Commodity shocks with diverse impacts: how can different central banks tailor their policies? *

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May 21, 2024

Abstract

Is the inflation targeting framework robust to an environment with commodity price swings? This paper revisits Svensson (2000)'s seminal article on open economy inflation targeting and studies the macroeconomic impact of commodity price shocks in economies that have different exposures to commodity trade. It sets out a flexible but tractable model for an economy that imports and/or exports commodities. In line with empirical evidence, international borrowing conditions are also endogenously related to the commodity cycle, which gives rise to additional costs and benefits of active exchange-rate management. The paper analyses the implied volatility of inflation and activity under different Taylor-type rules and exchange rate regimes, and derives the social planner's optimal solution.

Keywords: Monetary policy; Exchange rates; Inflation targeting; Commodity prices; Small open economy
JEL Classification: E31, E52, E58, F41, Q02, Q30.

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1 Introduction

The recent surge and reversion in energy prices has revived the question of how monetary policy should be conducted in the face of drastic commodity price swings. The prospect of more frequent shocks caused by geopolitical or climate-related events has also raised questions over the appropriate monetary policy framework. In a seminal paper, Svensson (2000) finds that inflation targeting is optimal in a New Keynesian setting subject to both demand and productivity shocks. We revisit those results in an environment characterised by commodity prices that are subject to exogenous shocks in international markets, from the perspective of both commodity-importing and exporting countries.

The conclusions of Svensson (2000) have since been expanded and refined by various authors. Major contributions, which followed the new open macroeconomics tradition launched by Obstfeld and Rogoff (1995), include Gali and Monacelli (2005), Benigno and Benigno (2006), and De Paoli (2009).[1] These studies have largely confirmed the optimality of inflation targeting (whether domestic or CPI inflation targeting), supported by a freely floating exchange rate. However, these findings have also come under scrutiny, as they are in stark contrast with the observation that many countries, especially emerging and developing economies, exhibit a 'fear of floating' (Calvo and Reinhart, 2002; Bianchi and Coulibaly, 2023).

This paper revisits the question by studying how monetary policy should be conducted in different economies subject to swings in international commodity prices, and, in particular, when those price swings may also affect the economy's borrowing risk premium. It generalizes the frameworks presented in Drechsel and Tenreyro (2018) and Drechsel, McLeay, and Tenreyro (2019) along various dimensions, while retaining the simplicity of Gali and Monacelli (2005). The model is tractable, but flexible enough that it can be configured to capture different types of economies: net commodity importers and exporters, as well as both emerging and advanced economies facing different constraints in global financial markets. The applicability of our framework to a range of economies is a contribution to the existing macroeconomic literature on commodities, which has typically focused on either emerging economies that export commodities, or advanced economies that import commodities. [2]

[1] Corsetti, Dedola, and Leduc (2010) provide a comprehensive survey.

[2] A review of that literature is provided in Drechsel, McLeay, and Tenreyro (2019). See also

Obstfeld (2020) critiques several 'newer objections' to flexible exchange rates. Those objections related to the implications of (i) the global financial cycle; (ii) global value chains; (iii) dominant currency pricing; and (iv) the zero lower bound. Our model relates to the first three of these objections.

In particular, the literature on the global financial cycle (Rey, 2013) provides evidence of the links between US monetary policy and financial and borrowing conditions, particularly in emerging markets. These effects are potentially difficult for floating exchange rates to offset. In our model, we capture these channels in a tractable way using an imperfect risk sharing setup, with a quantitatively meaningful endogenous risk premium on emerging markets' foreign currency debt.[3] The quantitative sensitivity of this risk premium is one key difference between advanced and emerging economies in our framework.

We also link emerging market financial conditions closely to the commodity cycle, consistent with the findings of Miranda-Agrippino and Rey (2020).[4] In line with the empirical evidence (Drechsel and Tenreyro, 2018), we postulate that the risk premium faced by developing or emerging commodity exporters is negatively related to the prices of those commodities. For commodity or energy importers, a positive relationship holds.

Moreover, our model's imported commodities are used in the production process and priced in global markets. These can also be interpreted as imported (non-commodity) intermediates, allowing us to characterise the impact of global value chains. Exports, meanwhile, are also priced in dollars, in line with the dominant currency pricing models formulated by Gopinath et al. (2020). But exports are also priced flexibly and in a competitive market, leading to the standard allocative effects of flexible exchange rates on exports, in line with the arguments set out in McLeay and Tenreyro (2024).

We use our model to compare the performance of different monetary policy and

Guerrieri et al. (2024) and Auclert et al. (2024) for more recent contributions on the the impact of energy prices in commodity-importing countries. An important paper in the literature is Hevia and Nicolini (2013), who study a model with two types of commodities, one produced by the home economy, the other one imported; a key difference from their analysis, as well as the papers aforementioned, is that they do not consider the connection between risk premia and commodity prices, which is how we distinguish advanced economies and emerging/developing countries; moreover, their analysis assumes perferct international risk sharing.

[3] As in Schmitt-Grohe and Uribe (2003), but calibrated to match the evidence in Drechsel and Tenreyro (2018).

[4] Juvenal and Petrella (2024) also document a connection between the global financial cycle and commodity price swings.

exchange rate frameworks in response to commodity price shocks. Specifically, after setting out the model, we characterise the behaviour of different types of economies when the policymaker seeks to implement a fixed exchange rate. We compare the volatility and performance of the economy under different inflation-targeting Taylor rules, and to the benchmark of the social planner's optimal policy.

Our main findings are that some form of inflation targeting still performs better than the alternatives in response to most shocks, and for different model configurations. In some cases, the monetary response is of limited benefit overall in response to large shocks, or faces significant trade-offs. Depending on policymakers' preferences, and comparing across the class of simple policy rules, there are indeed cases and shocks where more active exchange-rate management could be helpful.

More specifically, our results suggest that for emerging or developing economy commodity *exporters*, facing commodity price shocks, exchange rate pegs potentially create enormous volatility in inflation and output. A fall in commodity prices necessitates a domestic currency depreciation, and the peg sacrifices efficient internal adjustment for the sake of exchange rate stability. This volatility is amplified by an endogenous tightening of financial conditions, which leads to further pressure to loosen and depreciate.

For advanced economies, facing a shock to the *import* price of a commodity, which we describe as energy, there is far smaller differentiation between the different policies. The efficient response involves little change in employment, with higher energy prices leading to lower energy import volumes, resulting in lower production and consumption. The exchange rate peg implements a looser monetary stance, limiting some of this efficient output volatility, as well as the exchange-rate related volatility in import prices. But it does so at the cost of greater volatility in the output gap and domestic inflation.

When emerging economies face the same energy price shock, there are some more distinct advantages to the exchange rate peg. A rise in the risk premium leads to a more depreciated currency under inflation targeting rules, which the peg prevents. By doing so, it is able to limit the volatility in both domestic and CPI inflation, relative to Taylor rules targeting those variables.

Given the relevance of the risk premium for this result, we explore its role in more detail. Recent work has also highlighted the importance more broadly of financial shocks in explaining exchange-rate dynamics (Itskhoki and Mukhin, 2021; Fukui, Nakamura, and Steinsson, 2023). Unsurprisingly, we find that for an emerging economy, facing a pure risk premium shock, exchange-rate pegs do relatively well at stabilising CPI inflation, since the volatility comes largely via the exchange rate. There is a trade-off, however, as in our framework, this is at the expense of greater volatility in the real economy. Overall, our results are consistent with active exchange-rate management being particularly costly in response to fundamentals-driven movements, but with some countervailing benefits for volatility driven exclusively by financial channels.[5]

2 Model

This section presents our model to study monetary policy and exchange-rate dynamics following commodity import or export price fluctuations.

