To Cap or Not to Cap? Energy Crises in a Currency Union

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Abstract

With integrated energy markets, unilateral policy interventions create strategic tensions. I characterize the trade-offs euro area countries faced in the 2022 energy crisis, using novel estimates of non-homothetic preference and energy substitution parameters. The cooperative, distortion-free outcome is for no country to impose an energy price cap. However, countries have incentives to cap, imposing higher inflation and lower welfare on uncapped neighbors, mostly through the terms-of-trade channel. For uncapped countries, bearing these spillovers proves less costly than also capping, explaining the asymmetric policy response. In 2022, caps accounted for 10 (0.5) percentage points of energy (headline) inflation in uncapped countries.

JEL codes: E31, E65, F45, Q43, Q48

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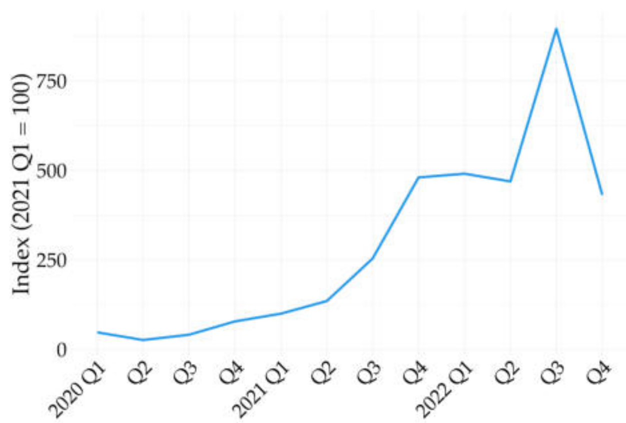
1 Introduction

Currency unions typically feature highly integrated energy markets among member countries. When one country caps energy prices during a crisis, it directly affects energy availability and prices in its neighbors through shared supply networks. This paper investigates the strategic trade-offs such countries face: while policy coordination may be collectively optimal, individual members have strong incentives to intervene unilaterally, distorting the integrated energy market and imposing costs on others. The 2022 European energy crisis provides a striking illustration. As natural gas prices soared following Russia's invasion of Ukraine, as shown in Figure 1, some euro area countries introduced energy price caps while others did not. I characterize the trade-offs underlying such policy decisions and quantify the spillovers from unilateral price interventions in shared energy markets.

Figure 1: Natural gas price in Europe



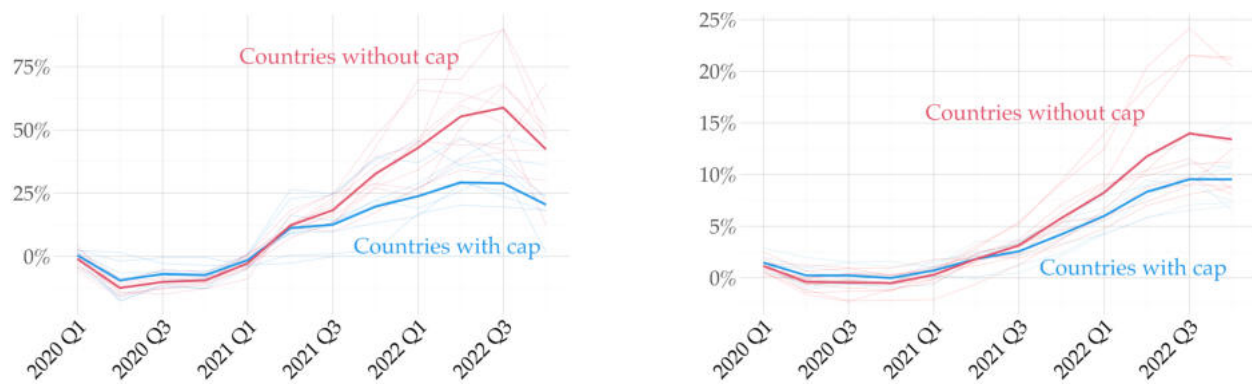
Notes: This is the price index of the Title Transfer Facility (TTF) gas in the Netherlands. Most price setters use this price as the reference price and gas contracts are indexed to it; the TTF price index is the standard gas price benchmark for Europe (Rogge 2024).[2] For longer time series, see Figure C.1a in Appendix B. Data source: IMF Data (2024).

Inflation rates in uncapped countries were considerably higher than in capped countries, as shown in Figure 2. In 2022, France and Germany, among others, decided to impose an energy price cap, whereas other countries including the Netherlands and Italy did not. Energy inflation in uncapped countries was about 30 percentage points higher than in capped countries in 2022Q3, and headline inflation about 5 percentage points. Figure C.1b in Appendix B shows that the divergence of both energy and headline inflation in 2022 was at an unprecedented magnitude since the start of the euro area.

[2] Moreover, gas prices drive wholesale electricity prices as the highest marginal cost of energy production, so they are a good indicator for energy/electricity price movements (Pescatori and Steurmer 2022).

Figure 2: Inflation in the euro area 2020 – 2022

(a) Energy inflation (b) Headline inflation



Notes: Annualized energy and headline inflation rates in the euro area. Source: Eurostat. Countries with an energy price cap in 2022 are Austria, Estonia, France, Germany, Luxembourg, Malta, Portugal, Slovakia, Slovenia, Spain. Countries without are Belgium, Cyprus, Finland, Greece, Ireland, Italy, Latvia, Lithuania, The Netherlands. Bold lines are weighted averages for each group.

To investigate the trade-offs of an energy price cap, this paper develops a two-country currency union model with a novel joint characterization of household preferences and the energy sector. I apply the non-homothetic preferences introduced by Boppart (2014) to energy and non-energy goods, ensuring that the share of income spent on energy consumption increases when income decreases or the energy price increases.[3] For the energy sector, I model an exogenous supply of gas, shared between the two countries, as in Bayer et al. (2026), but extend the framework with an endogenous energy production sector in each country.[4] During the European energy crisis in 2022, the elasticity of substitution between gas, subjected to the exogenous supply shock, and non-gas energy was crucial, since the total energy consumption per capita did not decrease (Energy Institute 2024). The paper provides novel estimates of the non-homotheticity parameters and the elasticity of substitution between gas and non-gas energy. I estimate these parameters using two complementary approaches: a reduced-form panel regression and Bayesian structural estimation, with consistent results across both methods.

In the absence of price caps, an adverse gas supply shock not only reduces energy consumption, but also acts as a cost-push shock to an economy: a decline in the exogenous supply of gas depresses output while increasing inflation. I define the energy price cap as a policy that fixes the retail energy price, with the government paying the difference

[3] Non-homothetic preferences are common in the literature handling necessity goods like energy and food (Blanco and Diz 2021; Olivi et al. 2023).

[4] The assumption of an exogenous gas supply reflects the high dependency of Europe on Russian gas before 2022 (Pescatori and Steurmer 2022; Moll et al. 2023).

between the actual market price and the capped retail price. While this is more extreme than most real-world caps, the strictness shifts the level of responses but does not alter the underlying mechanisms. The main findings of the paper follow.

First, I find that capping the energy price allows a country to avoid the crisis while imposing negative spillovers on the uncapped country. Here, the paper identifies a novel terms-of-trade channel: while the energy price distortion creates direct spillovers through the shared gas supply, the quantitatively dominant effect operates through terms-of-trade movements that shift purchasing power between countries. Empirical evidence from bilateral terms-of-trade data confirms this mechanism, showing an unprecedented terms-of-trade improvement for cap countries during the 2022 crisis.

The capped country does not suffer from the gas supply shock: output does not fall and inflation does not soar, hence households maintain their energy consumption. Additionally, the capped country experiences a terms-of-trade improvement: goods from the crisis-hit uncapped country become relatively cheaper, allowing households in the capped country to increase consumption of traded goods under a temporary current account deficit. By contrast, the uncapped country experiences a welfare loss due to the large energy shortage and deterioration of the terms of trade.

Second, for policymakers facing the decision—to cap or not to cap—there is a trade-off between the cost of the price cap and the cost of the spillovers. I analyze the welfare implications of energy price caps in the two-country model, in which each country faces two policy options at the onset of an energy supply shock. The optimal, cooperative outcome occurs when both countries refrain from imposing a price cap. This outcome avoids market distortions, as energy prices reflect true scarcity during the crisis. However, because of the lack of cooperation, each country has an incentive to deviate from the cooperative strategy: if one country does not impose an energy price cap, the other country has an incentive to impose one to avoid the energy crisis as described above.

If one country imposes a price cap, should the other country follow suit? On one hand, imposing the price cap leads to inefficiencies and high costs, as artificially low prices in both countries encourage excessive energy consumption despite scarcity. On the other hand, not imposing the cap means bearing the negative spillovers from the first country's cap. In the estimated model, the cost of these negative spillovers is less than imposing a cap. Hence, the outcome of a static decision game is a scenario where one country imposes a price cap while the other does not, even though the cooperative strategy is for neither of the countries to impose the cap. This game-theoretic approach is particularly relevant for the 2022 crisis, when countries made cap decisions simultaneously over the summer with limited opportunity for coordination. During European policy debates in

2022, EU officials criticized unilateral energy relief measures imposed by some countries and advocated for collective approaches to avoid imposing higher energy prices on other member states (Chazan et al. 2022; Fleming and Chazan 2022).

Two key modeling features, absent from prior work, drive this result. First, non-homothetic preferences amplify both the cost of imposing a cap and the severity of spillovers. Second, endogenous energy production allows the uncapped country to partially mitigate the shock by substituting away from gas. These features operate jointly: removing either one shifts the equilibrium to both countries capping. With homothetic preferences, the distortion from the price cap is relatively low, so both countries cap; without substitution possibilities, spillovers become unbearable and both cap. With both features together, spillovers fall in the intermediate range where the cap-no cap outcome emerges.

Third, I provide counterfactual evidence for the 2022 European energy crisis. I perform a historical shock decomposition of energy and headline inflation rates with the energy price cap as one of the shocks. I find that the cap contributed 10 percentage points to energy inflation and 0.5 percentage points to headline inflation in uncapped countries in 2022. Moreover, the inflation rates in capped countries would not have been much higher without caps, confirming that the cooperative outcome involves no price caps.

Last, I compare the energy price cap to targeted transfers as an alternative policy measure, using a model version with two agents. Shielding low-income households from rising energy costs was a priority for many governments (Sgaravatti et al. 2023). I show that targeted transfers are a cheaper and more effective way to support consumption by poor households during an energy crisis. Moreover, since targeted transfers do not distort the energy market, they do not cause large spillovers or divergence within the union.

Last, I compare energy price caps to targeted transfers as an alternative policy for protecting vulnerable households, a priority for many governments (Sgaravatti et al. 2023). While both policies shield low-income households from energy cost increases, they differ sharply in their spillover effects. Targeted transfers avoid distorting energy markets and generate no cross-border spillovers, eliminating the strategic tensions under asymmetric policy adoption. Price caps, by contrast, create the terms-of-trade externalities identified above, imposing welfare costs on trading partners.

In the remainder of the paper, I first review the related literature, then proceed as follows. Section 2 outlines the model, calibration and estimation, and the solution method. Section 3 discusses the simulation results of the three possible scenarios (no cap in both countries, cap in one country, and caps in both countries) and their welfare implications, showing how non-homothetic preferences and substitutability of energy sources drive the results. Section 4 discusses targeted transfers as an alternative policy. Section 5 concludes.

Related Literature. This paper contributes to three strands of the literature. First, it builds on the vast literature on monetary and fiscal policy in a currency union. Beetsma et al. (2001), Beetsma and Jensen (2005), Galí and Monacelli (2008), Ferrero (2009), and Hjortsoe (2016) are pioneers and explore the optimal joint conduct of monetary and fiscal policy as stabilization tools under asymmetric shocks. Other authors like Anderson (2007) and Keen and Konrad (2013) focus on strategic interactions of regulatory policies, like taxes, trade policies, and industrial regulation. Later, papers on this topic consider long-term coordination, with the sovereign debt crises in mind (Trichet 2013; Chang 2015). In this paper, I introduce a new dimension of integration for policy coordination: a shared gas supply. I analyze the international coordination of energy price cap policies during a union-wide adverse gas supply shock. The analysis focuses on the determinants of the magnitude of the cap's spillovers and the strategic trade-offs involved.

Second, this paper contributes to the literature explicitly embedding energy markets in structural macroeconomic frameworks of the euro area. Early works by Jacquinot et al. (2006) and Sanchez (2008) focus on oil price pass-through and price markups, whereas more recent work by Pfeiffer et al. (2025) estimates a large-scale structural model of the euro area with oil, gas and electricity. This paper contributes by jointly modeling non-homothetic household preferences and the energy sector. I provide novel macroeconomic estimates of both the elasticity of substitution between gas and other energy sources and non-homothetic preference parameters, enabling the assessment of price cap policies.

Third, this paper contributes to an expanding literature on energy crises. Erceg et al. (2024) and Bayer et al. (2026) study the effectiveness of fiscal policies, including energy price caps, in stabilizing the domestic economy. Bayer et al. (2026) also considers the spillovers abroad. Both papers model energy as an exogenous endowment. Auclert et al. (2023) and Chan et al. (2024) study the macroeconomic effects of an energy price shock and look at the coordination of fiscal policies and optimal monetary policy, respectively. Both papers assume energy as an imported good only. Glocker and Wegmüller (2024) study the effectiveness of fiscal policies, including energy subsidies, in stabilizing inflation, using a model with energy producers. Unlike prior work, which either models energy as an exogenous endowment (Erceg et al. 2024; Bayer et al. 2026) or as imported only (Auclert et al. 2023; Chan et al. 2024), this paper jointly models substitutability of imported gas and endogenous energy production alongside non-homothetic preferences. This combination is essential for capturing the strategic trade-offs countries faced: without both features, the cap-no cap equilibrium does not emerge.

2 Model

The model is a currency union with two countries, Home and Foreign $\{H, F\}$, and incomplete financial markets. The relative size of the Home country is $\Theta \in (0, 1)$. Time is discrete and indexed by $t \in \{0, \dots\}$. Both countries are inhabited by households, firms and a fiscal authority. There is one central bank setting monetary policy for the entire currency union. The model's main contribution lies in its joint characterization of household preferences and the energy sector, both of which feature estimated structural parameters.

Following Boppart (2014), I model household preferences as non-homothetic, though applied here to the distinction between energy and non-energy consumption rather than goods and services. These preferences deviate from homothetic preferences in two ways: 1. the expenditure share of energy increases when income decreases 2. the expenditure share of energy increases when the energy price increases. The non-energy goods consist of Home and Foreign-produced goods, with a home bias. Firms in both countries produce those goods under monopolistic competition using energy and labor as inputs.

