature has shed light on three main channels through which a change in the monetary stance might have distributional effects on household wealth and income: the employment channel, the asset price channel, and the household balance sheet channel, which stem from the impact on income, wealth and credit capacity, respectively. The first channel arises because the cyclical elasticity of the employment status and wages depends on individual characteristics that vary across income levels. In particular, a very general result is that the effects of the business cycle become increasingly smaller as one goes up the income distribution (Bitler and Hoynes 2015; Heathcote, Perri and Violante 2010). As the labor earnings at the bottom of the distribution are most affected by business cycle fluctuations and more sensitive to swings in aggregate employment (Coibion et al., 2012; Bivens, 2015), monetary policy expansions would benefit more the poor and middle-class, by supporting relatively more their employment and income. The balance sheet channel, instead, hinges on the fact that, keeping everything else unchanged, decreases in real interest rates would benefit net borrowers and disadvantage net savers. Hence differences in the size and composition of household balance sheets might determine relevant heterogeneity in monetary policy impact (for a critical argument against this view see Bindseil, Dominick and Zeuner 2015 and Panetta 2015). Finally, the asset price channel depends on heterogeneity in agents' portfolios that is reflected in diverse capital gains or losses associated to movements in asset prices induced by changes in the monetary policy stance. In particular, expansionary monetary policies favor holders of longer-term assets, who tend to be wealthier households. Most papers focus on only one of these mechanisms, but recently the importance of a comprehensive assessment has been emphasized in the debate (Panetta 2015, Draghi 2016). Along this line, Casiraghi et al. (2018) conclude that the effects on inequality of unconventional monetary loosening are overall negligible.

With respect to this literature, we contribute by focusing on a more specific and less investigated channel: we are interested in the implications of monetary policy in terms of inflation inequality. Namely, in our model, changes in interest rates have heterogeneous consequences across households as they affect relative prices across goods consumed by different households. In this perspective, a paper that speaks to ours is Cravino et al. (2020), albeit with different conclusions. Their starting point is that, based on US data, the prices of goods consumed by high-income households are stickier than those of goods consumed by middle-income households. As a consequence, the overall consumer price indexes of households at the top of the income distribution will react less to monetary policy shocks. Instead, our crucial assumption is that households at the top of the spending distribution consume relatively more *core* goods and relatively less energy with respect to more vulnerable households. As energy prices are more exogenously determined, and arguably less sensitive to monetary policy and internal demand, the consumer price indexes of households at the top of the distribution will respond more to changes in the monetary policy stance.

The second strand to which our paper contributes is the relationship between inflation and inequality. Cross-country evidence on inflation and income inequality suggests that they are positively related (see Albanesi 2007). This is a well-known result to which several explanations have been offered. Erosa and Ventura (2002) argue that low income households hold more cash as a fraction of total assets and hence are more exposed to inflation which, seen from this perspective, operates as a non-linear regressive consumption tax. Along this line, some authors build theoretical frameworks where distributional conflicts result in high inflation, like for instance Albanesi (2007), Alesina and Drazen (1991) Mondino et al. (1996) Dolmas et al. (2000), among others[16].

Our research question here is different, since we look at the other side of the coin. Namely we study how inflation cycles hide a strong heterogeneity in the levels of price growth experienced by different households and how the greater or lesser disparity in inflation experienced by different households depends on the business cycle drivers and the associated monetary policy response.

Seen from this perspective, our paper is related to Gnocato (2023), who starts from the observation that the unemployed devote a higher share of their overall expenditure to energy-intensive consumption and studies the optimal monetary policy response to energy shocks if households are not able to perfectly insure against unemployment spells. In his framework, strict inflation targeting is not optimal because the central bank should partly accommodate inflation to contain the rise in unemployment and limit households' exposure to energy shocks. Our analysis is not normative but rather positive, as it offers a historical decomposition of the inflation gap into its main drivers, allowing a narrative of what forces have been guiding it over time and to what extent monetary policy stance is able to influence it.

Furthermore, using microsimulation tools, Curci, Savegnagno, Zevi and Zizza (2022) analyze the impact of the recent inflation spike on Italian household spending and quantify the extent to which government measures mitigated the distributional impact of the inflationary shock. They find that these interventions have mitigated the inequality in disposable income associated with the rise in inflation by around 70 per cent, with the most effective measure being the targeted measures of electricity and gas social bonuses. Our

[16] The key channel is that the determination of government policy is a bargaining game where the government must finance an exogenous level of fiscal expansion by taxing labor or by resorting to inflationary monetary financing. Higher inequality, arising from greater differences in labor productivity, determines a weakening of low income households' bargaining position, resulting in an outcome of higher equilibrium inflation.

paper adopts a macro perspective to tackle the relation between inflation and inequality, focusing more on the role played by monetary policy. The topic of inflation inequality and the need for targeted fiscal policies is also related to the climate change literature. In this context, Känzig (2023) shows that carbon pricing policies that increases energy prices have an heterogenous impact across households since, similarly to our paper, more vulnerable households have higher energy expenditure share and, hence, would experience a larger fall in their disposable income.