2.1 Households

Households maximize expected lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right) \tag{1}$$

by choosing a sequence of consumption, labor supply and asset positions $\{C_t, N_t, D_{t+1}, B_{t+1}\}_{t=0}^{\infty}$, subject to the sequence of budget constraints

$$P_t C_t + Q_{t,t+1} D_{t+1} + Q^*_{t,t+1} \mathcal{E}_t B_{t+1} = W_t N_t + D_t + \mathcal{E}_t B_t \Phi(B_{t-1}, P^*_{\tilde{c},t-1}, P^*_{c,t-1}) + \Psi_t \tag{2}$$

where $Q_{t,t+1}$ denotes the discount factor on a domestic security, D_{t+1}; $Q^*_{t,t+1}$ is the discount factor on an internationally traded bond, B_{t+1}; W_t is the wage rate and Ψ_t is a rebate of profits. The parameters β, σ and ϕ capture the discount factor, the inverse intertemporal elasticity of substitution and the inverse Frisch elasticity, respectively.

While households have access to a complete set of *domestic* state-contingent securities, there is imperfect international risk sharing, with access only to an international bond priced in foreign currency. This bond is subject to a risk premium

[5] See Kalemli-Özcan (2019) on this point.

over the risk-free global discount factor, which can depend on the debt level and global commodity prices $P^*_{\tilde{c},t-1}$ and $P^*_{c,t-1}$: $\Phi(B_{t-1}, P^*_{\tilde{c},t-1}, P^*_{c,t-1})$. These global commodity prices will be defined in more detail below.

Total consumption is a CES aggregate of domestic and foreign goods

$$C_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} C_{h,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{f,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}. \tag{3}$$

$C_{h,t}$ is a bundle of consumption goods produced in the domestic economy ('home'), given by

$$C_{h,t} \equiv \left(\int_0^1 C_{h,t}(i)^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{4}$$

where ϵ is the elasticity of substitution. The price index for home goods is given by $P_{h,t} \equiv \left(\int_0^1 P_{h,t}(i)^{1-\epsilon} di\right)^{\frac{1}{1-\epsilon}}$.

$C_{f,t}$ is a bundle of goods produced abroad ('foreign'), which can be split into commodity and non-commodity goods:

$$C_{f,t} \equiv \left[(1-\alpha_{\tilde{c}})^{\frac{1}{\vartheta}} C_{nc,t}^{\frac{\vartheta-1}{\vartheta}} + \alpha_{\tilde{c}}^{\frac{1}{\vartheta}} C_{\tilde{c},t}^{\frac{\vartheta-1}{\vartheta}}\right]^{\frac{\vartheta}{\vartheta-1}}, \tag{5}$$

where $C_{\tilde{c},t}$ and $C_{nc,t}$ denote respectively consumption of commodity and non-commodity foreign goods, and ϑ is the elasticity of substitution.

The term α captures a preference weight on $C_{f,t}$ and $1-\alpha$ is the 'home bias' of the economy; $\alpha_{\tilde{c}}$ is the preference weight on commodities relative to non-commodity foreign goods. An analogous set of preferences apply to the foreign economy, with C^*_t representing total foreign consumption, $C^*_{h,t}$ foreign consumption of the home good, and $(1-\alpha^*)$ home bias, the preference weight on foreign goods.

We study Cole-Obstfeld preferences where $\sigma = \eta = \vartheta = 1$. This gives log utility in consumption,

$$C_t \equiv \frac{C_{h,t}^{1-\alpha} C_{f,t}^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}, \tag{6}$$

and

$$C_{f,t} \equiv \frac{C_{nc,t}^{1-\alpha_{\tilde{c}}} C_{\tilde{c},t}^{\alpha_{\tilde{c}}}}{\alpha_{\tilde{c}}^{\alpha_{\tilde{c}}}(1-\alpha_{\tilde{c}})^{1-\alpha_{\tilde{c}}}}, \tag{7}$$

with the CPI given by

$$P_t \equiv P_{h,t}^{1-\alpha} P_{nc,t}^{\alpha(1-\alpha_{\tilde{c}})} P_{\tilde{c},t}^{\alpha\alpha_{\tilde{c}}}. \tag{8}$$

We denote by $\mathcal{T}_t$ the price of imports in terms of the price of domestic goods:

$$\mathcal{T}_t \equiv \frac{P_{f,t}}{P_{h,t}}, \tag{9}$$

which gives the relations to relative prices $\mathcal{T}_t^{-\alpha} = P_{h,t}/P_t$ and $\mathcal{T}_t^{1-\alpha} = P_{f,t}/P_t$. We let asterisks indicate prices and quantities abroad and define $\mathcal{E}_t$ as the nominal exchange rate.

The demand functions for the home and foreign good bundles can be derived from the usual expenditure minimization problems as

$$C_{h,t} = (1-\alpha)\left(\frac{P_t}{P_{h,t}}\right) C_t = (1-\alpha)\mathcal{T}_t^{\alpha} C_t \tag{10}$$

$$C_{f,t} = \alpha\left(\frac{P_t}{P_{f,t}}\right) C_t = \alpha\mathcal{T}_t^{\alpha-1} C_t, \tag{11}$$

where the second equalities use the relation between $\mathcal{T}_t$ and relative prices derived above. Demand for foreign goods can be split into the two subcategories as:

$$C_{nc,t} = (1-\alpha_{\tilde{c}})\left(\frac{P_{f,t}}{P_{nc,t}}\right) C_{f,t} \tag{12}$$

$$C_{\tilde{c},t} = \alpha_{\tilde{c}}\left(\frac{P_{f,t}}{P_{\tilde{c},t}}\right) C_{f,t}, \tag{13}$$

Finally, the demand for an individual home good is given by

$$C_{h,t}(i) = \left(\frac{P_{h,t}^*(i)}{P_{h,t}}\right)^{-\epsilon} C_{h,t}. \tag{14}$$

The law of one price requires that $P_{\tilde{c},t} = \mathcal{E}_t P_{\tilde{c},t}^*$, $P_{nc,t} = \mathcal{E}_t P_{nc,t}^*$ and $P_{h,t} = \mathcal{E}_t P_{h,t}^*$. For our small open economy, we take the limit where $\alpha^* \to 0$ (though $\alpha^* C_t^* > 0$). We also assume that the foreign price basket includes only the non-commodity good, following Catão and Chang (2015). The foreign price level is therefore $P_t^* = P_{f,t}^* = P_{nc,t}^*$, and the real exchange rate is given by

$$S_t \equiv \frac{\mathcal{E}_t P_t^*}{P_t} = \frac{\mathcal{E}_t P_{nc,t}^*}{P_t} = \mathcal{T}_t^{1-\alpha} \left(\frac{P_{nc}^*}{P_{\tilde{c},t}^*} \right)^{\alpha_{\tilde{c}}}. \tag{15}$$

An analogous set of conditions can then be derived for foreign consumers, including foreign demand for the home good, given by:

$$C_{h,t}^* = \alpha^* \mathcal{T}_t \left(\frac{P_{nc}^*}{P_{\tilde{c},t}^*} \right)^{\alpha_{\tilde{c}}} C_t^*. \tag{16}$$

The household's optimality condition for labor gives the labor supply relation

$$N_t^{\varphi} C_t = \frac{W_t}{P_t}. \tag{17}$$

The first order condition for D_{t+1} is given by the Euler equation

$$Q_{t,t+1} = \mathbb{E}_t \left[\beta \frac{1}{\Pi_{t+1}} \frac{C_t}{C_{t+1}} \right] \tag{18}$$

where $\Pi_{t+1} \equiv \frac{P_{t+1}}{P_t}$ denotes gross CPI inflation. This can be combined with the first order condition for B_{t+1} to give the uncovered interest parity (UIP) condition:

$$\frac{1}{Q_{t,t+1}} = \frac{1}{Q_{t,t+1}^*} \mathbb{E}_t \left[\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \Phi \left(\mathcal{E}_t, P_{\tilde{c}}, P_c, B_t \right) \right] \tag{19}$$

where P_c is the price of exported commodities, which may differ from that of imported commodities, $P_{\tilde{c}}$.