There are two types of energy in the economy: an exogenous source of energy shared by the two countries and domestically produced energy in each country. The exogenous source of energy reflects the high dependency of Europe on imported natural gas (Eurostat 2023a). The natural gas clears with a single price for the whole union, reflecting the well-integrated natural gas market in Europe (Pescatori and Steurmer 2022). Crucially, when natural gas supply fell in 2022, total energy consumption per capita remained roughly constant (Energy Institute 2024), suggesting substantial substitution toward domestically produced energy. To capture this margin of adjustment, the model includes a domestic energy production sector in both countries. The energy good is a bundle of the exogenous natural gas and the domestically produced energy. The fiscal authority can introduce an energy price cap under a balanced budget, in which case the government pays for the difference between the actual price of energy and the retail price of energy.

Since the Home and Foreign countries are symmetric, I explain only the Home-side of the union, unless otherwise stated. Foreign variables are denoted with an *. The Online Appendix provides the full system of equilibrium conditions and the steady state.

2.1 Households

2.1.1 Preferences

Households derive utility from two types of goods: energy goods, E_t^h, and non-energy, other goods, C_{Ot}. Household preferences are non-homothetic as introduced by Boppart

(2014). In this specification of preferences, the total nominal expenditure of the household, defined as $exp_t = P_{Et}E_t^h + P_{Ot}C_{Ot}$, affects the share of expenditure spent on energy and other goods. P_{Et} and P_{Ot} are prices for energy and other goods respectively. The indirect utility function of the representative household with non-homothetic preferences is:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{\varepsilon_1} \left[\left(\frac{exp_t}{P_{Ot}} \right)^{\varepsilon_1} - 1 \right] - \frac{\alpha_E}{\varepsilon_2} \left[\left(\frac{P_{Et}}{P_{Ot}} \right)^{\varepsilon_2} - 1 \right] \right\} \tag{1}$$

where $\alpha_E > 0$ is the share of energy consumption in steady state and β is the discount factor. ε_1 governs the expenditure elasticity of demand: when $\varepsilon_1 > 0$, the expenditure elasticity of demand is smaller than unity for energy and larger than unity for other goods. So, when total nominal consumption expenditure decreases, the demand for energy decreases less than proportionally with income and the demand for other goods decreases more than proportionally. ε_2 controls the elasticity of substitution between energy and other goods. In steady state, the elasticity of substitution between energy and other goods is $\bar{\sigma} = 1 - \varepsilon_2 - \frac{\alpha_E}{1-\alpha_E}(\varepsilon_2 - \varepsilon_1)$.[5] E_t^h includes both natural gas and domestically produced energy. The energy market clearing condition determines the relative quantities for natural gas and endogenously produced energy from the energy demand of both households and firms. E_t^h can be interpreted as electricity, which can be generated using natural gas or other sources and is provided to households and firms as a single good.

Relative demand between energy and other goods. The relative demand for energy and other goods obtained using Roy's identity reads as:

$$C_{Ot} = \frac{1 - \alpha_E \varpi_t}{\alpha_E \varpi_t} \frac{P_{Et}}{P_{Ot}} E_t^h \tag{2}$$

where $\varpi_t = \left(\frac{P_{Ot}}{exp_t} \right)^{\varepsilon_1} \left(\frac{P_{Et}}{P_{Ot}} \right)^{\varepsilon_2}$ is the energy expenditure share wedge. This wedge increases when the total expenditure decreases or when the price of energy increases, relative to the price of the other goods. Consequently, the demand is non-homothetic in income since the share of expenditure on energy, $\alpha_E \varpi_t$, increases when the household becomes poorer. When $\varepsilon_1 = \varepsilon_2 = 0$, Eq. (2) simplifies to Cobb-Douglas, $C_{Ot} = \frac{1-\alpha_E}{\alpha_E} \frac{P_{Et}}{P_{Ot}} E_t^h$, under which the expenditure elasticity for both types of goods is equal to unity.

[5] See Lemma 3 in Boppart (2014) for the derivation and the Online Appendix for the steady state. Another commonly used non-homothetic preference specification is Stone-Geary preferences, with which the consumer derives utility from consumption that exceeds the subsistence level. Under Stone-Geary preferences the expenditure share of energy does not increase after a price increase. Since in practice the household energy expenditure share increased in Europe in 2022, I chose to use the preferences from Boppart (2014) (OECD 2023; European Commission 2024).

Relative demand between Home and Foreign goods. The consumption of non-energy goods is a composite index, bundling consumption of Home-produced goods C_{Ht} and Foreign-produced goods C_{Ft}:

$$C_{Ot} = \left[(1-\alpha_I)^{1/\gamma}(C_{Ht})^{(\gamma-1)/\gamma} + (\alpha_I)^{1/\gamma}(C_{Ft})^{(\gamma-1)/\gamma}\right]^{\gamma/(\gamma-1)} \tag{3}$$

where $\alpha_I \in (0,1)$ is the share of imported goods in the consumption basket and γ is the elasticity of substitution between Home and Foreign goods. Since the preferences between Home and Foreign-produced goods are homothetic, the intratemporal consumption demand between Home and Foreign goods is standard: $\frac{C_{Ht}}{C_{Ft}} = \frac{1-\alpha_I}{\alpha_I}\left(\frac{P_{Ht}}{P_{Ft}}\right)^{-\gamma}$. P_{Ht} and P_{Ft} are the price indices of Home and Foreign goods respectively. The aggregate expenditure on other consumption is then:

$$\int_0^1 P_{Ht}(i)C_{Ht}(i)di + \int_0^1 P_{Ft}(i)C_{Ft}(i)di = P_{Ht}C_{Ht} + P_{Ft}C_{Ft} = P_{Ot}C_{Ot} \tag{4}$$

where P_{Ot} is the aggregate price index for non-energy goods $P_{Ot} = \left[(1-\alpha_I)P_{Ht}^{1-\gamma} + \alpha_I P_{Ft}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}$.

2.1.2 Intertemporal choices

The household makes intertemporal choices trading in one-period bonds B_t with gross interest rate R_t. The household's income sources are labor income from supplying N_t units of labor at a nominal wage W_t per unit and profits of domestic firms, D_t, and natural gas sellers, D_t^{GAS}.[6] The nominal budget constraint of the households is the following:

$$exp_t = P_{Et}E_t^h + P_{Ot}C_{Ot} = W_tN_t + D_t + D_t^{GAS} + R_{t-1}B_{t-1}^h - B_t^h - HC_t - T_t \tag{5}$$

where $HC_t = \frac{\tilde{\nu}}{2}(B_t^h - \bar{B}^h)^2$ are the portfolio adjustment costs and T_t are lump-sum taxes. The Euler equation arises from the household's maximization problem:

$$\left(\frac{\mathbb{E}_t\left[exp_{t+1}\right]}{exp_t}\right)^{1-\varepsilon_1} = \beta\frac{R_t}{1+P_t\tilde{\nu}(b_t^h - \bar{b}^h)}\mathbb{E}_t\left[\left(\frac{1}{\Pi_{O,t+1}}\right)^{\varepsilon_1}\right] \tag{6}$$

where $b_t^h = \frac{B_t^h}{P_t}$ denotes real bond holdings and $\Pi_{Ot} = \frac{P_{Ot}}{P_{O,t-1}}$ is gross inflation of other goods. P_t is the aggregate price index. Households supply labor inelastically, such that $N_t = \bar{N}\ \forall t$. In the Online Appendix, I discuss results under elastic labor supply.

[6]As in Bayer et al. (2026), households earn profits determined by deviations from steady state when selling natural gas.

2.2 Firms

There are three types of firms in each country: energy good producers that produce a substitute for the exogenous supply of natural gas, a final good producer, and intermediate good producers for the production of non-energy, other goods.

Energy good producer. Energy firms use labor N_{Et} as an input in their production Y_{Et}:

$$Y_{Et} = A_{Et} N_{Et}^{\eta} \tag{7}$$

where A_{Et} is the total factor productivity in the energy sector. η determines the share of profits from total revenue. The production function uses a diminishing-return technology, as in Ferrero and Seneca (2019), to capture capacity constraints in the energy sector.

The representative energy producer takes the wage as given, since the energy sector is a small fraction of the demand for labor. Energy firms sell any quantity of energy at the prevailing price, which reflects the findings by Zakeri et al. (2022) who find that the European electricity prices depend highly on natural gas prices. Energy producers are competitive price-takers, but earn rents due to decreasing returns to scale. The energy firm maximizes its profits, $D_{Et} = P_{NGt} Y_{Et} - W_t N_{Et}$, subject to the production function (7). P_{NGt} is the price of the domestically-produced non-gas energy. As with the households, E_t^f can be interpreted as electricity. Energy prices adjust in a Walrasian fashion to clear the market; see equations (20)–(22) for the market clearing conditions.

Final good producer. The final good firms produce the other goods for final consumption, Y_{Ot}, using intermediate goods, $Y_{Ot}(i)$, according to $Y_{Ot} = \left[\int_0^1 Y_{Ot}(i)^{(1-\epsilon)/\epsilon} di\right]^{\epsilon/(1-\epsilon)}$, where $Y_{Ot}(i)$ is the output of the intermediate firm i and ϵ is the elasticity of substitution between different varieties of the intermediate good. The firms produce in a competitive market and maximize profits given by $P_{Ot} Y_{Ot} - \int_0^1 P_{Ot}(i) Y_{Ot}(i) di$. The first-order condition to the maximization problem gives the demand function of the intermediate good i:

$$Y_{Ot}(i) = \left(\frac{P_{Ht}(i)}{P_{Ht}}\right)^{-\epsilon} Y_{Ot} \tag{8}$$

and the price of the final good Y_{Ot}, $P_{Ht} = \left[\int_0^1 P_{Ht}(i)^{1-\epsilon} di\right]^{1/(1-\epsilon)}$, where $P_{Ht}(i)$ is the price of the intermediate good i.

Intermediate good producers. There are a continuum of $i \in [0,1]$ firms producing the non-energy, other goods under monopolistic competition. They use labor N_{Ot} and energy E_t^f as inputs in their Constant Elasticity of Substitution (CES) production function:

$$Y_{Ot}(i) = A_{Ot}\left[\left(\alpha^f\right)^{1/\theta^f}\left(E_t^f(i)\right)^{(\theta^f-1)/\theta^f} + \left(1-\alpha^f\right)^{1/\theta^f}\left(N_{Ot}(i)\right)^{(\theta^f-1)/\theta^f}\right]^{\theta^f/(\theta^f-1)} \tag{9}$$

where α^f is the share of energy used in production and θ^f is the elasticity of substitution between energy and labor. A_{Ot} is the total factor productivity following an AR(1) shock process. Firms face adjustment costs à la Rotemberg (1982), so their profit maximization problem is:

$$\max_{P_{Ht}(i),N_{Ot}(i)} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta\left[\frac{P_{Ht}(i)}{P_{Ht}}Y_{Ot}(i) - \frac{W_t}{P_{Ht}}N_{Ot}(i) - P_{Et}E_t^f(i) - Y_{Ot}FC_t\right] \tag{10}$$

subject to the demand curve (8) and adjustment costs $FC_t(i) = \frac{\xi}{2}\left(\frac{P_{Ht}(i)}{P_{H,t-1}(i)} - 1\right)^2$, where ξ governs the level of price adjustment costs. The first-order condition with respect to $P_{Ht}(i)$ yields the New Keynesian Phillips Curve (NKPC). Log-linearizing around the steady state (where hatted variables denote log-deviations), the NKPC reads:

$$\hat{\pi}_{H,t} = \beta\mathbb{E}_t[\hat{\pi}_{H,t+1}] + \kappa\widehat{mc}_t \tag{11}$$

where $\hat{\pi}_{H,t}$ is Home goods inflation, $\widehat{mc}_t$ is the real marginal cost, and $\kappa \equiv \frac{\epsilon-1}{\xi}$ is the slope of the Phillips curve, increasing in the elasticity of substitution ϵ and decreasing in the adjustment cost parameter ξ. The real marginal cost depends on both the real wage and the real energy price:

$$\widehat{mc}_t = \left(1-\alpha^f\right)\left(\hat{W}_t - \hat{P}_{H,t}\right) + \alpha^f\left(\hat{P}_{E,t} - \hat{P}_{H,t}\right) - \hat{A}_{O,t} \tag{12}$$

where the weights reflect the cost shares of labor and energy in production. Thus, energy price shocks affect inflation through the marginal cost channel. Since energy is a flexible price sector, as in Aoki (2001), when re-writing the NKPC in terms of headline inflation, energy inflation also shows up as a cost-push shock, allowing energy supply shocks to generate inflation even when other-goods prices are sticky.

Since all intermediate goods are identical, $P_{Ht}(i) = P_{Ht}$ and $N_{Ot}(i) = N_{Ot}$. Aggregate firm's profits read:

$$D_{Ot} = P_{Ht}Y_{Ot}\left(1 - FC_t\right) - W_tN_{Ot} - P_{Et}E_t^f \tag{13}$$

2.3 Monetary policy

The monetary authority sets the nominal interest rate R_t targeting the headline inflation of the two countries:

$$R_t = \frac{1}{\beta}\left(\frac{\Pi_t^W}{\bar{\Pi}^W}\right)^{\phi_\pi} \exp(\nu_t) \tag{14}$$

where superscript W indicates a union-wide variable, defined as the weighted average of the variables in both countries: $\Pi_t^W = (\Pi_t)^{\Theta}(\Pi_t^*)^{1-\Theta}$. The monetary authority only targets inflation, not the output gap, reflecting the European Central Bank's price stability mandate. The inflation that the central bank targets is: $\Pi_t = (\Pi_{Et})^{\alpha_E}(\Pi_{Ot})^{1-\alpha_E}$, which corresponds to the Consumer Price Index (CPI), or headline inflation in common literature and data sources. The price level follows from the inflation term $\Pi_t = P_t/P_{t-1}$. In Section 3.3, I discuss the implications of core targeting on inflation rates.

2.4 Fiscal policy: The energy price cap

If the Home country introduces a cap on energy prices, the fiscal policy and the government budget constraint of the country become relevant. With an energy price cap in the Home country, the effective energy price becomes:

$$P_{Et}^{eff} = \begin{cases} \bar{P}_E & \text{with cap and } P_{Et} > \bar{P}_E \\ P_{Et} & \text{otherwise} \end{cases} \tag{15}$$

Hence, under the cap, the effective price for energy for the households and firms is equal to the steady state price of energy, $\bar{P}_E$. Consequently, when the fiscal authority introduces the price cap, the price of energy in households' and firms' equilibrium conditions is given by the effective price of energy $P_{Et}^{eff} = \bar{P}_E$.[7] The government runs a balanced budget and finances the cap by a lump-sum tax. The government budget constraint reads:

$$COST_t(E_t^h + E_t^f) = T_t \tag{16}$$

where $COST_t = P_{Et} - \bar{P}_E$ denotes the cost of the cap per unit of energy for the government. Ricardian Equivalence holds because consumption does not respond to changes in expected future taxes and government spending. Later, I introduce hand-to-mouth agents to the model as an extension in which case Ricardian Equivalence does not hold.

[7] The results are robust to changing the price cap target from both households and firms to just households.