Finally, another strand in the literature to which our paper speaks is that of the macroeconomic effects of energy shocks. The literature on this subject is huge, referring mainly to oil innovations and ranging from analyses of how the consequences of these shocks have varied over time (Blanchard and Gali 2007 and Blanchard and Riggi 2013, among others) to how these implications depend on the nature of the shock (Kilian 2009 and Lippi and Nobili 2012, among others). The way we contribute to this literature is by exploring the heterogeneity of energy shocks' effects on different households, investigating the implications in terms of inflation inequality.

7 Conclusions

The paper has delved into the inflation inequality implications of energy shocks and how they hinge upon the behaviour of monetary policy. By means of theoretical and empirical analyses we have shown that movements of the gap between price levels experienced by different households mostly reflect energy price cycles but also changes in the monetary policy stance.

We see our paper as contributing to different streams of research. The literature on the distributional consequences of monetary policy has typically focused on the employment channel, the asset price channel and the household balance sheets channel, studying the inequality stemming from the impact on income, wealth and credit capacity. In this paper, we have concentrated on the monetary policy effects in terms of disparities in the way households are hit in their purchasing power via heterogenous inflation developments.

Our analysis suggests that the joint implementation of fiscal and monetary policies may prevent pernicious and unintended distributional consequences of the monetary tightening required to counter the impact of the energy shock. While a formal welfare analysis is needed to draw conclusions regarding the fiscal-monetary mix and the optimal design of fiscal interventions, our results suggest that targeted fiscal measures would be desirable considering how energy shocks hit more vulnerable households. A normative analysis that jointly considers the monetary policy trade-off between counteracting aggregate inflation and inflation inequality with the relative role played by fiscal policy is avenue for future research.

Appendix

The model is estimated by using quarterly data on Harmonized Indices of Consumer Prices for energy (E_t) and net of food and energy (X_t), industrial production (I_t) and the shadow rate (Z_t). Consumer prices and industrial production are taken from the ECB, while the shadow rate is taken from the LJK macro finance analysis by Leo Krippner.

The measurement equations linking the model variables to observables are the following, where lower case letters denote proportional deviations from steady state.

$$\begin{bmatrix} \triangle \log I_t \\ \triangle \log X_t \\ \triangle \log E_t \\ \log(1+\frac{Z_t}{400}) - \log(1+\frac{Z_{t-1}}{400}) \end{bmatrix} = \begin{bmatrix} \widehat{q}_t - \widehat{q}_{t-1} \\ p_{q,t} - p_{q,t-1} \\ p_{m,t} - p_{m,t-1} \\ r_t - r_{t-1} \end{bmatrix}$$

The parameters that can be directly inferred from the data are calibrated, in line with Section 4, to which we refer for more details on the calibration. Hence we set the share of nominal consumption expenditure of the first quintile of households to 11%, as obtained from the Household Budget Survey. The shares of imported energy in the consumption basket of the two types of families are set at $\chi_h = 0.3$ and $\chi_S = 0.15$,while the share of energy in production is set at $\alpha_m = 0.2$, based on our computation on Istat data and input-output tables. For the share of the labour input we assume a standard parameterization borrowed from the literature, setting $\alpha_n = 2/3$. Based on the arguments reported in Section 4.1, the fraction of population that merely consumes its current income is set at $\lambda = 0.2$. Finally, the discount factor β is fixed at 0.99, a standard calibration for macroeconomic models. Similarly, we follow the literature to calibrate the elasticity of substitution among differentiated goods and set $\epsilon = 6$, which implies a steady state price markup equal to 20%.

All remaining parameters are estimated. Table A1 reports the prior and the posterior distributions. The priors on the stochastic processes are harmonized and weakly informative, reflecting the very imprecise opinion about the dimensionality and the persistence of shocks. The standard errors of the innovations have a prior mean of 0.08 with two degrees of freedom. All shocks are assumed to be serially correlated with autoregressive coefficient having a prior mean of 0.8 and a prior standard deviation of 0.1. The priors on the structural parameters are in line with the calibration suggested in Section 4.