2.2 Domestic good sector

Firms produce with labor, $N_t(i)$ and imported commodities $X_{\tilde{c},t}(i)$, paying the wage rate W_t and the commodity price $P_{\tilde{c},t}$, both of which they take as given. They are monopolistically competitive and prices are staggered. Technology of firm i is given by the CRS production function

$$Y_{h,t}(i) = A_{h,t} N_t(i)^{1-\mu} X_{\tilde{c},t}(i)^{\mu}. \tag{20}$$

Its first order condition is

$$\mathbb{E}_t \left[\sum_{\tau=0}^{\infty} \theta^{\tau} Q_{t,t+\tau} Y_{h,t,t+\tau}(i) \left(P_{h,t}(i) - \frac{\epsilon}{\epsilon - 1} MC_{t+\tau}(i) \right) \right] = 0. \tag{21}$$

θ captures the probability of not being able to re-set the price in a given period, and $MC_t(i)$ are the firm's marginal costs of production in period t. In the absence of nominal rigidities prices are set as a markup $\mathcal{M} = \frac{\epsilon}{\epsilon-1}$ over marginal costs every period. Cost minimisation in this case implies that marginal costs are equal across firms and given by:

$$MC_t(i) = \frac{1}{1+\varsigma} \frac{N_t(i) W_t}{(1-\mu) Y_{h,t}(i)}, \tag{22}$$

where ς is a production subsidy given by the government;

$$MC_t(i) = \frac{1}{1+\varsigma} \frac{X_{\tilde{c},t}(i) P_{\tilde{c},t}}{\mu Y_{h,t}(i)}, \tag{23}$$

and combining with (20):

$$MC_t = \frac{1}{1+\varsigma} \frac{W_t^{(1-\mu)} P_{\tilde{c},t}^{\mu}}{(1-\mu)^{(1-\mu)} \mu^{\mu} A_{h,t}}. \tag{24}$$

The aggregate production function is given by

$$Y_{h,t} = \frac{A_{h,t} N_t^{(1-\mu)} X_{\tilde{c},t}^{\mu}}{\Delta_t}, \tag{25}$$

where $N_t = \int_0^1 N_t(i) di$, $X_{\tilde{c},t} = \int_0^1 X_{\tilde{c},t}(i) di$ and Δ_t denotes the familiar domestic price dispersion term of NK models with Calvo pricing.

2.3 Commodity export sector

The commodity export sector is competitive, taking prices as given. We assume that the dynamics in the international price of commodities $P^*_{c,t}$ are driven by developments in world markets and are thus taken as an exogenous variable by the small open economy. Firms in the commodity sector require a quantity $M_{h,t}$ of domestic goods as intermediate input, taking their price $P_{h,t}$ as given. The production function is

$$Y_{c,t} = A_{c,t} M_{h,t}^{\nu}, \tag{26}$$

where $0 < \nu < 1$ reflects the presence of decreasing returns in the sector.

Profits from the commodity sector are rebated as a lump sum payment to the household. The real commodity price can be rewritten as a function of the real foreign currency commodity price:

$$\frac{P_{c,t}}{P_t} = \frac{\mathcal{E}_t P^*_{c,t}}{P_t} = \frac{P^*_{c,t}}{P^*_t}\mathcal{T}_t^{1-\alpha}. \tag{27}$$

Profit maximization gives

$$P_{c,t}\nu A_{c,t}M_{h,t}^{\nu-1} = P_{h,t}. \tag{28}$$

Rearranging (28), and using (27) as well as $P_{h,t}/P_t = \mathcal{T}_t^{-\alpha}$ gives

$$M_{h,t} = \left(\nu\frac{P^*_{c,t}}{P^*_t}\mathcal{T}_t A_{c,t}\right)^{\frac{1}{1-\nu}}. \tag{29}$$

2.4 Market clearing and equilibrium

Domestic goods market clearing gives

$$C_{h,t} + C^*_{h,t} \quad = \quad Y_{h,t} - M_{h,t} \tag{30}$$

We close the model using three alternative monetary policies: Taylor rules that focus more on domestic inflation or CPI inflation, and an exchange rate peg.

Given commodity prices $P^*_{c,t}$, $P^*_{\tilde{c},t}$, monetary policy determining i_t, foreign inflation, and interest rates $\Pi^*_{f,t} = \Pi^*_t$, $Q^*_{t,t+1}$, and initial conditions on price dispersion and asset holdings, the equilibrium is given by a sequence of quantities $\{C_{h,t}, C_{f,t}, C_{\tilde{c},t}, C_{nc,t}, C_t, N_t, X_{\tilde{c},t}, D_{t+1}, B_{t+1}, Y_{h,t}, Y_{c,t}, M_{h,t}, X_{\tilde{c},t}\}_{t=0}^{\infty}$ and prices $\{Q_{t,t+1}, \Pi_{h,t+1}, \Pi_{t+1}, \mathcal{T}_t, S_t, \mathcal{E}_t, \Delta_t, W_t\}_{t=0}^{\infty}$ so that agents maximize their objectives and markets clear.

3 Model intuition and application

3.1 Intuition

In this section, we highlight some of the intuition underlying our model mechanism and results. We log-linearise the model around an efficient steady state with relative prices normalised to 1, and a zero initial net foreign asset position. The full model equations are listed in Appendix B.

Trade balance. The linearised trade balance can be written as:

$$\hat{tb}_t = \frac{s_{m,ss}}{\nu}(\hat{p}^*_{c,t} + \hat{y}_{c,t}) + s_{c^*,ss}\hat{c}^*_t - \mu(\hat{x}_{\tilde{c},t} + \hat{p}^*_{\tilde{c},t}) - \frac{\alpha s_{c,ss}}{1-\alpha}(\hat{c}_{f,t} + \alpha_{\tilde{c}}\hat{p}^*_{\tilde{c},t}), \tag{31}$$

where lowercase letters with hat notation represent percentage deviations from steady state. The parameter $s_{m,ss}$ denotes the steady state share of home production used as materials in commodity production; $s_{c*,ss}$ the share exported directly to foreign consumers; and $s_{c,ss}$ the share consumed by home consumers.

This equation highlights several effects of a shock that raises commodity prices:

1. for a commodity exporter, increases in $\hat{p}^*_{c,t}$ increase profits for a given amount of production, providing a **windfall income channel**.
2. given higher profit margins, competitive commodity exporting firms are incentivised to expand output ($\hat{y}_{c,t}$) until (upward sloping) marginal cost equals the new, higher price, via an **export supply channel**;
3. for a commodity importer, when $\hat{p}^*_{\tilde{c},t}$ increases, a given amount of production becomes more costly via a **domestic production channel**;
4. there is also a **direct consumption channel**, whereby the value of the same import basket increases by $\alpha_{\tilde{c}}\hat{p}^*_{\tilde{c},t}$, worsening the trade balance.