2.5 Equilibrium

The equilibrium of this economy is characterized by a sequence of prices $\{W_t, W_t^*, P_{Ht}, P_{Ft}, P_{Et}, P_{NGt}, R_t\}$ and allocations $\left\{E_t^h, E_t^{h*}, C_{Ht}, C_{Ft}, C_{Ht}^*, C_{Ft}^*, N_{Ot}, N_{Ot}^*, N_{Et}, N_{Et}^*, \; E_t^f, E_t^{f*}, b_t^h, b_t^{h*}\right\}$ such that the goods market is cleared for all goods, the energy market is cleared, the assets are in zero net supply between the countries, and the labor markets are cleared. The full list of equilibrium conditions is in the Online Appendix.

2.5.1 Goods and labor market clearing

The goods market clears for Home when the production is equal to the demand for consumption goods produced in that country. Hence, the goods market clearing condition in Home includes the demand for Home-produced goods in the Foreign country:

$$Y_{Ot} = C_{Ht} + C_{Ht}^* + \frac{HC_t}{P_{Ht}} + Y_{Ot} \cdot FC_t \tag{17}$$

$$= (1-\alpha_I)\left(\frac{P_{Ht}}{P_{Ot}}\right)^{-\gamma} C_{Ot} + \alpha_I^* \left(\frac{P_{Ht}}{P_{Ot}^*}\right)^{-\gamma} C_{Ot}^* + \frac{HC_t}{P_{Ht}} + Y_{Ot} FC_t \tag{18}$$

where C_{Ht}^* is the consumption of Home-produced goods in Foreign, and C_{Ot}^* is the consumption of other goods (both Home and Foreign-produced) in Foreign.

The labor market clears when the demand and supply for labor are equal:

$$N_{Et} + N_{Ot} = N_t \tag{19}$$

Since labor in the energy sector and the other-goods sector is identical, the market clearing condition ensures that the wages are equalized.

2.5.2 Energy market clearing

The energy market is partially integrated across the two countries. Energy prices adjust in a Walrasian fashion: the energy price P_{Et} adjusts so that demand for energy by households and firms equals supply in each country:

$$E_t^h + E_t^f = \left[(1-\alpha_G)^{1/\zeta} (Y_{Et})^{(\zeta-1)/\zeta} + \alpha_G^{1/\zeta} (GAS_t)^{(\zeta-1)/\zeta}\right]^{\zeta/(\zeta-1)} \tag{20}$$

$$E_t^{h*} + E_t^{f*} = \left[(1-\alpha_G^*)^{1/\zeta} (Y_{Et}^*)^{(\zeta-1)/\zeta} + \alpha_G^{*\,1/\zeta} (GAS_t^*)^{(\zeta-1)/\zeta}\right]^{\zeta/(\zeta-1)} \tag{21}$$

where α_G is the share of gas in energy use and ζ governs the substitutability of gas and other energy. The right-hand side is the supply of energy as a Constant Elasticity of Substitution aggregattion of domestically produced energy and natural gas, which is exogenously supplied to the union. Hence, there is a third energy market clearing condition clearing the market for natural gas:

$$GAS_t + GAS_t^* = GAS_t^W \tag{22}$$

which reflects the fact that the natural gas market is highly integrated in the union (Pescatori and Steurmer 2022).

2.5.3 Current account and the dynamics of net foreign assets

I derive the dynamics of net foreign assets, and hence the current account, by consolidating households' and firms' resource constraints, (5) and (13):

$$B_t^h - B_{t-1}^h = r_{t-1}B_{t-1}^h + P_{Ht}Y_{Ot}\left(1 - FC_t\right) - P_{Ot}C_{Ot} - HC_t \tag{23}$$

where $r_t = R_t - 1$ is the net nominal interest rate set by the monetary authority. The current account follows from the above equation:

$$CA_t = B_t^h - B_{t-1}^h \tag{24}$$

Since the union is a closed economy, to ensure mutual consistency of current accounts $CA_t = -CA_t^*$ needs to hold. The assets are in zero net supply between countries.

2.6 Calibration and estimation

I calibrate and estimate the model at quarterly frequency. Parameters fall into three categories. First, I calibrate standard New Keynesian parameters and those with direct data counterparts. Second, I set a subset of parameters to match steady-state targets. Third, I estimate the remaining parameters, governing the non-homothetic preferences and the substitutability of energy sources, which are the key contributions of the model. The countries are identical except for their relative size, unless otherwise stated.

Table 1 provides an overview of the baseline calibration values, including those set to match steady-state targets. On the household side, Eurostat (2023b) reports that in 2022, the share of internationally traded goods and services relative to GDP was 25%. Hence, the share of imports in consumption, α_I, is 0.25. The share of energy in total consumption expenditure is on average 10%, so I set α_E as 0.10.[8]. The elasticity of substitution within

[8]Eurostat data, online data code: hbs_str_t223.

Table 1: Baseline calibration of parameters

Parameter	*Description*	*Value*
Households		
α_I	Share of imports in consumption	0.25
α_E	Share of energy in consumption	0.10
γ	Elasticity of substitution between Home and Foreign goods	6
ϵ	Elasticity of substitution between varieties	9
$\tilde{\nu}$	Adjustment cost for bonds	0.001
β	Discount factor	0.99
Firms		
α^f	Share of energy in production	0.011
θ^f	Elasticity of substitution between energy and labor	0.2
ξ	Price-adjustment cost	93.20
Energy		
α_G	Share of gas in energy, "Cap"	0.18
α_G^*	Share of gas in energy, "No cap"	0.22
η	Share of profits for energy firms	0.19
$\bar{A}_E$	Steady-state productivity energy sector	0.17
Monetary policy		
ϕ_π	Taylor-coefficient on inflation	1.5
α^{CB}	Share of energy for central bank's consideration	0.10
Currency union		
Θ	Relative GDP size Home country (with cap)	0.68

different varieties of Home and Foreign, ϵ, is 9, in line with standard literature. The adjustment cost for bond-holdings, $\tilde{\nu}$, is 0.001, to match the canonical work by Schmitt-Grohé and Uribe (2003). The discount factor β is 0.99 as is standard in the literature.

For firms producing non-energy, other goods, I set the share of energy in production, α^f, to 1.1% to target the steady-state energy expenditure of the industry as share of total production value of 1%.[9] The elasticity of substitution of energy and labor, θ^f, is 0.2, following Bachmann et al. (2024) and Bayer et al. (2026). I calibrate the Rotemberg (1982) price adjustment cost parameter, ξ, such that the slope of the New Keynesian Philips Curve matches that of the Calvo (1983) price rigidities for the Calvo parameter 0.75, implying an expected price duration of three quarters. The corresponding price adjustment cost parameter is $\xi = [(\epsilon - 1)0.75]/[(1 - 0.75)(1 - 0.75\beta)] \approx 93.20$. The Taylor (1993) coefficient on headline inflation ϕ_π is 1.5.

In the energy sector, for the share of gas in energy use, α_G and α_G^*, I use the Harmonized Index of Consumer Prices (HICP) item weights from Eurostat and set them to 0.18 and 0.22 respectively for the capped and uncapped countries.[10] Even though the data for estimation starts a decade earlier than 2022, I group the countries already into capped and

[9] I calculate the steady-state energy expenditure as share of total production value with data from Rademaekers et al. (2020) and Eurostat data (online data code: sbs_sc_ovw). The sectors included are selected manufacturing sectors, wholesale and retail trade, accommodation and restaurants, and information and communication, and the countries included are the 27 European Union members in 2020.

[10] Eurostat data, online data code: prc_ hicp_inw. I take the weighted average according to Eurostat's country weights (data code: prc_ hicp_cow) when calculating the values for capped and uncapped countries. The categorization of capped and uncapped countries is in Footnote 12.

uncapped countries, referring to the energy price cap policy in 2022. To set steady-state productivity of the energy sector, $\bar{A}_E$, and share of profits, η, I match the following targets: the share of workers in the energy sector, 3.66% in Europe,[11] and the relative price of energy and other goods of 1. The values that match the targets are $\eta = 0.19$ and $\bar{A}_E = 0.17$.

To obtain the relative size of the two countries, I calculate the GDP ratio of countries that introduced a cap in 2022 and that did not introduce a cap in 2022.[12] Since the sum of GDPs of countries with an energy price cap in 2022 was about 68% of the total of countries in the euro area, I set the size of the Home country $\Theta = 0.68$.

2.6.1 Estimation of the key parameters

I estimate the non-homotheticity parameters, $\varepsilon_1 = \varepsilon_1^*$ and $\varepsilon_2 = \varepsilon_2^*$, and the elasticity of substitution between gas and non-gas energy, ζ and ζ^*. I assume that the preference parameters are equal across countries, and do not differentiate between the "Cap" and "No cap" blocks, unlike the parameters governing the energy market.

Estimation strategy: dual approach. In the Bayesian estimation, I impose the restriction $\varepsilon_1 = \varepsilon_2$ rather than estimating these parameters separately. Estimating ε_1 and ε_2 individually within the structural model would not yield sufficiently precise estimates, as the two parameters govern closely related aspects of the preferences. To validate this approach, I conduct a reduced-form estimation exercise using a panel regression. This reduced-form approach suggests that ε_1 and ε_2 are not significantly different from each other, supporting the restriction imposed in the Bayesian estimation. Both estimation strategies yield similar parameter values, in the range of 0.2 to 0.3, providing cross-validation. For both the Bayesian estimation and the reduced-form estimation, I use data up to 2019Q4 to leave out the COVID-19 pandemic as well as the energy crisis in 2022, ensuring the estimates capture long-run structural relationships rather than transitory crisis dynamics.

Reduced-form estimation. To validate the restriction $\varepsilon_1 = \varepsilon_2$ in the Bayesian estimation and to provide a first indication of the parameter values, I obtain empirical estimates of the preference parameters using cross-country panel data from the euro area.

[11] Own calculations from the World Energy Employment report in 2022 by the International Energy Agency (IEA 2022) and Eurostat data.

[12] Euro area countries with an energy price cap in 2022: Austria, Estonia, France, Germany, Luxembourg, Malta, Portugal, Slovakia, Slovenia, Spain. euro area countries without an energy price cap in 2022: Belgium, Cyprus, Finland, Greece, Ireland, Italy, Latvia, Lithuania, The Netherlands. Croatia joined the euro area in 2023 and therefore excluded from the analysis in this paper.

The model gives the following equation for the energy expenditure share:

$$\eta_{Et}^{h} = \frac{P_{Et}E_t^h}{exp_t} = \alpha_E \varpi_t = \alpha_E \left(\frac{P_{Ot}}{\text{exp}_t}\right)^{\varepsilon_1} \left(\frac{P_{Et}}{P_{Ot}}\right)^{\varepsilon_2} \tag{25}$$

As discussed,when $\varepsilon_1 = \varepsilon_2 = 0$, the energy expenditure share collapses to $\eta_{Et}^{h} = \alpha_E$, the Cobb-Douglas specification. When using data, energy expenditure shares are small (typically 5–10%), so taking logs of the share directly poses numerical issues. For the empirical specification I rearrange the equation using log-linear approximation and express the left-hand side of the equation in levels:

$$s_{E,it} = \alpha_i + \gamma_t + \beta_1 \log\left(\frac{\tilde{C}_{it}}{\tilde{P}_{O,it}}\right) + \beta_2 \log\left(\frac{\tilde{P}_{E,it}}{\tilde{P}_{O,it}}\right) + \varepsilon_{it} \tag{26}$$

where $s_{E,it}$ is the energy expenditure share for country i in period t, $\tilde{C}_{it}$ is real aggregate consumption per capita, $\tilde{P}_{E,it}$ and $\tilde{P}_{O,it}$ are the price indices for energy and other goods, α_i are country fixed effects, and γ_t are time fixed effects. From the estimated coefficients, I recover the structural parameters:

$$\varepsilon_1 = -\frac{\beta_1}{\bar{s}_E} \qquad \varepsilon_2 = \frac{\beta_2}{\bar{s}_E} \tag{27}$$

where $\bar{s}_E$ is the average energy expenditure share in the sample. I use publicly available data from Eurostat for the variables. The database for Harmonised index of consumer prices (HICP) provides the item weights and the price indices. I obtain the household final consumption expenditure from the quarterly national accounts data set. All data except item weights are quarterly. I use data from 2000Q1 to 2019Q4 for this exercise.

Table 2 presents the results. The estimated non-homotheticity parameters are $\varepsilon_1 = 0.34$ and $\varepsilon_2 = 0.18$. Both estimates are significantly different from zero, confirming the presence of non-homothetic preferences. The formal hypothesis test cannot reject the null that $\varepsilon_1 = \varepsilon_2$ ($p = 0.36$), providing empirical support for imposing this restriction in the structural Bayesian estimation. The point estimates from this reduced-form approach are broadly consistent with the Bayesian estimates of 0.27 presented below.

Bayesian estimation. I estimate the model using Bayesian techniques programmed in Dynare (Adjemian et al. 2024), closely following Smets and Wouters (2007). The estimation uses the following observable data series from 2008Q1 to 2019Q4:[13] energy inflation,

[13]The sample starts in 2008Q1 due to data availability for gas consumption.

Table 2: Reduced-form estimation of non-homothetic preference parameters

Parameter	Estimate	Std. Error	90% CI	t-stat	p-value
ε_1	0.336	0.131	[0.120, 0.552]		
ε_2	0.177	0.100	[0.012, 0.342]		
Test: $H_0 : \varepsilon_1 = \varepsilon_2$					
$\varepsilon_1 - \varepsilon_2$	0.159	0.169		0.944	0.357

Notes: Structural parameters recovered from panel regression of energy expenditure share on log real consumption and log relative energy prices. Sample: 19 euro area countries, 2008Q1–2019Q4 (1511 observations). Clustered standard errors at the country level. The null hypothesis $\varepsilon_1 = \varepsilon_2$ cannot be rejected at conventional significance levels ($p = 0.357$).

gas inflation, CPI inflation, energy consumption, gas consumption, output, and the nominal interest rate. Since the union has an integrated energy market, there are single energy and gas inflation rates for the entire union in the absence of price caps. Similarly, the model implies a shared supply of gas. All data are from Eurostat.

To match the data, I include the following shocks and measurement errors: total factor productivity (TFP) shocks for the other goods and energy sectors, demand shocks, cost-push shocks in the other goods sector, gas supply shocks, monetary policy shock, and measurement errors for energy consumption and energy inflation.[14] All shocks and measurement errors are country-specific except for the monetary policy shock and the energy inflation measurement error, which are union-wide.

For the prior distributions, I use a Gamma distribution for the non-homotheticity parameter $\varepsilon_1 = \varepsilon_2$, which is bounded between zero and one. As discussed above, the reduced-form estimation provides empirical support for this restriction. I set the prior mean to 0.8, substantially different from the reduced-form estimates, ensuring that the Bayesian estimation is not biased toward those results. For the elasticity of substitution between gas and non-gas energy, ζ and ζ^*, I use Beta distributions with prior mean 2 and a loose standard error. Following Krause et al. (2008), all shock processes follow an AR(1) process with prior means of 0.9 for the AR-coefficients, which follow Beta distributions, and Inverse-gamma distributions for the standard deviations.