Table A1. Prior and Posterior distribution of structural parameters and shock processes

		Prior Distribution		Posterior Distribution 1970Q1-1990Q4
		Distr.	Mean (St. Dev)	Mean (5 perc; 95 perc)
φ	inverse of the Frisch elasticity	$\mathcal{N}$	1.0 (0.1)	0.9784 (0.8140; 1.1448)
θ	calvo parameter	$\mathcal{B}$	0.5 (0.1)	0.9271 (0.9125; 0.9417)
ϕ_π	Taylor coefficient on inflation	$\mathcal{N}$	1.5 (0.35)	1.8094 (1.2884; 2.3418)
ϕ_y	Taylor coefficient on economic activity	$\mathcal{N}$	0.5 (0.2)	0.8318 (0.6186; 1.0347)
ρ_i	interest rate smoothing	$\mathcal{B}$	0.25 (0.1)	0.2219 (0.1076; 0.3359)
ρ_Ω	persistence monetary policy shock	$\mathcal{B}$	0.8 (0.1)	0.9729 (0.9651; 0.9808)
ρ_Ψ	persistence demand shock	$\mathcal{B}$	0.8 (0.1)	0.9664 (0.9484; 0.9847)
ρ_Γ	persistence TFP shock	$\mathcal{B}$	0.8 (0.1)	0.9326 (0.9161; 0.9491)
ρ_m	persistence energy shock	$\mathcal{B}$	0.8 (0.1)	0.9835 (0.9737; 0.9937)
σ_Ω	std monetary policy shock	$\mathcal{IG}$	0.08 (2)*	0.0174 (0.0132; 0.0213)
σ_Ψ	std demand shock	$\mathcal{IG}$	0.08 (2)*	0.0414 (0.0216; 0.0611)
σ_Γ	std TFP shock	$\mathcal{IG}$	0.08 (2)*	0.06595 (0.0532; 0.078)
σ_m	std energy shock	$\mathcal{IG}$	0.08 (2)*	0.0442 (0.0390; 0.0493)

Notes. The posterior distribution is obtained using the Metropolis-Hastings algorithm. *For the inverted gamma distributions degrees of freedom are indicated.

As specified in Section 5, for each sample we run three chains of 1,000,000 Metropolis-Hastings simulations. If the results are sensible, they should be similar within any of the 1,000,000 iterations of Metropolis-Hastings simulations and close across chains. We test for convergence using the Brooks and Gelman (1998) methodology that we briefly recall herein.

Let ξ_{ij} be the i^{th} draw out of I, in the j^{th} sequence out of J. Let $\overline{\xi}_{\bullet j}$ be the mean of the j^{th} sequence and let $\overline{\xi}_{\bullet\bullet}$ be the mean across all available data. We denote with $\widehat{B} = [1/(J-1)] \sum_{j=1}^{J} \left(\overline{\xi}_{\bullet j} - \overline{\xi}_{\bullet\bullet}\right)^2$ the estimate of the "between" variance of the mean σ^2/I, and $B = \widehat{B}I$ an estimate of the variance. Also, we denote with $\widehat{W} = (1/J) \sum_{j=1}^{J} (1/I) \sum_{i=1}^{I} \left(\overline{\xi}_{ij} - \overline{\xi}_{\bullet j}\right)^2$ and with $W = (1/J) \sum_{j=1}^{J} [1/(I-1)] \sum_{i=1}^{I} \left(\overline{\xi}_{ij} - \overline{\xi}_{\bullet j}\right)^2$

two estimates of "within" variance. To have sensible results one should have $\lim_{I\to\infty}\widehat{B} \to 0$ and $\lim_{I\to\infty}\widehat{W} \to$constant. Note that this diagnostic can be performed for any moments, not just the variance. In particular, for each parameter we test $\lim_{I\to\infty}\widehat{B} \to 0$ and $\lim_{I\to\infty}\widehat{W} \to cons\tan t$ for three measures of parameters moments: "m2", a measure of the variance, "m3" based on third moments and "interval", being constructed from 80% confidence interval around the parameter mean.

Results, not shown here for space constraints, are available upon request and confirm convergence and stability in all measures of the parameter moments. Here we report (Figure A1) an aggregate measure of W (red line) and $\left(\widehat{W}+\widehat{B}\right)$ (blue line) based on the eingenvalues of the variance-covariance matrix of the three measures of parameters moments specified above (i.e. "m2", a measure of the variance, "m3" based on third moments and "interval", being constructed from 80% confidence interval around the parameter mean). The horizontal axis represents the number of Metropolis-Hastings iterations, whereas the vertical axis the measure of the parameter moments. They are remarkably constant and converge, confirming the reliability of the results. Figure A2 reports prior and posterior distribution of the estimated parameters.