Emerging economies' commodity exports are priced in a global, dominant currency (e.g. the dollar), in line with evidence in Gopinath et al. (2020). But as in McLeay and Tenreyro (2024), these exports are competitive, with high demand elasticities and flexible prices, so exports are also sensitive to the currency.

For our advanced economy, $c^*, ss > 0$: it also exports monopolistic, sticky price goods priced in domestic (producer) currency. For advanced economies there is also a **global demand channel**, captured by $\hat{c}^*_t$, independently of the commodity cycle.

Consumption. The full general equilibrium effects of commodity-price increases also depend on the responses of the endogenous variables, including to changes in the risk premium. We can characterise consumption by solving forward households' Euler equation, and using the UIP condition, to give:

$$\hat{c}_t = \hat{s}_t - \mathbb{E}_t \sum_{i=0}^{\infty} (\hat{\phi}_{t+i} + \hat{r}^*_{t+i}) = -\mathbb{E}_t \sum_{i=0}^{\infty} \hat{r}_{t+i}. \tag{32}$$

Consumption depends on the current real exchange rate $\hat{s}_t$, but also on the expected future path of the risk premium. Given an increase in the risk premium, policymakers are presented with a choice. They must either increase the real interest rate, reducing consumption, or allow a real depreciation. This is the situation for emerging market commodity exporters following a commodity price fall, and importers after a commodity price increase. The opposite effect occurs when the price rises are reversed.

Inflation. CPI inflation is given by:

$$\hat{\pi}_t = \frac{\alpha}{1-\alpha} \Delta \hat{s}_t + \frac{\alpha \alpha_{\tilde{c}}}{1-\alpha} \Delta \hat{p}^*_{\tilde{c},t} + \mathbb{E}_t \sum_{i=0}^{\infty} \beta^i \hat{mc}_t, \tag{33}$$

$$\hat{mc}_t = (1-\mu)(\hat{c}_t + \varphi \hat{n}_t) + \mu(\hat{p}^*_{\tilde{c},t} + \hat{s}_t) - \hat{a}_{h,t}$$

This equation, combined with the determinants of consumption, highlights the channels through which commodity prices, the exchange rate, and the risk premium affect inflation:

1. For a commodity importer, there is a **direct CPI impact** on the inflation basket, given by $\frac{\alpha \alpha_{\tilde{c}}}{1-\alpha} \Delta \hat{p}^*_{\tilde{c},t}$.
2. There is also **domestic production channel**, as a higher path for $\mu \hat{p}^*_{\tilde{c},t}$ increases domestic inflation via higher real marginal costs.
3. For both commodity importers and exporters, there is an **exchange rate impact**, whereby a depreciation increases import-price inflation.
4. In emerging markets, a higher risk premium for commodity importers drives a wedge between domestic and CPI inflation. It either depreciates the currency, leading to higher import price inflation; or reduces consumption, leading to lower domestic price inflation via a **labour market channel**.

3.2 Calibration: parameters for different types of economies

Our model is parsimonious enough that we can differentiate between four different cases by varying a few key parameters, as summarised in Table 1.

Table 1: MODEL CALIBRATION: DIFFERENT PARAMETERS

Parameter	Description	Advanced econ.	Emerging econ.
ϕ_c	Elast. risk pr. to comm. exp.	0.0002	0.2
$\phi_{\tilde{c}}$	Elast. risk pr. to comm. imp.	0.0002	0.2
ϕ_b	Elast. risk pr. to asset position	0.0028	2.8
$s_{c*,ss}$	Output share of monop. exports	0.3	0.0003
		Comm. exporter	**Comm. importer**
μ	Input share of imp comm.	0.001	0.2

For advanced economies, the risk premium sensitivity is set to a low level, as is common in the small open economy literature, as discussed in Schmitt-Grohe and Uribe (2003). For emerging economies, the elasticity with respect to the net asset position and commodity exports is set to match the evidence in Drechsel and Tenreyro (2018). The parameter for commodity imports is set to the same value.

Emerging economies are assumed to export only competitive commodities, or commodity-like goods, with flexible dollar prices that they take as given in global markets. This is in line with the discussion in McLeay and Tenreyro (2024). The output share of monopolistic, sticky price export goods (i.e. $\frac{alpha^* C^*}{Y_h}$) is set to a very low level. For advanced economies, this is set to 0.3, which, ensures around three-quarters of exports are monopolistic domestic goods.

3.3 Calibration: common parameters

The remaining, common parameters are given in Table 2.

3.4 Welfare

Before examining the performance of different policy rules, we first build intuition by calculating a benchmark to compare them to. We examine the efficient allocation that would be chosen by a benevolent social planner in the relevant small open economy. We assume that the planner maximises household utility taking production, resource constraints and international prices as given. The solution is

Table 2: MODEL CALIBRATION: COMMON PARAMETERS

Parameter	Description	Value	Calibration target/source
$1-\alpha$	Home bias	0.6	Gali and Monacelli (2005)
ϕ	Inverse Frisch elasticity	3	Gali and Monacelli (2005)
β	Discount factor	0.996	SS interest rate $\approx 1.5\%$
$1-\theta$	Price re-set probability	0.25	Standard Calvo value
ϵ	Elasticity of substitution	6	Gives markup of 20%
ν	Returns of scale in comm. prod.	0.6	Gives $s_{m,ss} = 0.4$ in Emerg.

sketched in Appendix A. Importantly, the planner is also a price taker with respect to the exogenous parts of the international borrowing premium, although the planner does internalise the impact of asset holdings on the premium.

Figure 1 shows (blue lines) the responses of the planner's efficient allocation in our commodity exporter setup, faced with a 10% increase in commodity prices. The solid lines show the advanced economy calibration, and the dashed lines show the emerging market. For output, we also show (purple lines) the equivalent natural allocations that would be achieved in a competitive equilibrium where all prices were fully flexible.

Advanced economy. For our small open economy, a rise in commodity prices, which it takes as given, is equivalent to a positive productivity shock. At a given exchange rate, households can transform their labour into a greater amount of (foreign) consumption than before.

With temporarily higher prices (or productivity), the planner in the advanced economy finds it optimal for agents to work more (to increase commodity production), so employment increases. Consumption temporarily falls slightly, as home goods are diverted into commodity production.

Emerging economy. In our emerging economy, the same mechanisms are present, all else equal. And these are quantitatively larger, given the larger size of the commodity sector relative to domestic good output. But they are also partly offset by the planner's response to the risk premium, such that the responses of employment and output are muted, while consumption goes in the opposite direction.

The increase in commodity prices lowers the risk premium exogenously. From the planner's perspective, they face a lower effective path of interest rates, so it is optimal to have more consumption today, all else equal, substituted from the future.