The estimation proceeds in two steps. First, I compute the mode of the posterior distribution using a Monte Carlo-based optimization routine. Second, the Metropolis-Hastings algorithm evaluates the marginal likelihood and produces the posterior distributions of the parameters. More details on the estimation method are in the Online Appendix.

Table 3 presents the results of the Bayesian estimation. The posterior mean of the non-homotheticity parameters $\varepsilon_1 = \varepsilon_1^* = \varepsilon_2 = \varepsilon_2^*$ is 0.27. This estimate is nearly identical to the average of the two separately estimated parameters from the reduced-form exercise. In

[14] I add the measurement error for energy inflation with a tight prior to avoid stochastic singularity.

Table 3: Priors and posteriors

Parameter	Prior dist.	Prior mean	Prior std.	Post. mean	Post. std.	90% HPD interval
$\varepsilon_1 = \varepsilon_2$	Gamma	0.8	0.1	0.27	0.07	[0.165,0.380]
ζ	Beta	2	1	15.21	1.86	[12.190,18.265]
ζ^*	Beta	2	1	35.31	3.31	[29.981,40.802]

Notes: The prior distribution, mean, standard deviation, posterior mean and standard deviation, and the Highest Posterior Density (HPD) interval of the Bayesian estimation. The posterior distributions plots and some more details about the estimation results are in the Online Appendix.

the numerical exercises, I use this estimate as the baseline calibration.

The posterior means of the parameters governing substitutability of gas and non-gas energy, ζ and ζ^*, are 15.21 and 35.31 respectively. Interestingly, the country-bloc that in 2022 implements an energy price cap has a much lower elasticity of substitution between gas and non-gas energy. This policy decision seems to make sense given the relatively low ability to substitute away from gas. The parameters are well-identified because I use both gas and energy inflation rates and gas and energy consumption for the estimation.[15]

Shock specification. In the numerical analyses in the following sections, I shock the economy with an adverse gas supply shock of 15% that lasts for six quarters. In this way, I capture the decline in the supply of Russian gas in summer 2022 and the expectations of governments that the shock would last until spring 2023.[16] I also model the price cap as a shock that brings the effective price of energy down to the steady-state price of energy for the duration of the gas shortage.

3 Results

In this section, I conduct a series of simulations with the dynamic model to investigate the effect of an adverse gas supply shock on a currency union. First, I investigate the three different scenarios for the currency union when hit with a gas supply shock: neither of the countries imposes a cap, one of the countries imposes a cap, or both countries impose a cap. In addition, I study the welfare implications important for policy decisions. Second, I discuss how the two key features of the model, non-homothetic preferences and substitutability of energy sources, drive the main results. Third, I perform a historical

[15]Since gas inflation/consumption is a fraction of energy inflation/consumption, the data implies inflation/consumption of non-gas energy.

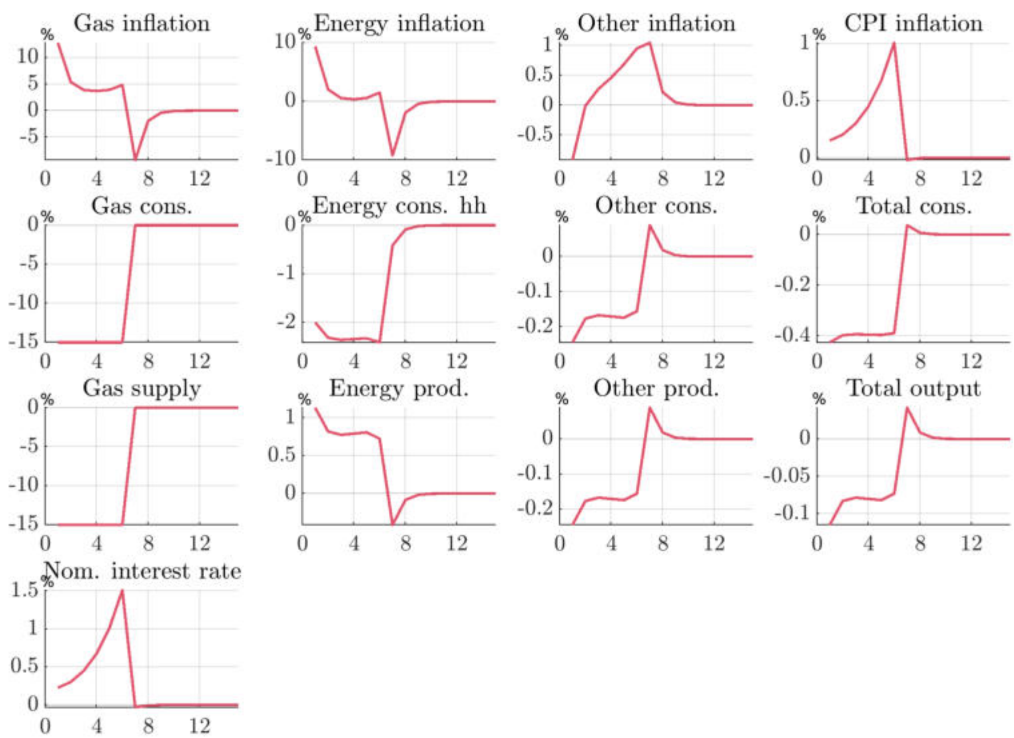
[16]More concretely, in July 2022 the European Union member states agreed to a gas consumption reduction target of 15% between August 2022 and March 2023, and another extension until March 2024, to prepare for possible supply disruptions (European Commission 2023). Moreover, most countries introduced energy price caps lasting four to nine quarters in 2022.

shock decomposition to quantify the spillovers of the energy price cap in Europe in 2022. Last, I check that the main results are robust for various model alterations.

3.1 Cap vs. no cap: simulation results and welfare implications

Energy crisis without caps. The shock is a 15% shock to the gas supply of the currency union and lasts six quarters. Since there are no gas price caps in either country and the countries are otherwise symmetric, the responses for the two countries are the same. Hence, the results in Figure 3 show one response per variable.

Figure 3: Responses to an adverse gas supply shock | No caps

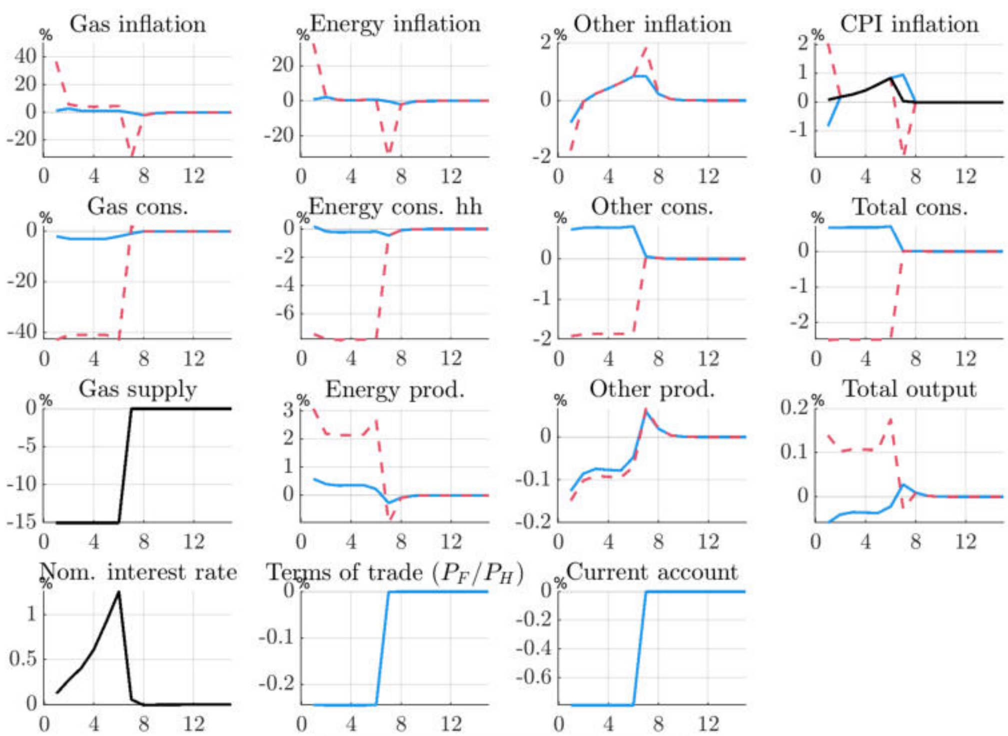


Notes: Impulse responses to a 15% decline in gas supply. The y-axis is in terms of percentage deviations from steady state. The x-axis is in quarters. Inflation and interest rates are annualized.

The adverse gas supply shock pushes gas and energy inflation up. The recessionary shock decreases inflation for other goods on impact, but in later periods other goods inflation increases since energy is a production input. Consumer Price Index (CPI) inflation, the weighted average of energy inflation and other goods inflation, peaks when other goods inflation is highest. Gas consumption drops by 15%, but an increase in energy production dampens the decline in overall energy consumption of households. Production and consumption of other goods decrease as a consequence of the energy supply declining. The decline in total consumption is larger than the decline in consumption of other goods because of the decrease in energy consumption. Since the energy shock increases CPI inflation while depressing output, the shock acts as a cost-push shock. The monetary authority conducts contractionary policy to dampen inflationary pressures, and returns to steady state together with CPI inflation.

Energy crisis with one capped and one uncapped country. Now consider the case in which the larger country introduces a price cap on the energy price, such that the retail energy price stays constant. Figure 4 shows the impulse responses for the economy. When gas supply decreases by 15%, the bigger country (blue solid lines) introduces an energy price cap, keeping gas and energy inflation constant. The uncapped country (red dotted lines) absorbs all of the gas supply shock, which means that the response of gas consumption more than doubles due to the smaller country size.

Figure 4: Responses to an adverse energy supply shock | Cap vs. no cap



Notes: Impulse responses to a 15% decline in energy supply. Preferences are non-homothetic. The bigger country, of size Θ imposes a price cap on the energy price (blue, solid) and the smaller country, of size $1-\Theta$ does not (red, dashed). The black solid lines show the union-wide variables. The y-axis is in terms of percentage deviations from steady state. The x-axis is in quarters. Inflation and interest rates are annualized.

In the capped country, the economy avoids most of the energy crisis. Because their energy prices do not increase, households keep their gas and energy consumption relatively constant. Other goods inflation responses show that the goods from the capped country become relatively more expensive because the uncapped country is hit with a big recessionary shock. Hence, terms of trade appreciate for the capped country, increasing the purchasing power of households. Households increase their overall consumption through an increase in the traded good, becoming net-borrowers at the expense of households in the uncapped country[17] Since energy prices and energy demand stay roughly constant, the energy production in the capped country barely increases during the gas crisis. Firms producing other goods also hardly change their output.

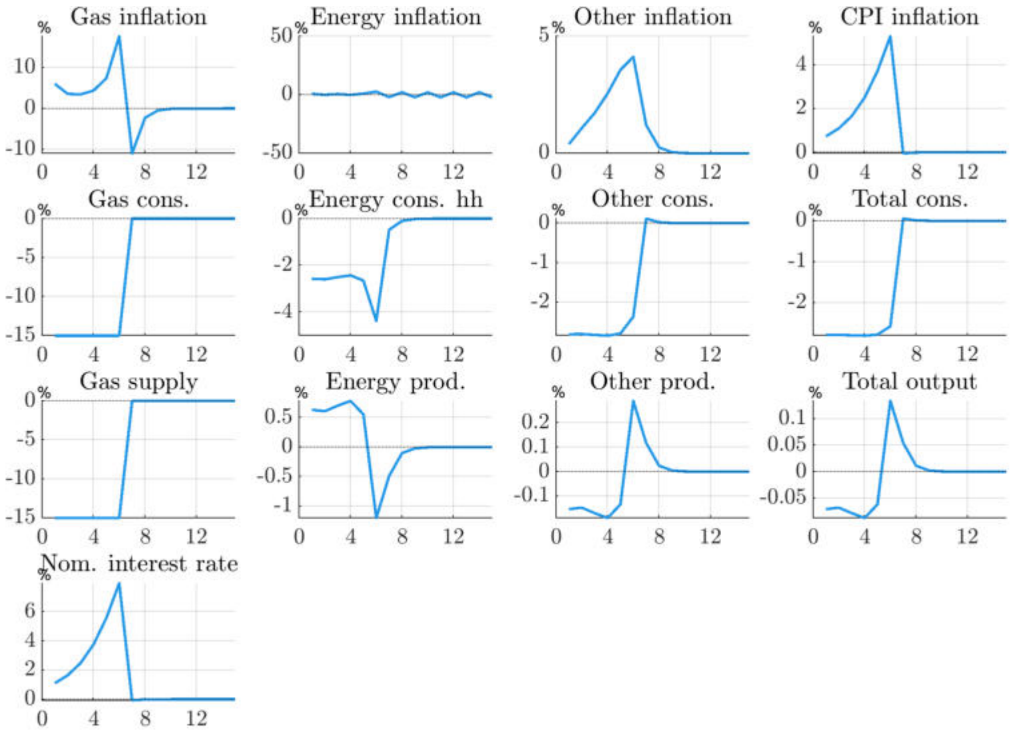
In the uncapped country, the energy price more than triples compared to the previous case without caps in the union. Since the capped country does not decrease their gas nor energy consumption, they are even scarcer goods in the uncapped country. Crucially, the other goods inflation fluctuations in both countries imply a terms-of-trade depreciation for the uncapped country, which means that households in this country face a relative decrease in purchasing power. As net-savers, they consume less of the traded good which contributes to the decline in total consumption. On the production side, the scarcity in energy incentivizes domestic energy production, and with other goods production barely decreasing, it increases the total output of the country. So, the uncapped country faces an overheating of the economy with higher inflation and higher output.

The common monetary policy adopts a similar stance to that when neither of the countries implemented the energy price cap, in Figure 3. The central bank targets the weighted-average headline inflation in its Taylor rule, which is the black line in the CPI inflation graph in Figure 3 and 4. Since the inflation rates of the capped and uncapped countries peak at different times, the weighted-average inflation does not change much compared to the case when neither of the countries imposed the cap.

Energy crisis with price caps in both countries. Figure 5 shows the responses when both countries impose an energy price cap. In this case, the price of energy stays constant in the entire union. Because of the distorted price, consumers try to maintain their energy and other goods consumption. However, since the supply of gas is exogenous, the supply side of the economy cannot increase its production accordingly. Hence, there is high pressure on other goods inflation as well as the actual price of energy. Because the government pays the difference between the actual and retail price of energy, the price cap becomes a large cost for the government and ultimately for the consumers. Combined with the high other goods inflation, such high costs cause a big decline in the total consumption of the households as a deadweight loss.

[17] This result is similar to the terms-of-trade externality by for example Corsetti and Pesenti (2001), in which an expansionary fiscal policy causes a terms-of-trade appreciation for the country, hurting trading

Figure 5: Responses to an adverse energy supply shock | Caps



Notes: Impulse responses to a 15% decline in energy supply and a price cap in both countries. Preferences are non-homothetic. The y-axis is in terms of percentage deviations from steady state. The x-axis is in quarters. Inflation and interest rates are annualized.