Figure A1 Convergence diagnostic. Multivariate analysis

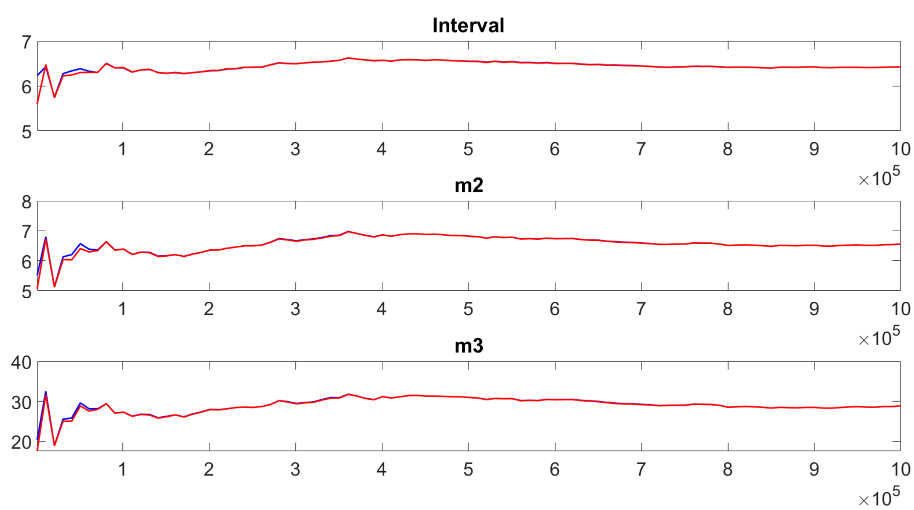
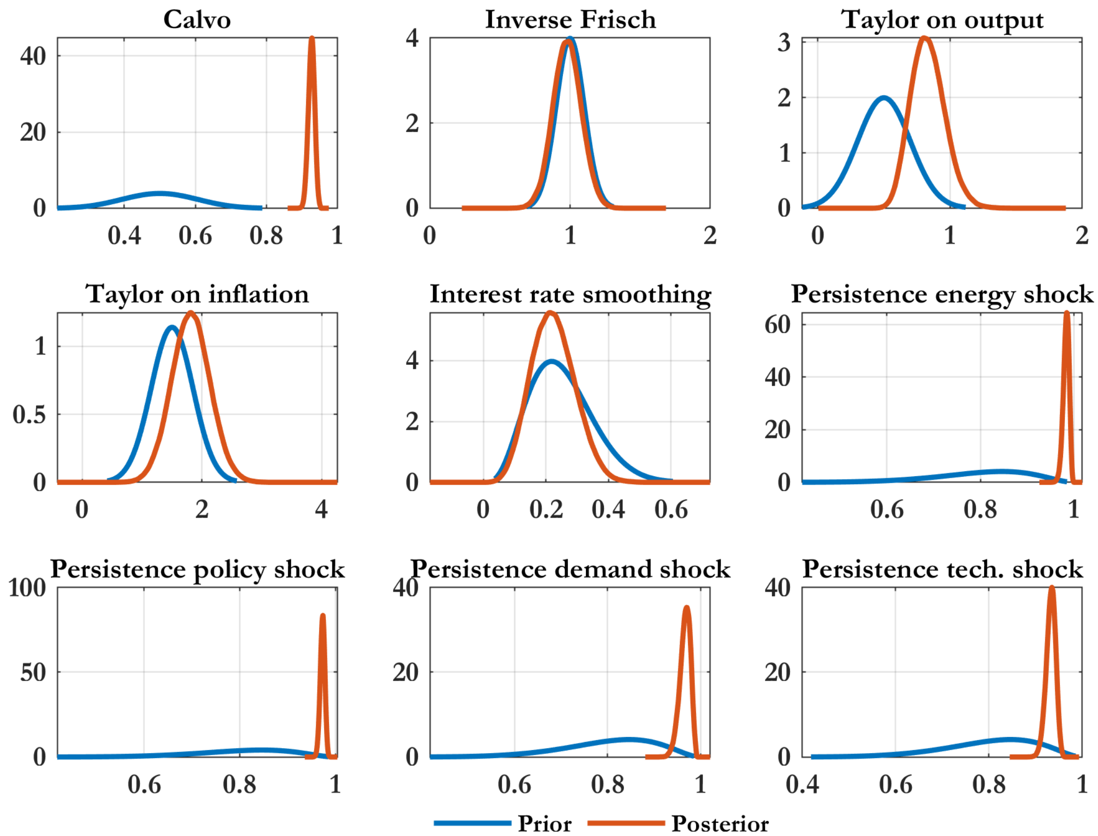


Figure A2 Prior and posterior distributions



Notes. The x-axis displays the support of the distribution, while the y-axis the corresponding density. The blu line refers to the prior distribution, while the red one refers to the posterior distribution.

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