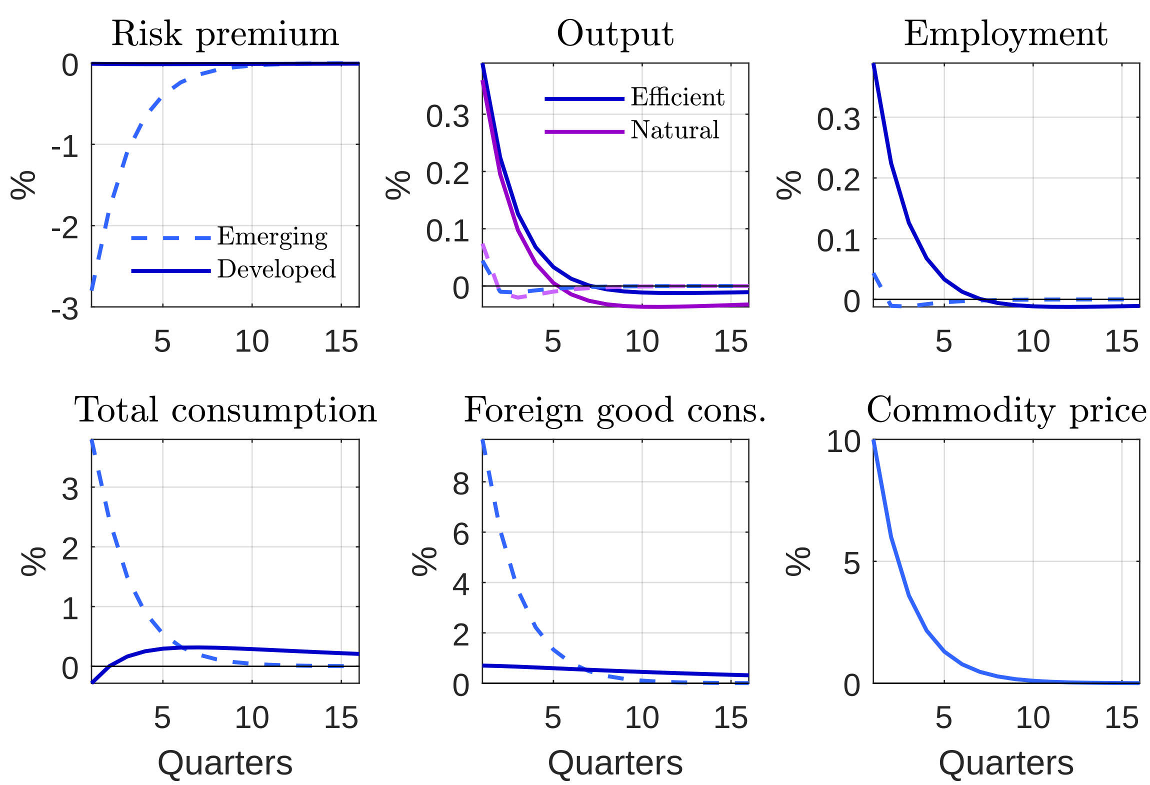
The natural allocation is very close quantitatively to the social planner's solution.

Figure 2 shows the equivalent efficient responses in our commodity importing economies. In these cases the planner wishes to cut foreign good consumption of the more expensive commodity input to leave the share of income spent unchanged, given unit elasticities.

The presence of the domestic production channel means that the planner also chooses to work less in the advanced economy, although this is reversed in the emerging economy, owing to a higher risk premium.

In both cases, however, the employment response is small relative to fall in the imported intermediate commodity, which implies sharply lower output.

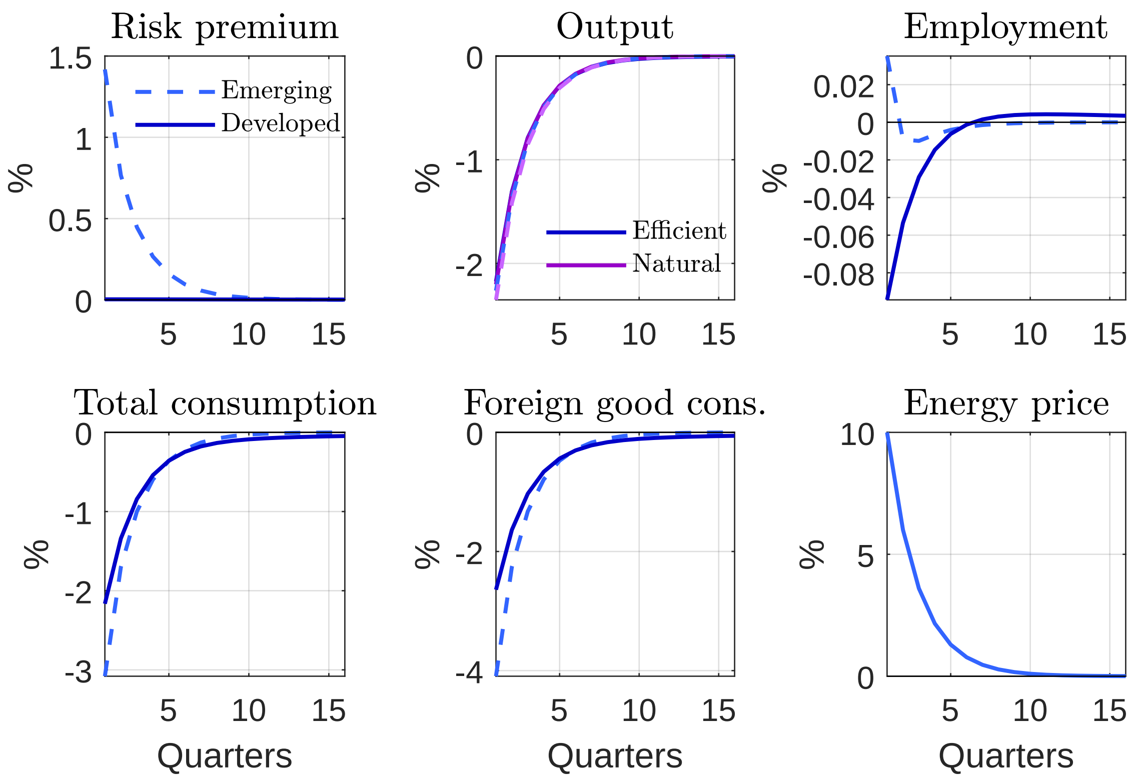
Figure 1: SOCIAL PLANNER RESPONSE TO COMMODITY EXPORT PRICE SHOCK FOR COMMODITY EXPORTER



Note: IRFs to a 10% positive commodity export price shock with efficient or natural response. The results are generated under the calibration shown for a commodity exporter in Tables 1 and 2.

Again, the natural allocation differs only by a small amount to the efficient allocation.

Figure 2: SOCIAL PLANNER RESPONSE TO COMMODITY/ENERGY IMPORT PRICE SHOCK FOR COMMODITY IMPORTER



Note: IRFs to a 10% positive commodity import price shock with efficient or natural response. The results are generated under the calibration shown for a commodity importer in Tables 1 and 2.

4 Commodity price shocks

In this section, we use our model to compare the performance of different exchange rate and monetary policy frameworks in response to commodity price shocks. We aim to understand the behaviour of four different types of economies, in response to different shocks.

Specifically, we examine four cases. First, we characterise the response of an advanced-economy commodity *exporter* in response to an increase in the prices of those commodities. We switch off commodity imports by setting the parameter governing these, μ, to a low level. To represent an advanced economy, we set the parameters determining the risk premium sensitivity to a low level.

Second, we study the response of an emerging or developing economy commodity exporter, where we allow the risk premium to decrease in response to an increase in commodity prices. We assume that commodity exports are the only source of exports for the emerging economy, unlike our advanced economy commodity exporter, which still exports mainly monopolistic goods.

Third, we examine the case of an increase in commodity or energy prices for an advanced economy that is a net importer of energy. Energy is used both as in input in production, and directly consumed in by households.