Implications for policy decisions and welfare. Next, I analyze the welfare implications for each combination of policy strategies (cap and no cap, for both countries) and show the decision game that policymakers face. Table 4 summarizes the welfare results in a two-by-two matrix. The relevant metric is the consumption equivalent welfare gains and losses relative to the steady state of the economy.[18]

First, focus on the cells on the diagonal where the policies are symmetric (cap-cap and no cap-no cap). Since the currency union is a closed economy, the symmetric benchmark is equivalent to the closed economy case. The adverse gas supply shock causes a welfare loss of 0.02% without an energy price cap and 0.16% with the cap. With an energy price

partners.

[18]For the consumption equivalent, I find χ which satisfies:

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{\varepsilon_1} \left[\left(\frac{exp_t}{P_{Rt}} \right)^{\varepsilon_1} - 1 \right] - \frac{\alpha_E}{\varepsilon_2} \left[\left(\frac{P_{Et}}{P_{Rt}} \right)^{\varepsilon_2} - 1 \right] \right\} = \sum_{t=0}^{\infty} \beta^t \frac{1}{\varepsilon_1} \left\{ [\overline{exp}(1+\chi)]^{\varepsilon_1} - 1 \right\} \tag{28}$$

So, χ is the fraction of total expenditure, i.e. total consumption, that the household would be willing to forgo in the economy in steady state (right-hand side) to live in the economy with the energy supply shock, as evaluated by the left-hand side of the equation.

Table 4: Welfare gains/losses after gas supply shock

	%	1/3 of union: Cap	1/3 of union: No cap
2/3 of union	Cap	$(-0.16, -0.16)$	$(0.04, -0.14)$
	No cap	$(-0.06, 0.00)$	$(-0.02, -0.02)$

Notes: Welfare gains and losses after a 15% gas supply shock, in a model with energy production. Preferences are non-homothetic. The gains and losses are in terms of the consumption equivalent relative to the steady state. The circles are around the preferred policy choices (Cap or No cap) for the countries.

cap in the entire union the welfare loss is almost tenfold bigger. As discussed, the cap-cap scenario is detrimental for household consumption since the demand distortions under the price cap increase the fiscal cost for the government to finance the cap, ultimately borne by households.

When the individual countries are free to choose their energy price cap policy, is the non-distortionary no-cap strategy the Nash equilibrium? As the circles around the welfare values indicate in Table 4, the cooperative case is not the Nash equilibrium. Instead, countries have an incentive to deviate and impose an energy price cap, outsourcing the energy crisis onto the other country.

Given 1/3 of the union does not impose an energy price cap, does the rest, 2/3 of the union, have an incentive to deviate from the no-cap strategy? If they keep to the no-cap strategy, they would choose the cooperative case, in which both countries experience a welfare loss of 0.02%. However, the country representing 2/3 of the union has an incentive to deviate to the cap policy, which improves welfare in that country (0.04%) at the expense of the uncapped country (–0.14%).

Given 2/3 of the union imposes an energy price cap, does the rest, 1/3 of the union, also have an incentive to impose the price cap? The large, negative spillovers are very costly for the uncapped country; they cause a welfare loss of 0.14%. However, the highly distortionary cap-cap case creates a welfare loss of 0.16%. So, even if the spillovers from the capped country are costly, the rest of the union is better off not imposing the price cap.

The above argument also applies when the small and large countries switch: even though the spillovers are smaller due to the smaller size of the capped country, the outcome of the strategic game remains the cap and no-cap scenario.

These spillovers are consistent with the policy debates during the 2022 energy crisis. When Germany announced a large unilateral energy relief package in October 2022, European leaders criticized the decision, with concerns that Germany's package would put households and companies in the rest of the bloc at risk of paying higher energy prices (Chazan et al. 2022). European Union officials advocated for collective approaches, with European Council President Charles Michel stating that "the best way to reduce prices is to take a more collective approach" (Fleming and Chazan 2022). The model provides a framework for understanding these tensions: while the cooperative outcome is for neither country to impose price caps, each country has an incentive to deviate unilaterally. Once one country implements a cap, it is optimal for the other to bear the spillovers rather than impose its own cap.

The terms-of-trade channel. To understand the forces behind the spillovers, I decompose the welfare gain and loss from the top-right cell in Table 4: 0.04% for the capping country and –0.14% for the non-capping country. By computing the welfare losses in the cases of (i) two autarkies sharing a gas supply and (ii) two trading countries, not in a currency union, sharing a gas supply, Table 5 decomposes the total welfare gain and loss into three components: energy price distortion channel, terms-of-trade channel, and the currency union channel.

Table 5: Decomposition of the welfare gain and loss from Cap-No cap case

%	**(i) Autarkies** ($\alpha_I = 0$, indep. CBs)	**(ii) Trade partners** ($\alpha_I = 0.25$, indep. CBs)	**(iii) In union** ($\alpha_I = 0.25$, one CB)
Total effect	**(–0.1035, –0.0022)**	**(0.0405, –0.1410)**	**(0.0393, –0.1423)**
Energy price	(–0.1035, –0.0022)	(–0.1035, –0.0022)	(–0.1035, –0.0022)
Terms of trade	-	(0.1440, –0.1388)	(0.1440, –0.1388)
Currency union	-	-	(–0.0012, –0.0013)

Notes: Decomposition of the welfare gain and loss for the cap and no-cap country after a 15% gas supply shock. The losses are in terms of the consumption equivalent relative to the steady state. The first column indicates the welfare loss in the case in which the countries are autarkies, i.e. do not trade ($\alpha_I = 0$) and have independent central banks. The second column relaxes the no-trading assumption ($\alpha_I = 0.25$) but still assumes independent central banks. The third column is the full model, with countries trading and in a currency union.

The first column in Table 5 shows the welfare results for a decline in the shared gas supply for two autarkies in the case when the larger country caps the energy price and the other does not. The model diverts from the baseline by two dimensions: no trade in goods, and hence no trade in bonds, and the countries have independent central banks. Therefore, the spillover from the price cap only consists of the distortion in the energy market. The households in the capped country face a lower price for energy and gas, such that they do not adjust their consumption in line with the supply shortage. Households in the uncapped country therefore face a higher shortage, leading to welfare losses. However, those losses are relatively small, –0.0022%, compared to –0.1423 for the baseline currency union model. Contrary to the currency union model, the capping country incurs a welfare *loss* from the policy. This result shows that the cap does not generate a welfare gain when the common gas supply is the only market that connects the two countries. In this case, the fiscal cost of implementing the price cap outweighs the gains.

In the second column in Table 5, I consider a model in which the countries can trade in goods and bonds, but each still have their own central bank. The total effect shows the welfare gain and loss for the capped and uncapped country after a common gas supply shock. From the results with autarkies, I infer the decomposition: I take the spillovers from energy price distortion from the autarky result, and assign the residual to the terms-of-trade channel.[19] The terms-of-trade channel provides welfare gains for the capped country that outweigh the losses from the autarky case. The capped country benefits by using trade to shift the burden of the gas shortage onto its trading partner through more favorable terms of trade. For the uncapped country, the negative effect on welfare increases a lot more with trade opennes.

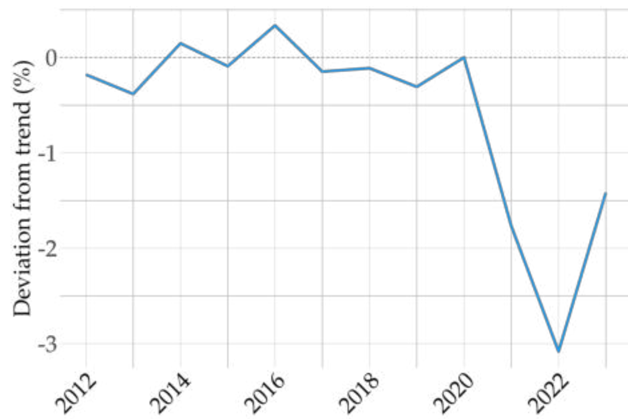
The last column in Table 5 shows, similarly to Table 4, the results of the baseline model: a currency union. I take values of the energy price distortion channel and the terms-of-trade channel from the alternative models, and calculate the cost of being in a currency union. In a currency union, the single central bank sets a common interest rate. This constraint generates welfare losses for both countries (-0.0012% and -0.0013%), though these are relatively small compared to the losses incurred from the terms-of-trade channel.

Figure 6 presents the bilateral terms-of-trade index for cap and no-cap countries over 2012–2023, constructed from OECD data. During the pre-crisis period (2012–2020), deviations from trend remained minimal, as the cap/no-cap classification had no policy relevance. Beginning in 2021, the index exhibits a marked decline, indicating a substantial terms-of-trade improvement for capped countries. This empirical pattern aligns with the model's predictions and provides evidence for the quantitative importance of the terms-of-trade channel in generating cross-country spillovers.

By decomposing the channels for the spillovers, I find that distorting the shared energy price does not benefit the capping country unless the countries are also trade partners. Through changes in relative purchasing power from distorting energy prices, the capped country experiences welfare gains, whereas the uncapped country incurs losses. The empirical evidence in Figure 6 corroborates this mechanism, showing an unprecedented terms-of-trade improvement for cap countries during the 2022 energy crisis. Sharing a common central bank lessens the welfare gains and worsens the losses, but those effects are relatively small compared to the terms-of-trade channel.

[19] I decompose the channels additively. The energy price distortion is isolated in column (i) where countries are autarkies. The terms-of-trade channel is the incremental effect from adding trade (column (ii) minus column (i)). The currency union channel is the incremental effect from sharing a central bank (column (iii) minus column (ii)).

Figure 6: Bilateral terms of trade between cap and no-cap countries



Notes: Bilateral terms of trade, constructed as the ratio of aggregated no-cap to cap countries' terms-of-trade indices. Each country's terms-of-trade index measures the ratio of its export to import prices with all trading partners. The series is detrended using a linear trend estimated from 2012–2019 and normalized to zero in 2020. Negative values indicate an improvement for cap countries. Data source: OECD National Accounts. Aggregates use ECB-published country weights for the euro area.

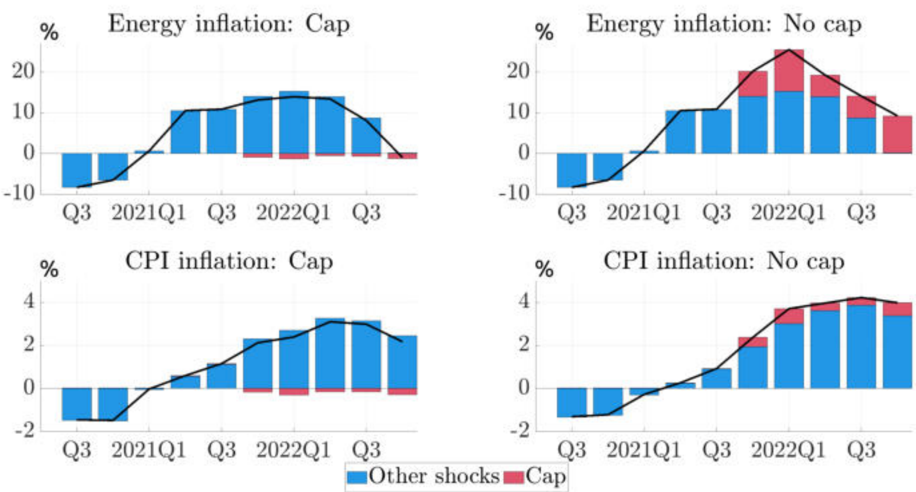
3.2 Quantitative results from historical shock decomposition

The simulation results show that the cooperative outcome, with no price caps, is optimal. This section quantifies what the inflation rates could have been during the 2022 energy crisis under such cooperation.

Using the calibrated and estimated values in Table 1, I perform a historical shock decomposition for the period 2008Q1–2022Q4. I employ the Bayesian estimation techniques in Dynare (Adjemian et al. 2024) with the same data series and shock processes described above, but add the energy price cap as an additional shock. All shocks follow an AR(1) process, and I estimate the AR coefficients using the same approach. Importantly, I estimate structural parameters and the shock decomposition separately: I use only pre-crisis data (through 2021Q4) to estimate structural parameters, then use those parameters to decompose what happened during the 2022 energy crisis. This ensures that the estimated parameters reflect normal times rather than the crisis itself. More details on the data and estimation method are in the Online Appendix.

The historical shock decomposition decomposes the fluctuations in the data series into the contributions from various shocks in the model. The results are in Figure 7. I group all shocks but the energy price cap in one (blue bars) and keep the contributions from the cap separate (red bars). On one hand, the top-left graph in Figure 7 shows that the energy inflation in the countries that imposed the energy price cap would not have been much lower had they not imposed the cap. In that case, none of the countries impose an energy price cap and the countries share the burden equally across the union. Without the distortions that the price cap introduces, inflation rates are only a few percentage points higher than the realized outcome in which those countries imposed an energy price cap.

Figure 7: Historical shock decomposition | Contributions from the energy price cap



Notes: Historical shock decomposition of the annual inflation rates in deviations from the sample mean. "Other shocks" consist of total factor productivity (TFP) shocks for other goods and energy sector, demand shocks, cost-push shocks in the other goods sector, shocks to gas supply, monetary policy shock, and measurement errors for energy consumption and energy inflation. Those shocks and measurement errors are separate for the two countries in the union, except for the monetary policy shock. Mean energy inflation is 2.15% and 2.72% for capped and no-cap countries respectively. Mean CPI inflation is 1.42% and 1.46% for capped and no-cap countries respectively. The red bars indicate the contributions from the energy price cap, whereas the blue bars aggregate all other shocks. More details are in the Online Appendix.

On the other hand, the top-right graph in Figure 7 shows that the energy price cap contributed to about 10 percentage points of energy inflation in the uncapped countries in 2022. In the last quarter of 2022, the price cap was responsible for virtually all energy inflation in the uncapped countries. This result supports the large spillovers found in the simulation results, stemming from the shared gas supply.

Without price caps in 2022, energy inflation would not have been much higher for the countries that imposed caps, as the burden would have been shared across the union. For countries that did not implement caps, energy inflation would have been substantially lower due to the absence of spillovers. The bottom two graphs in Figure 7 show a similar pattern for CPI inflation, for which the price cap was responsible for about 0.5 percentage points in the uncapped countries.

3.3 Robustness checks

In this section I discuss the robustness checks of the model's main findings. First, I show that the results are not robust to omitting the key features of the model, non-homothetic preferences and substitutability of energy sources. Second, I test for other model specifications and for parameter values: heterogenous agents, core inflation targeting, and trade parameters. Most Figures and Tables accompanying this section are in Appendix B. Additional robustness checks are in the Online Appendix. They check for model robustness under elastic labor supply, flexible prices, and the relative size of countries.