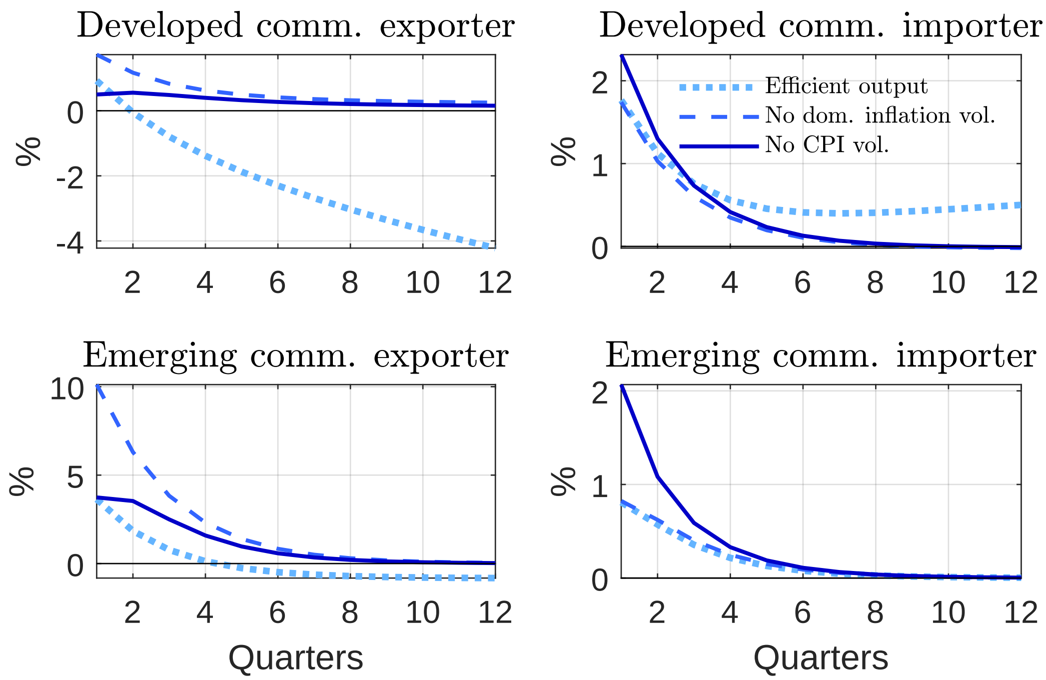
Finally, we examine the same imported-commodity price shock from the perspective of an emerging economy with a borrowing risk premium sensitive to energy prices and the economy's net asset position.

For each case, we examine the behaviour of the economy when the policymaker seeks to implement a fixed exchange rate and compare the volatility and performance with two inflation-targeting Taylor rules. The first focuses only on CPI inflation, with $i_t = 1.5\hat{\pi}_t$, while the other focuses on domestic inflation, with $i_t = 1.5\hat{\pi}_{h,t}$. We also plot the evolution of real variables in the social planner's efficient solution.

Our main findings are that some form of inflation targeting still performs better than the alternatives in response to most shocks, and for different model configurations. But depending on policymakers' preferences, and comparing across the class of simple policy rules, there some cases and shocks where more active exchange-rate management can be helpful.

As a preview of some of our results, Figure 3 shows the nominal depreciation

Figure 3: NOMINAL EXCHANGE RATE RESPONSES TO MINIMISE OUTPUT OR INFLATION LOSSES IN DIFFERENT MODEL SETUPS



Note: IRFs to a 10% positive commodity price shock with efficient, natural or CPI inflation minimising response. The results are generated under the calibrations shown in Tables 1 2.

that would be required to stabilise different metrics, under each model setup. The dotted lines show what would be needed to replicate the planner's allocation for output and consumption. The dashed lines show the exchange rate path that replicates the natural allocation that would occur under flexible prices. Finally, the solid lines show the exchange rate response that would ensure CPI inflation at target.

Two points to highlight from this chart are that first, the required movements differ across different goals, so policymakers will face a trade-off between them.

And second, all goals, for all economies, require an initial appreciation. Clearly this could not occur in every country at the same time. Our model is therefore consistent with the idea that our small open economy commodity importers and exporters are trading with a large economy such as the US, which does not significantly export or import our commodities.

If all countries did try to appreciate simultaneously, this would trigger a rise in the global real interest rate. We explore later what the effect of such an increase would be.

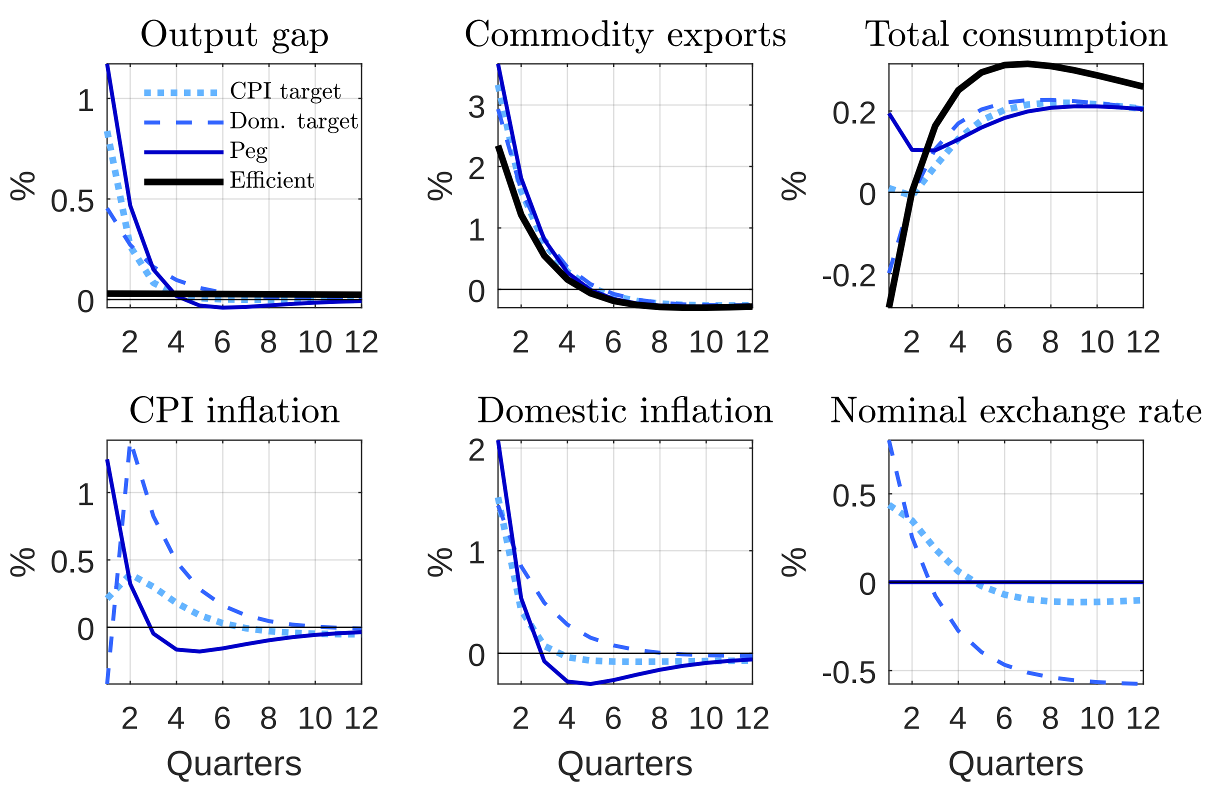
4.1 Advanced economy commodity exporters

For advanced economy commodity exporters, exchange rate targeting performs consistently worse than a CPI inflation targeting Taylor rule. It leads to more volatility in each of CPI inflation, domestic inflation, and the efficient output gap.

4.2 Emerging and developing economy commodity exporters

For *emerging or developing* economy commodity exporters, facing commodity price shocks, exchange rate pegs potentially create a large amount of volatility in

Figure 4: IRFS TO COMMODITY EXPORT PRICE SHOCK IN DEVELOPED ECONOMY COMMODITY EXPORTER



Note: IRFs to a 10% positive commodity export price shock under alternative policy rules. The results are generated under the calibration shown in Tables 1 2. Inflation is shown in annualized percent. The nominal exchange rate is plotted as $\hat{e}_t^{-1}$ so that an increase corresponds to an appreciation.

Table 3: IMPLIED STANDARD DEVIATIONS ACROSS POLICIES - DEVELOPED COMMODITY EXPORTER, CONDITIONAL ON COMMODITY EXPORT PRICE SHOCK

	CPI inf. target	Dom. inf. target	Nominal peg
CPI inflation	0.15	0.44	0.33
Domestic inflation	0.40	0.44	0.56
Efficient output gap	0.86	0.52	1.25

the domestic economy, with domestic inflation, the output gap, and consumption all much more volatile than is efficient. By stabilising import prices, the peg does do slightly better in terms of volatility for CPI inflation, although none of the rules do particularly well, and this is at the cost of extreme domestic volatility.

Table 4: IMPLIED STANDARD DEVIATIONS ACROSS POLICIES - EMERGING COMMODITY EXPORTER, CONDITIONAL ON COMMODITY EXPORT PRICE SHOCK

	CPI inf. target	Dom. inf. target	Nominal peg
CPI inflation	3.75	4.20	2.84
Domestic inflation	2.26	0.06	4.73
Efficient output gap	4.16	0.23	12.54

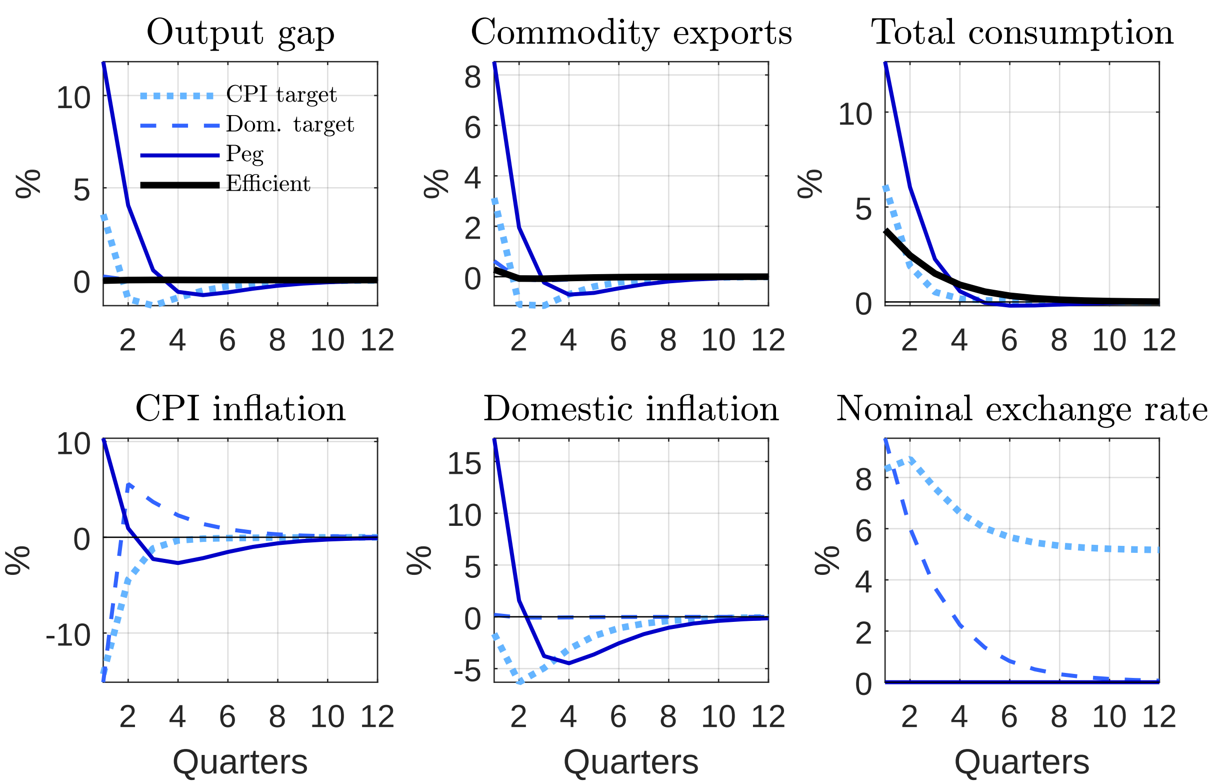
The exchange rate peg creates a large commodity boom in response to commodity price rises, as policy is too loose to replicate the large appreciation that would be required under an efficient solution or under flexible prices. This leads to a positive output gap, driving up domestic inflation, such that CPI inflation also increases, compared to falling in the inflation targeting cases, which involve appreciations.

This mechanism is amplified by the large improvement in the foreign asset balance, given the the fall in the risk premium from higher commodity prices. Both of these effects create further loosening in financial conditions, which monetary policy cannot offset under a peg.

4.3 Advanced economies - energy import prices

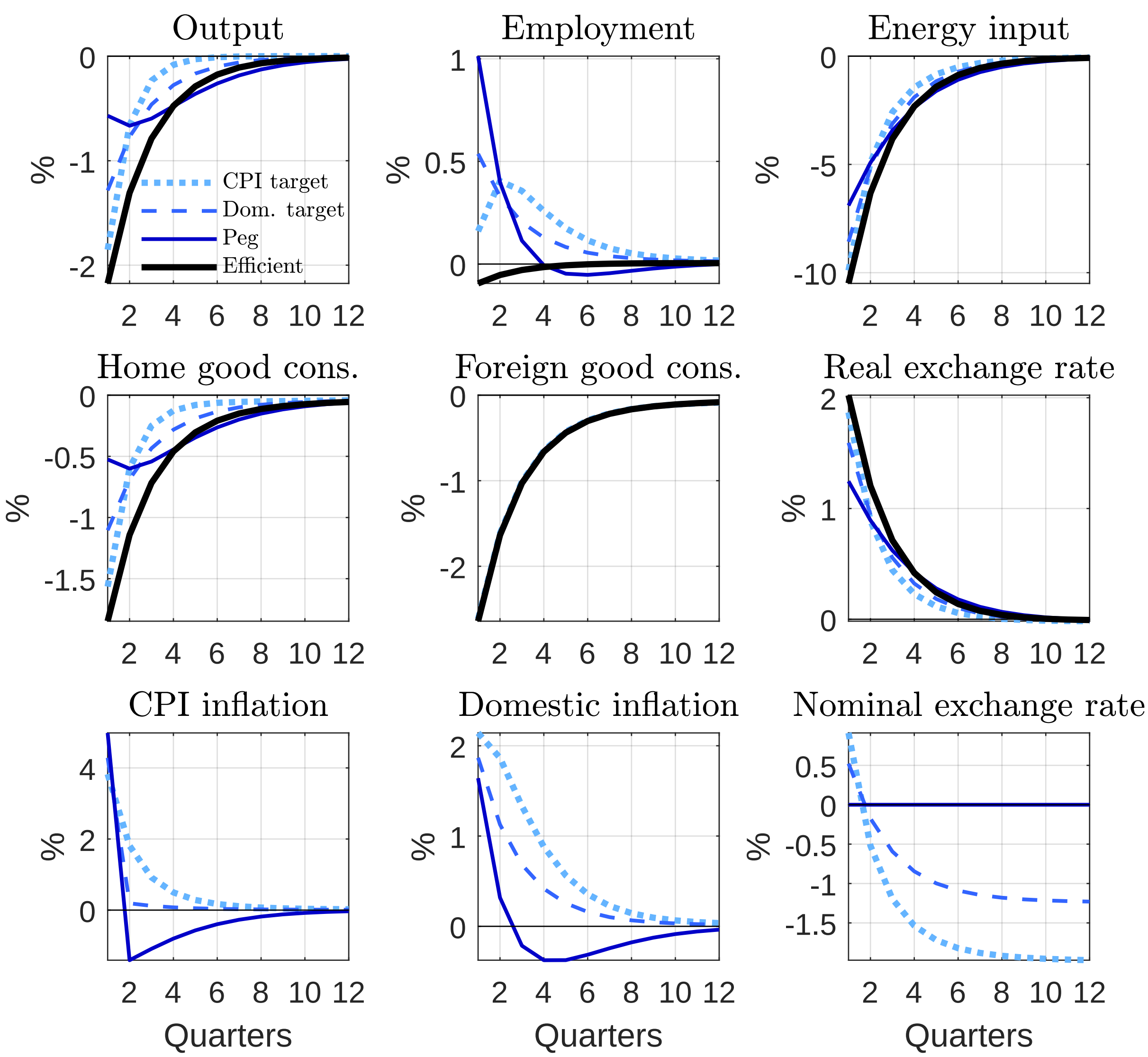
We next examine the case of an advanced economy commodity/energy *importer*, facing a 10% positive energy price shock. In the social planner's efficient solution,