3.3.1 Homothetic preferences and no substitutability of energy sources

Homothetic preferences. The welfare table under homothetic preferences are in Figure 8a.[20] For these simulations, I set parameters $\varepsilon_1 = \varepsilon_2 = 0$, making the preferences Cobb-Douglas. The impulse responses show that the non-homothetic preferences amplify the result of the adverse gas supply shock. When energy is not a necessity good, the effect of the energy crisis is a lot milder.

Figure 8: Welfare gains/losses under alternative model specifications

(a) Homothetic preferences

	%	1/3 of union: Cap	1/3 of union: No cap
2/3	Cap	(−0.05, −0.05)	(0.03, −0.13)
	No cap	(−0.06, 0.00)	(−0.02, −0.02)

(b) No substitution of energy sources

%	1/3 of union: Cap	1/3 of union: No cap
Cap	(−1.0, −1.0)	(0.5, −1.1)
No cap	(−1.1, 0.4)	(−0.1, −0.1)

Notes: Welfare gains and losses to a 15% decline in gas supply, in terms of consumption equivalent relative to steady state. Left panel shows results with homothetic preferences ($\varepsilon_1 = \varepsilon_2 = 0$). Right panel shows results without endogenous energy production. Circles indicate preferred policy choices.

Again, countries are better off in the cooperative case when neither country imposes any price caps (–0.02%) than in the case when both countries impose a cap (–0.05%). Compared to the case of non-homothetic preferences, the welfare loss of the cap-cap scenario under homothetic preferences is small. Since energy is not a necessity good, the government's spending on the price cap is lower, creating a smaller distortion.

Non-homotheticity of preferences affects the magnitude of the spillovers too. Because energy is not a necessity, compared to the non-homothetic case, the welfare loss from negative spillovers if the other country imposes a cap is smaller, –0.13% and –0.06%. However, the welfare loss relative to the cap-cap case changes. Since the cap-cap scenario is only mildly distortionary under homothetic preferences, the dominant strategy for policy makers is to impose an energy price cap, rather than bearing the spillovers if the other country has a cap. Hence, non-homothetic preferences are key in explaining why the no-cap strategy makes sense when the good involved is a necessity good.

[20]For impulse responses, see the Online Appendix

No substitution of energy sources. Here, I consider an economy in which there is no substitution available for the exogenous supply of gas, similar to Bayer et al. (2026) and Erceg et al. (2024). The results are in Figure 8b. Without endogenous energy production, the gas supply shock hits the economy substantially stronger in all scenarios, amplified through non-homothetic preferences.

Similarly to the case with homothetic preferences, though the cooperative outcome is for neither of the countries to impose an energy price cap, both countries have a dominant strategy to impose the cap. Without the ability of the domestic energy production sector to respond to the shortage in gas, the negative spillovers when the other country imposes the cap are larger than the distortion the cap-cap scenario creates.

Overall, the simulation results under alternative model specifications reveal that modelling energy as a necessity good and accounting for substitution of various energy sources is important in explaining the decision space the policymakers face in an energy crisis. Non-homothetic preferences and endogenous energy production affect the degree of distortion a cap-cap scenario imposes, as well as the magnitude of the spillovers when the other country imposes the cap but the own country does not. To explain why certain countries, especially those with a high elasticity of substitution between gas and other sources of energy, are better off bearing negative spillovers, non-homothetic preferences and endogenous energy production are crucial model features.

3.3.2 Other robustness checks

Heterogeneous agents. Since an energy crisis hits poorer households more, I perform a robustness check with a two-agent version of the baseline model. In the two-agent model, poor hand-to-mouth households consist of 10% of the population following standard literature. Hand-to-mouth households only derive income from labor and transfers from the government, whereas the other households, as modelled in the baseline, have access to the bonds market. Since hand-to-mouth households only rely on labor income, I introduce elastic labor supply as discussed in the Online Appendix. More details of the two-agent model, including the equations, are in Appendix A. Figure C.2 shows that for all three scenarios, no cap in the union, only caps in the union, and a cap in one country, the impulse responses are roughly similar to the baseline. Importantly, the values in the pay-off matrix for policymakers remain stable. This result is in line with findings by Debortoli and Galí (2018) that representative agent models reproduce aggregate dynamics of heterogeneous agent models quite closely. In Section 4 I study targeted transfers using the two-agent model as an alternative to the energy price cap.

Core inflation targeting. The mandate of the European Central Bank is price stability in terms of headline inflation, but during times of crises it might give more weight to core measures (Wellink 2023). Figure C.3 shows select impulse responses under core inflation targeting and the welfare gains and losses. The results under the cooperative scenario in which both countries impose the cap are qualitatively and quantitatively similar to the baseline case, except the nominal interest rate response, which is lower since the monetary authority does not react to energy inflation. When considering the case in which only one country implements the cap, the divergence between the countries becomes larger: the capped country benefits more from the policy and negative spillovers to the uncapped country are larger. Under core inflation targeting, the monetary policy response is relatively expansionary compared to the baseline case because it does not take energy inflation into account. This policy response hurts the consumers in the uncapped country more, because inflation is higher. Hence, with core inflation targeting, the central bank exacerbates the divergence between the two countries.

Trade parameters. Since the terms-of-trade externality plays an important role in the mechanism for the spillovers of the energy price cap, I perform robustness checks with different values of the degree of home bias, α_I, and the elasticity of substitution between Home and Foreign goods, γ. Table C.1 shares the results of the exercise. After simulating the model with a range of values for both parameters, the magnitude of the spillovers is close to stable. The negative spillovers increase slightly with less trade (lower α_I or lower γ), but not to the degree that it affects the baseline decisions for policymakers.

4 Alternative Policy Instrument: Targeted Transfers

In this section I compare the energy price cap with targeted transfers using the two-agent model developed for the robustness checks. Most national governments conducted transfers to vulnerable groups in 2022, since the energy crisis affected them the most (Sgaravatti et al. 2023). To create heterogeneity within households, I add poor hand-to-mouth households to the model. For more details, see Appendix A. I find that with much lower cost for the government, targeted transfers to these constrained households achieve more favorable results in terms of boosting consumption for the poor. Moreover, since the transfer does not distort the energy market, there is barely any divergence within the union even if only one country implements the transfers. With impulse response decomposition, I investigate the consumption responses of constrained and unconstrained households in detail. I decompose the consumption responses as in Eq. (37) and (42), finding the relative size of the forces behind the consumption response.

First, I study the baseline scenario in which one country imposes a price cap and the other does not, as shown in Figure 9a. In the capped country, the consumption of the unconstrained increases, whereas the consumption of the constrained decreases on impact. The unconstrained households increase their consumption both by increasing their energy consumption and from consumption smoothing. Recall the mechanism through which households benefit from the energy price cap in the baseline model: households increase their consumption because they consume cheap goods from the uncapped country, i.e. the capped country consumes more than it produces. This mechanism is *intertemporal*, since the capped country temporarily runs a current account deficit and borrows from abroad while the energy shock takes place. In the two-agent version, only unconstrained households make *intertemporal* decisions. Hence, unconstrained households increase their consumption, whereas constrained households cannot during the energy shock. The rightmost graph displays the large spillovers from the capped to uncapped country, similar to previous versions of the model. Because the price cap distorts the energy market in the union, it creates spillovers to the uncapped country.

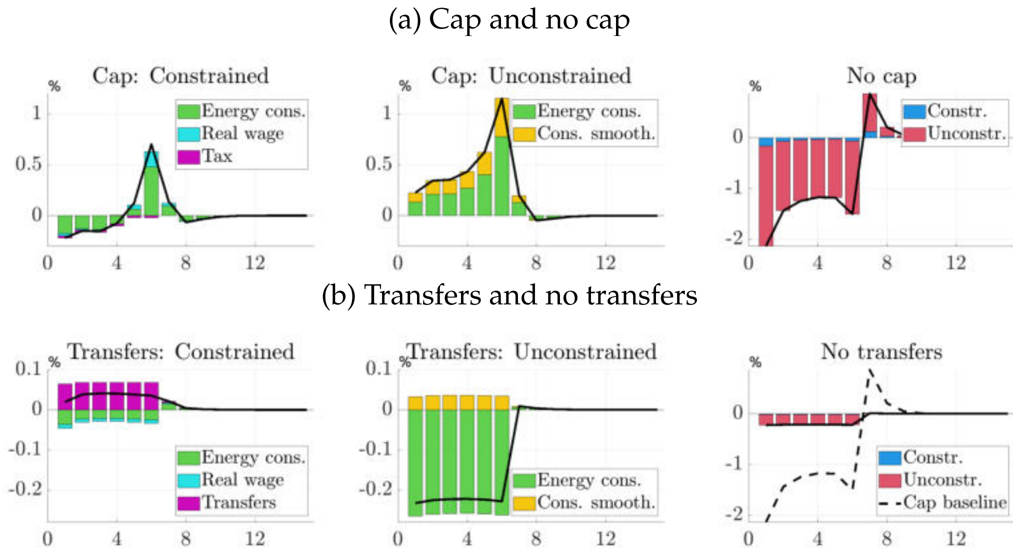
Second, I introduce targeted transfers as an alternative for the price cap. I set the targeted transfers to the same per person government expenditure, but only for the constrained households. Since they are 10% of the population, the specified targeted transfer only costs 10% of the cost of the price cap. The consumption responses are in Figure 9a. The left graph shows that the targeted transfers are effective in increasing the constrained household's consumption, without lowering the consumption of the unconstrained too much. Moreover, the right-most graph shows that the spillovers to the country without transfers are substantially smaller than under the cap.

Last, Figure 10 shows responses of some other macroeconomic variables for both the country with and without transfers. Because transfers do not distort the integrated energy market in the currency union, they do not create much divergence within the union. The inflation response is significantly milder than in the case with price caps. So, together with the absence of divergence, the transfers are more preferable for the common central bank when stabilizing the inflation rates across the union. Moreover, the spillovers in terms of consumption are also substantially lower than with the price cap.

5 Conclusion

This paper investigates the trade-offs of imposing an energy price cap during an energy crisis, based on the euro area energy crisis in 2022. The analysis uses a two-country currency union New Keynesian model. The key contribution of the model is the joint

Figure 9: Consumption response decomposition in the two-agent model



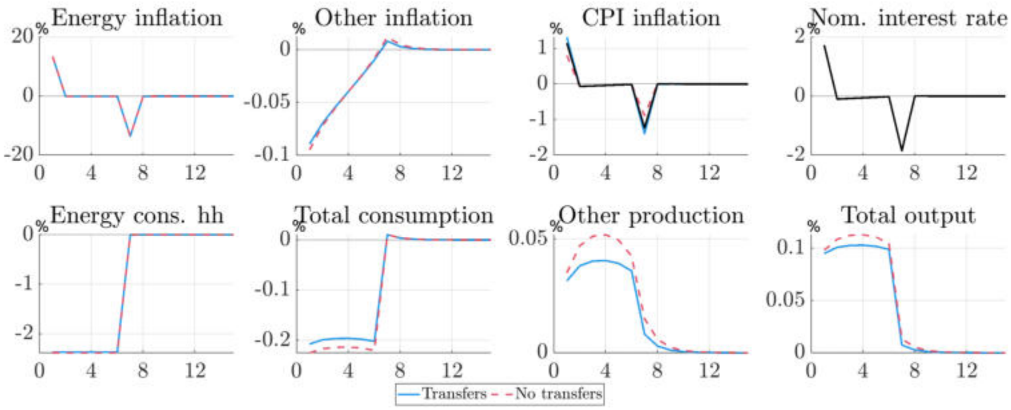
Notes: Impulse responses to a 15% decline in energy supply (black lines) and the decomposition of the responses (colored bars). The bigger country, of size Θ imposes a price cap, in panel (a) or conducts targeted transfers to constrained households, in panel (b), while the smaller country, of size $1-\Theta$ does not. In panel (b), the dashed line indicates the baseline scenario with the energy price cap. The y-axis is in terms of percentage deviations from steady state. The x-axis is in quarters.

characterization of household preferences and the energy sector. Preferences are non-homothetic with energy as a necessity good. In the energy sector, there is an exogenous supply of gas shared by the two countries and an endogenous energy production sector in each country. The paper provides novel estimates of the non-homotheticity parameters and the elasticity of substitution between gas and non-gas energy.

An adverse gas supply shock causes high energy inflation and a contraction in the production sector. I show that the cooperative policy is to refrain from introducing price caps. However, for an individual country it is welfare improving to impose a price cap if the other country does not: the capped country avoids the crisis while the uncapped country experiences the spillovers. This effect occurs primarily through a terms-of-trade channel not emphasized in prior work on energy price interventions: while energy price distortions create direct spillovers through the shared gas supply, the bulk of welfare divergence stems from relative price movements that shift purchasing power from the uncapped to the capped country. Bilateral terms-of-trade data provide empirical support for this mechanism.

The magnitude of those spillovers determines the preferred policy decisions—to cap or not to cap? On one hand, a price cap ensures that households can maintain energy consumption levels. On the other hand, a cap is a cost to the government, and therefore ultimately to households. When one country imposes a price cap, the uncapped

Figure 10: Responses to an adverse energy shock | Transfers vs. no transfers



Notes: Impulse responses to a 15% decline in gas supply. The bigger country, of size Θ conducts targeted transfers to the constrained (c) households (blue, solid) and the smaller country, of size $1-\Theta$ does not (red, dashed). The y-axis is in terms of percentage deviations from steady state. The x-axis is in quarters. Inflation and interest rates are annualized.

country incurs negative spillovers. So, there is a trade-off between paying for the cap and paying for the negative spillovers. The magnitude of the spillovers depends on the non-homotheticity of preferences and the substitutability of energy sources. The baseline model with both ingredients shows that the cost of funding the price cap exceeds the cost of bearing negative spillovers. This result explains why some euro area countries did not introduce a price cap in 2022, while others did.

I quantify these mechanisms through a historical shock decomposition for the 2022 energy crisis. The counterfactual exercise examines what inflation would have been if all euro area countries had coordinated and refrained from imposing price caps. The results show that the energy price cap contributed about 10 percentage points to energy inflation and 0.5 percentage points to headline inflation in uncapped countries in 2022. Meanwhile, inflation in capped countries would not have been substantially higher under coordination, reinforcing that the cooperative outcome dominates.

The analysis yields clear policy implications. While coordination on refraining from price caps is collectively optimal, it may be difficult to achieve when individual countries face strong unilateral incentives to deviate. If coordination fails and caps are imposed, uncapped countries should not retaliate with their own caps, as the costs of market distortions exceed the costs of bearing spillovers. Targeted transfers emerge as a superior policy instrument: they are cheaper and more effective at supporting poor households during energy crises, and because they do not distort energy markets, they avoid creating the divergence and spillovers that price caps generate within the union.

While this paper focuses on the 2022 European energy crisis, the framework has broader applicability to any setting where countries within an integrated market face asymmetric policy responses to common shocks. The key mechanism, unilateral price controls creating spillovers through shared supply networks, extends beyond the 2022 energy crisis. Similar tensions could arise in agricultural commodity markets during food crises, in carbon pricing coordination as countries pursue climate policies at different speeds, or in pharmaceutical markets during health emergencies. More generally, as economic integration deepens while political coordination remains limited, the strategic trade-offs characterized in this paper will become increasingly relevant.

Appendices

A Adding hand-to-mouth households to the model

In the two-agent version of the model, there are financially constrained households who represent share $\lambda \in [0,1]$ of the population, and unconstrained households who are share $1-\lambda$. Financially constrained households have no access to the one-period bonds. Moreover, they earn no profits from firms nor the energy sellers. The budget constraints of the constrained and unconstrained households are respectively:

$$exp_t^c = P_{Et}e_t^{h,c} + P_{Ot}C_{Ot}^c = W_t n_t^c + P_t \tau_t^c + \mathcal{T} - T_t^c \tag{29}$$

$$\begin{aligned} exp_t^u = P_{Et}e_t^{h,u} + P_{Ot}C_{Ot}^u = W_t n_t^u + \frac{1-\delta}{1-\lambda}D_t + \frac{1}{1-\lambda}D_t^E \\ + R_{t-1}\frac{B_{t-1}}{1-\lambda} - \frac{B_t}{1-\lambda} - HC_t + P_{Ot}\tau_t^u - T_t^u \end{aligned} \tag{30}$$

where superscript c refers to variables belonging to constrained households and u to unconstrained ones. τ_t are redistributive transfers from the government explained below. $\mathcal{T}$ is a steady-state transfer from the constrained to unconstrained, to make sure their consumption is equal in steady state. The preferences are the same for both households and include the disutility for labor supply as in 3.3.

I aggregate energy and other goods consumption and labor as:

$$\lambda e_t^{h,c} + (1-\lambda)e_t^{h,u} = E_t^h \tag{31}$$

$$\lambda C_{Ot}^c + (1-\lambda)C_{Ot}^u = C_{Ot} \tag{32}$$

$$\lambda n_t^c + (1-\lambda)n_t^u = N_t \tag{33}$$

Labor supply of constrained and unconstrained households are therefore identical to the firms.

Following Debortoli and Galí (2018) and Komatsu (2023), the fiscal authority redistributes the taxed profits from firms D_t as transfers to the constrained households, τ_t^c, and unconstrained households, τ_t^u, according to the rules:

$$\tau_t^c = (1-\tau_0)\delta D_t \tag{34}$$

$$\tau_t^u = \left(1 + \frac{\tau_0 \lambda}{1-\lambda}\right)\delta D_t \tag{35}$$

where δ is the tax rate on firms' profits, where τ_0 indicates how much of the profits go to (un)constrained households, using $\lambda\tau_t^c + (1-\lambda)\tau_t^u = \delta D_t$. So, when τ_0 is equal to unity, all profits go back to the unconstrained households.

Calibration. The Household Finance and Consumption Survey (HFCS 2022) collects household-level data in the euro area and estimates that credit-constrained households make up around 5-10% of the population. Hence, in the TANK version, the share of hand-to-mouth households, λ, is 0.1.[21] For the redistribution of taxed firms' profits, I set the tax rate on firm's profits at $\delta = 0.215$, which was the average corporate tax rate in 2022 of European OECD countries (Bray 2023). The redistribution rule, τ, is equal to unity, such that all profits go to unconstrained households. All other calibration values are identical to the baseline model and the model with domestic energy production.

Consumption response decomposition. In the main text I investigate the consumption responses of constrained and unconstrained households in detail. Hence, I perform an impulse response decomposition by rearranging the log-linearized equations. Hatted variables indicate log-linear deviations from steady state.

For constrained households, take total consumption as a sum of energy consumption and other goods consumption:

$$\hat{c}_t^c = \frac{\bar{e}^c}{\bar{c}^c}\hat{e}_t^c + \frac{\bar{C}_O^c}{\bar{c}^c}\hat{C}_{Ot}^c \tag{36}$$

Using the choice between energy and other goods, Eq. (2), the definition of the energy expenditure wedge and their budget constraint, Eq. (29), I decompose the consumption of the constrained households:

$$\hat{c}_t^c = \underbrace{\mathbf{A^c}\hat{e}_t^c + \mathbf{B}\hat{p}_t^{rel,ER}}_{\text{energy consumption}} + \underbrace{\mathbf{C}\hat{w}_t}_{\text{real wage}} - \underbrace{\mathbf{D}\hat{t}_t}_{\text{taxes}} \tag{37}$$

[21] 5-10% is the share of so-called "poor" hand-to-mouth households. When including the share of "wealthly" hand-to-mouth households, who own illiquid assets, the share of hand-to-mouth households rises to about 30%.

where

$$\mathbf{A^c} = \frac{1}{\bar{c}^c}\left(\bar{e}^c + \bar{C}_O^c\right) \tag{38}$$

$$\mathbf{B} = \frac{\bar{C}_O^c}{\bar{c}^c}\left[1 + \frac{1}{1-\alpha_E}\left(\frac{1}{\overline{exp}}\varepsilon_1 \bar{W}\bar{N}\alpha_E - \varepsilon_2\right)\right] \tag{39}$$

$$\mathbf{C} = \frac{\bar{C}_O^c}{\bar{c}^c}\frac{1}{(1-\alpha_E)\overline{exp}}\varepsilon_1 \bar{W}\bar{N} \tag{40}$$

$$\mathbf{D} = \frac{\bar{C}_O^c}{\bar{c}^c}\frac{1}{(1-\alpha_E)\overline{exp}}\varepsilon_1 \lambda \tag{41}$$

Analogously for unconstrained households, decompose total consumption using the choice between energy and other goods, Eq. (2), the definition of the energy expenditure wedge:

$$\hat{c}_t^u = \underbrace{\mathbf{A^u}\hat{e}_t^u + \mathbf{E}\hat{p}_t^{rel,ER}}_{\text{energy consumption}} + \underbrace{\mathbf{F}\hat{exp}_t}_{\text{consumption smoothing}} \tag{42}$$

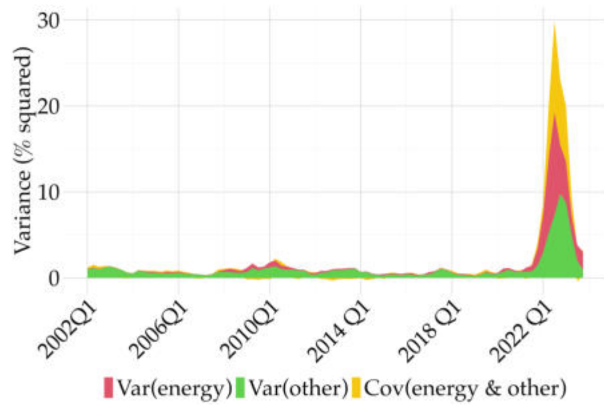
where $\mathbf{A^u} = \frac{1}{\bar{c}^u}\left(\bar{e}^u + \bar{C}_O^u\right)$, $\mathbf{E} = \frac{\bar{C}_O^u}{\bar{c}^u}\left(1 - \frac{1}{1-\alpha_E}\varepsilon_2\right)$, and $\mathbf{F} = \frac{\bar{C}_O^u}{\bar{c}^u}\frac{1}{1-\alpha_E}\varepsilon_1$. I call the last term "consumption smoothing", since the Euler equation (6) determines the total nominal expenditures of the unconstrained household, $\hat{exp}_t$.

B Additional figures

Figure C.1: Natural gas price and inflation variance decomposition

(a) Natural gas price in Europe

(b) Variance decomposition of headline inflation



Notes: Panel (a): The price index of the Title Transfer Facility (TTF) gas in the Netherlands. Data source: IMF Data (2024). Panel (b): The headline inflation in country i in quarter t is $\Pi_{it} = (1-\alpha^{E}_{it})\Pi^{O}_{it} + \alpha^{E}_{it}\Pi^{E}_{it}$ where α^{ENG} is the share of energy in the consumption basket, Π^{E}_{it} and Π^{O}_{it} energy and other goods inflation. The variance decomposition is across countries for each quarter, so $Var_t(\Pi_{it}) = Var_t\left[(1-\alpha^{E}_{it})\Pi^{O}_{it} + \alpha^{E}_{it}\Pi^{E}_{it}\right]$. Data source: Eurostat.

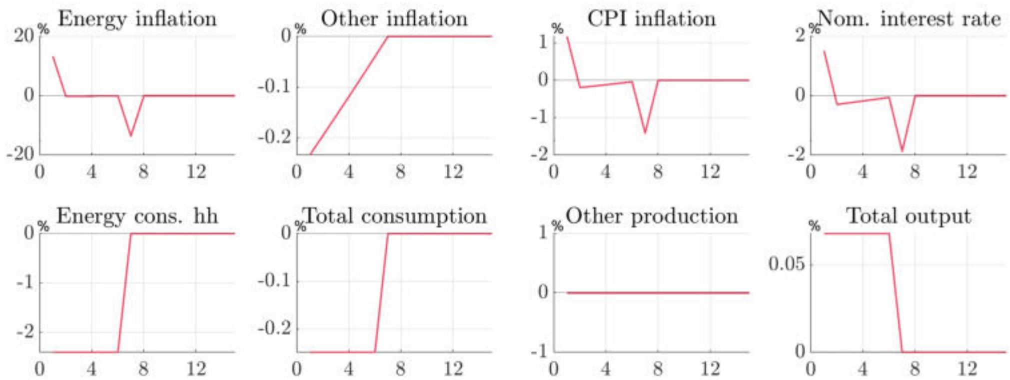
Table C.1: Welfare gains/losses cap/no-cap country under various parametrizations

	$\alpha_I = 0.1$			$\alpha_I = 0.25$		
%	$\gamma = 1.5$	$\gamma = 4$	$\gamma = 6$	$\gamma = 1.5$	$\gamma = 4$	$\gamma = 6$
Cap country	0.06	0.04	0.04	0.05	0.04	0.04
No-cap country	–0.16	–0.15	–0.14	–0.15	–0.14	–0.14

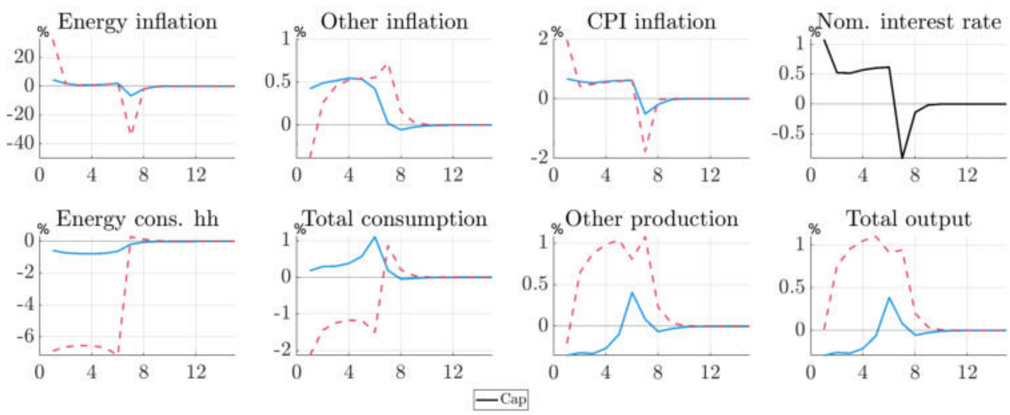
Notes: Welfare gains and losses for the capped and uncapped country after a 15% gas supply shock under different parametrizations of the trade parameters (values for top-right cell in other welfare tables). The losses are in terms of the consumption equivalent relative to the steady state. α_I is the share of imports in the consumption basket and γ is the elasticity of substitution between Home and Foreign goods.

Figure C.2: Results under heterogeneous agents

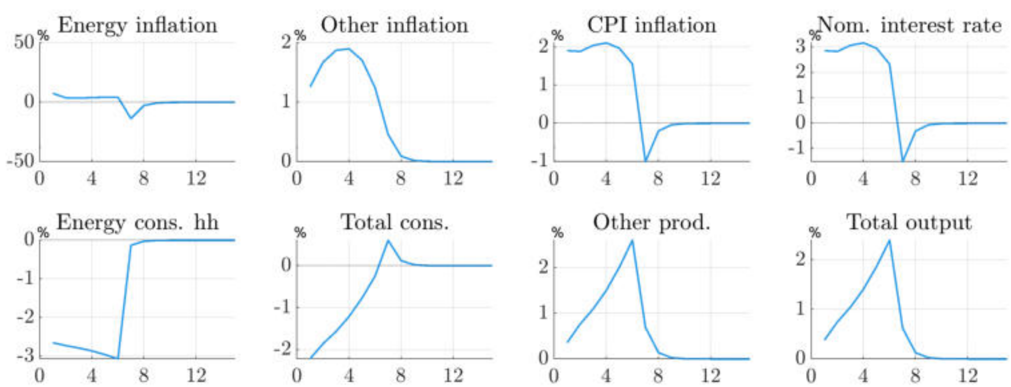
(a) No caps



(b) Cap vs. no cap



(c) Both caps



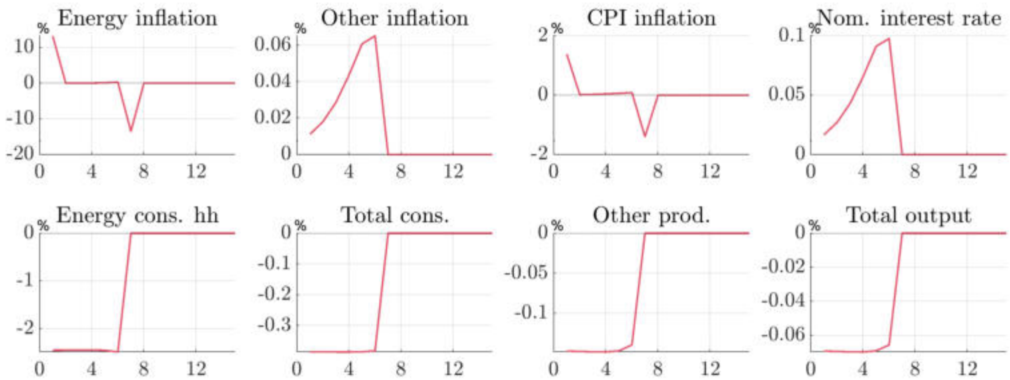
(d) Welfare gains/losses

		1/3 of union	
	%	Cap	No cap
2/3 of union	Cap	$(-0.07, -0.07)$	$(0.03, -0.07)$
	No cap	$(-0.06, 0.00)$	$(-0.01, -0.01)$

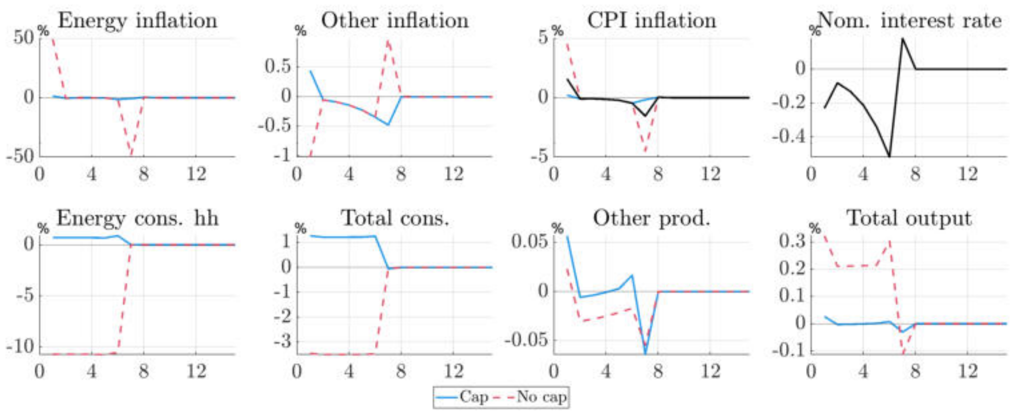
Notes: Impulse responses to a 15% decline in gas supply in a two-agent version of the model. Panel (d) shows welfare gains and losses in terms of consumption equivalent relative to steady state. Circles indicate preferred policy choices. The y-axis is in percentage deviations from steady state. The x-axis is in quarters. Inflation and interest rates are annualized.

Figure C.3: Results under core inflation targeting

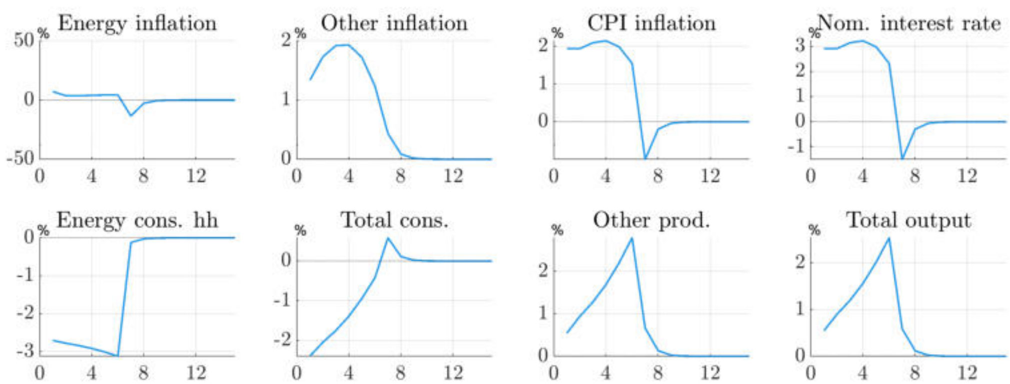
(a) No caps



(b) Cap vs. no cap



(c) Both caps



(d) Welfare gains/losses

		1/3 of union	
	%	Cap	No cap
2/3 of union	Cap	(-0.12, -0.12)	(0.07, -0.20)
	No cap	(-0.07, 0.00)	(-0.02, -0.02)

Notes: Impulse responses to a 15% decline in gas supply in a model where the central bank targets core inflation. Panel (d) shows welfare gains and losses in terms of consumption equivalent relative to steady state. Circles indicate preferred policy choices. The y-axis is in percentage deviations from steady state. The x-axis is in quarters. Inflation and interest rates are annualized.

References

Adjemian, S., M. Juillard, F. Karamé, W. Mutschler, J. Pfeifer, M. Ratto, N. Rion, and S. Villemot (2024). *Dynare: Reference Manual, Version 6*. Dynare Working Papers 80. CEPREMAP.

Anderson, T. M. (2007). "Fiscal Policy Coordination and International Trade". In: *Economica* 74.294, pp. 235–257. DOI: https://doi.org/10.1111/j.1468-0335.2006.00536.x. eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1468-0335.2006.00536.x. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1468-0335.2006.00536.x.

Aoki, K. (2001). "Optimal monetary policy responses to relative-price changes". In: *Journal of Monetary Economics* 48.1, pp. 55–80. ISSN: 0304-3932.

Auclert, A., H. Monnery, M. Rognlie, and L. Straub (2023). *Managing an Energy Shock: Fiscal and Monetary Policy*. NBER Working Paper No. w31543.

Bachmann, R., D. Baqaee, C. Bayer, M. Kuhn, A. Löschel, B. Moll, A. Peichl, K. Pittel, and M. Schularick (2024). "What if? The macroeconomic and distributional effects for Germany of a stop of energy imports from Russia". In: *Economica* n/a.n/a. DOI: https://doi.org/10.1111/ecca.12546. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/ecca.12546.

Bayer, C., A. Kriwoluzky, G. Müller, and F. Seyrich (2026). *Redistribution within and across borders: The fiscal response to an energy shock*. working paper.

Beetsma, R., X. Debrun, and F. Klaassen (2001). *Is Fiscal Policy Coordination in EMU Desirable?* Tech. rep. SSRN.

Beetsma, R. and H. Jensen (2005). "Monetary and Fiscal Interactions in a Micro-Founded Model of a Monetary Union". In: *Journal of International Economics* 67 (2), pp. 320–352.

Blanco, C. and S. Diz (2021). *Optimal monetary policy with non-homothetic preferences*. Tech. rep. MPRA Paper No. 107427.

Boppart, T. (2014). "Structural Change and the Kaldor Facts in a Growth Model With Relative Price Effects and Non-Gorman Preferences". In: *Econometrica* 82.6, pp. 2167–2196.

Bray, S. (2023). *Corporate Income Tax Rates in Europe, 2023*. URL: https://taxfoundation.org/data/all/eu/corporate-tax-rates-europe-2023/.

Calvo, G. A. (1983). "Staggered Prices in a Utility-Maximizing Framework". In: *Journal of Monetary Economics* 12.3, pp. 383–398.

Chan, J., S. Diz, and D. Kanngiesser (2024). "Energy prices and household heterogeneity: Monetary policy in a Gas-TANK". In: *Journal of Monetary Economics*. ISSN: 0304-3932.

DOI: https://doi.org/10.1016/j.jmoneco.2024.103620. URL: https://www.sciencedirect.com/science/article/pii/S0304393224000734.

Chang, M. (2015). "Redefining European Economic Governance". In: Routledge. Chap. 5. Fiscal Policy Coordination and the Future of the Community Method.

Chazan, G., S. Fleming, and M. Arnold (Oct. 2022). "EU neighbours criticise Germany's 200bn euro energy relief package". In: *Financial Times*. URL: https://www.ft.com/content/6f80d4d2-cde7-4771-895f-f92d130cd98f.

Corsetti, G. and P. Pesenti (May 2001). "Welfare and Macroeconomic Interdependence*". In: *The Quarterly Journal of Economics* 116.2, pp. 421–445. ISSN: 0033-5533. DOI: 10.1162/00335530151144069. eprint: https://academic.oup.com/qje/article-pdf/116/2/421/5375167/116-2-421.pdf. URL: https://doi.org/10.1162/00335530151144069.

Debortoli, D. and J. Galí (2018). *Monetary Policy and Heterogeneous Agents: Insights from TANK models*. Universitat Pompeu Fabra, Economics Working paper Series no. 1686.

Energy Institute (2024). *Statistical Review of World Energy*. Tech. rep. with major processing by Our World in Data.

Erceg, C. J., M. Kolasa, J. Lindé, and A. Pescatori (2024). *Can energy subsidies help slay inflation?* Tech. rep. IMF Working Papers No. 2024/081.

European Commission (2023). *Proposal for a council regulation amending Regulation (EU) 2022/1369 as regards prolonging the demand reduction period for reduction measures for gas and reinforcing the reporting and monitoring of their implementation*. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52023PC0174.

European Commission (2024). *Dashboard for household energy expenditure 2023*. URL: https://energy.ec.europa.eu/data-and-analysis/energy-prices-and-costs-europe/dashboard-household-energy-expenditure-2023_en.

Eurostat (2023a). *Energy Statistics - An Overview*. URL: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview#Imports_and_exports.

Eurostat (2023b). *World Trade in Goods and Services - An Overview*. URL: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=World_trade_in_goods_and_services_-_an_overview.

Ferrero, A. (2009). "Fiscal and Monetary Rules for a Currency Union". In: *Journal of International Economics* 77.1, pp. 1–10.

Ferrero, A. and M. Seneca (2019). "Notes on the Underground: Monetary Policy in Resource-Rich Economies". In: *Journal of Money, Credit and Banking* 51.4, pp. 953–

976. DOI: https://doi.org/10.1111/jmcb.12556. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/jmcb.12556.

Fleming, S. and G. Chazan (Oct. 2022). "EU mulls energy price cap amid fears of market distortion". In: *Financial Times*. URL: https://www.ft.com/content/04e641ec-b5d8-4dc3-80c6-fde196403f9f.

Galí, J. and T. Monacelli (2008). "Optimal Monetary and Fiscal Policy in a Currency Union". In: *Journal of International Economics* 76, pp. 116–132.

Glocker, C. and P. Wegmüller (2024). "Energy price surges and inflation: Fiscal policy to the rescue?" In: *Journal of International Money and Finance* 149, p. 103201. ISSN: 0261-5606. DOI: https://doi.org/10.1016/j.jimonfin.2024.103201. URL: https://www.sciencedirect.com/science/article/pii/S0261560624001888.

HFCS (2022). *The Household Finance and Consumption Survey: Wave 2017*. European Central Bank.

Hjortsoe, I. (2016). "Imbalances and fiscal policy in a monetary union". In: *Journal of International Economics* 102, pp. 225–241. ISSN: 0022-1996. DOI: https://doi.org/10.1016/j.jinteco.2016.07.002. URL: https://www.sciencedirect.com/science/article/pii/S0022199616300800.

IEA (2022). "World Energy Employment 2022". In: URL: https://www.iea.org/reports/world-energy-employment-2022.

IMF Data (2024). *Primary Commodity Price System*. Tech. rep. International Monetary Fund.

Jacquinot, P., R. Mestre, and M. Spitzer (2006). "An open-economy DSGE model of the Euro Area". In: *SSRN*. DOI: 10.2139/ssrn.951504.

Keen, M. and K. A. Konrad (2013). "Chapter 5 - The Theory of International Tax Competition and Coordination". In: *handbook of public economics, vol. 5*. Ed. by A. J. Auerbach, R. Chetty, M. Feldstein, and E. Saez. Vol. 5. Handbook of Public Economics. Elsevier, pp. 257–328. DOI: https://doi.org/10.1016/B978-0-444-53759-1.00005-4. URL: https://www.sciencedirect.com/science/article/pii/B9780444537591000054.

Komatsu, M. (2023). "The Effect of Monetary Policy on Consumption Inequality: An Analysis of Transmission Channels through TANK Models". In: *Journal of Money, Credit and Banking* 55.5, pp. 1245–1270.

Krause, M. U., D. Lopez-Salido, and T. A. Lubik (2008). "Inflation dynamics with search frictions: A structural econometric analysis". In: *Journal of Monetary Economics* 55.5. Carnegie-Rochester Conference Series on Public Policy: Labor Markets, Macroeconomic Fluctuations, and Monetary Policy November 9-10, 2007, pp. 892–916.

Moll, B., M. Schularick, and G. Zachmann (2023). *The Power of Substitution: The Great German Gas Debate in Retrospect*. Brookings Papers.

OECD (2023). *Energy expenditures have surged, posing challenges for policymakers*. URL: https://oecdecoscope.blog/2023/01/20/energy-expenditures-have-surged-posing-challenges-for-policymakers/.

Olivi, A., V. Sterk, and D. Xhani (2023). *Optimal Monetary Policy during a Cost-of-Living Crisis*. Tech. rep. URL: https://www.cerge-ei.cz/pdf/events/papers/Cost_of_Living_Crisis.pdf.

Pescatori, A. and M. Steurmer (2022). *From Abundance to Thirst*. Tech. rep. International Monetary Fund.

Pfeiffer, P., B. Pataracchia, M. Ratto, and J. Terenski (Nov. 2025). *Energy Commodity Price Shocks in the Euro Area: Evidence from a Large-Scale Structural Model*. ECB Discussion Paper 233. URL: https://economy-finance.ec.europa.eu/publications/energy-commodity-price-shocks-euro-area-evidence-large-scale-structural-model_en.

Rademaekers, K., M. Smith, A. Demurtas, P. Torres Vega, N. Janzow, L. Zibell, O. Hoogland, K. Pollier, M. Crènes, G. Radigois, F. Gaillard-Blancard, Y. El Idrissi, I. Sakhaoui, J. Pirie, S. Micallef, and M. Altman (2020). *Study on energy prices, costs and their impact on industry and households – Final report*. Publications Office. DOI: doi/10.2833/49063.

Rogge, E. (Apr. 2024). "The European energy crisis, the Dutch TTF, and the market correction mechanism: a financial markets perspective". In: *The Journal of World Energy Law & Business* 17.3, pp. 184–200. ISSN: 1754-9965. DOI: 10.1093/jwelb/jwae004. URL: https://doi.org/10.1093/jwelb/jwae004.

Rotemberg, J. J. (1982). "Sticky Prices in the United States." In: *Journal of Political Economy* 90, pp. 1187–1211.

Sanchez, M. (Jan. 2008). *Oil shocks and endogenous markups*. URL: https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp860.pdf.

Schmitt-Grohé, S. and M. Uribe (2003). "Closing Small Open Economy Models". In: *Journal of International Economics* 61.1, pp. 163–185.

Sgaravatti, G., S. Tagliapietra, C. Trasi, and G. Zachmann (2023). *National policies to shield consumers from rising energy prices*. Tech. rep. Bruegel Datasets. URL: https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices.

Smets, F. and R. Wouters (June 2007). "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach". In: *American Economic Review* 97.3, pp. 586–606. DOI: 10.

1257/aer.97.3.586. URL: https://www.aeaweb.org/articles?id=10.1257/aer.97.3.586.

Taylor, J. B. (1993). "Discretion versus Policy Rules in Practice". In: *Carnegie-Rochester Conference Series on Public Policy* 39, pp. 195–214.

Trichet, J.-C. (2013). "International policy coordination in the Euro area: Toward an economic and fiscal federation by exception". In: *Journal of Policy Modeling* 35.3. Special Issue: In Memory of Peter B. Kenen, PART A: From G7 to G20, PART B: International Policy Coordination, pp. 473–481. ISSN: 0161-8938. DOI: https://doi.org/10.1016/j.jpolmod.2013.03.011. URL: https://www.sciencedirect.com/science/article/pii/S0161893813000446.

Wellink, N. (2023). "Crises have shaped the European Central Bank". In: *Journal of International Money and Finance* 138, p. 102923. ISSN: 0261-5606. DOI: https://doi.org/10.1016/j.jimonfin.2023.102923. URL: https://www.sciencedirect.com/science/article/pii/S0261560623001249.

Zakeri, B., I. Staffell, P. Dodds, M. Grubb, P. Ekins, J. Jääskeläinen, S. Cross, K. Helin, and G. Castagneto-Gissey (2022). *Energy Transitions in Europe – Role of Natural Gas in Electricity Prices*. URL: https://ssrn.com/abstract=4170906.