Figure 5: IRFS TO COMMODITY EXPORT PRICE SHOCK IN EMERGING MARKET COMMODITY EXPORTER



Note: IRFs to a 10% positive commodity export price shock under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation is shown in annualized percent. The nominal exchange rates is plotted as $\hat{e}_t^{-1}$ so that an increase corresponds to an appreciation.

Figure 6: IRFS TO ENERGY IMPORT PRICE SHOCK IN ADVANCED ECONOMY



Note: IRFs to a 10% positive commodity/energy import price shock under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $\hat{e}_t^{-1}$ and $\hat{s}_t^{-1}$ so that an increase corresponds to an appreciation.

shown in black lines, there is only a small fall in employment, with most of the adjustment coming via a reduction in the energy input, leading to a drop in output and falls in both exports and consumption. A real exchange rate appreciation leads to some expenditure switching towards foreign consumption.

There is smaller differentiation between the different policies than the previous case, with all implementing a loose policy that prevents prevents output from falling as much as would be efficent, leading to higher domestic inflation. The exchange rate peg implements the loosest monetary stance, limiting some of the (desired) output volatility, as well as some of the domestic inflation volatility in import prices. But it does so at the cost of greater volatility in the efficient output gap.

Table 5: IMPLIED STANDARD DEVIATIONS ACROSS POLICIES - DEVELOPED COMMODITY IMPORTER, CONDITIONAL ON COMMODITY (ENERGY) IMPORT PRICE SHOCK

	CPI inf. target	**Dom. inf. target**	**Nominal peg**
CPI inflation	1.09	1.07	1.35
Domestic inflation	0.83	0.59	0.46
Efficient output gap	1.07	1.14	1.78

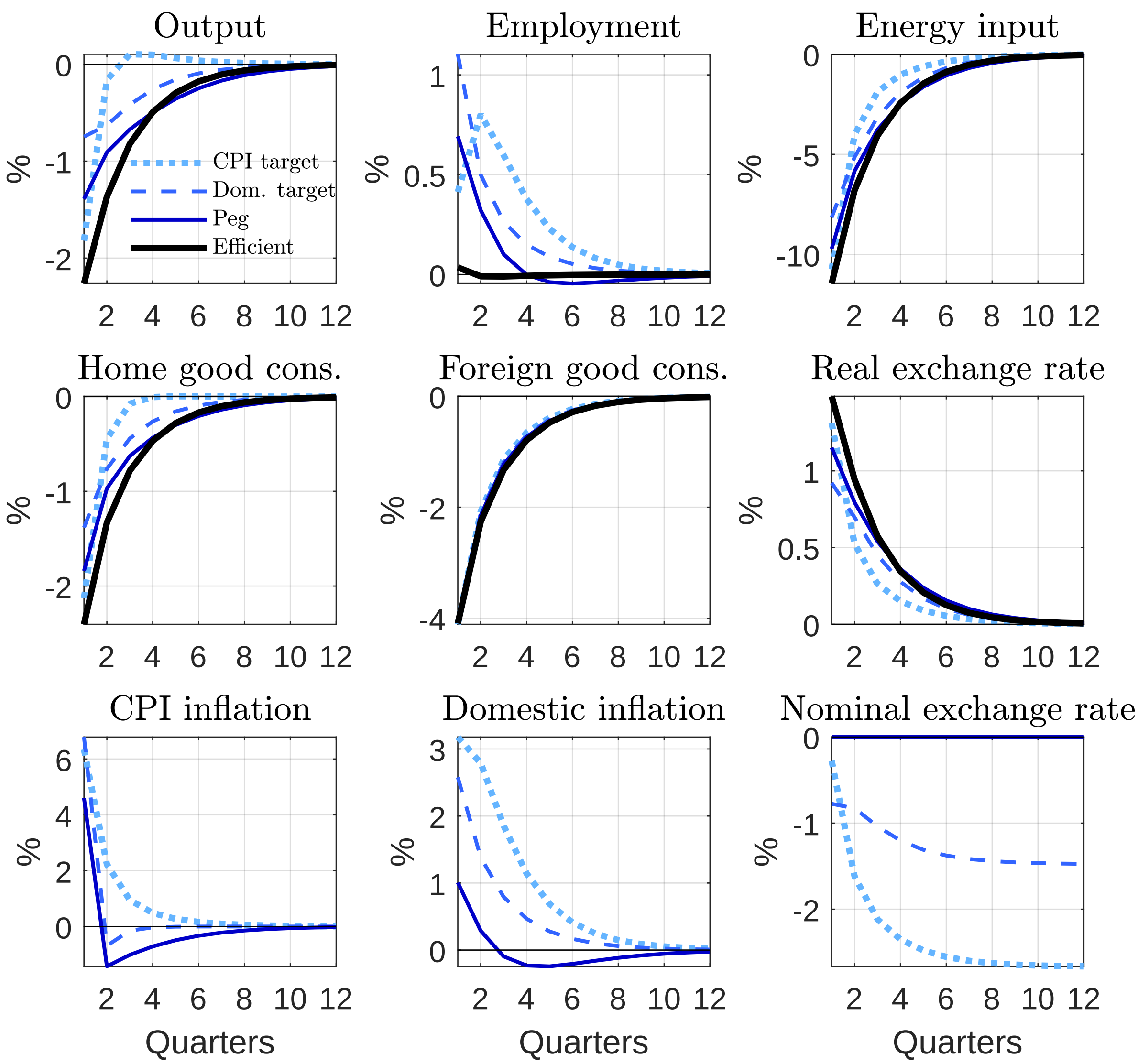
4.4 Emerging and developing economies - energy import price shocks

When emerging economies face the same energy price shock, there are some more distinct advantages to the exchange rate peg. A rise in the risk premium leads to a more depreciated currency under inflation targeting rules, which the peg prevents. By doing so, it is able to limit the volatility in both domestic and CPI inflation, relative to Taylor rules targeting those variables.

Table 6: IMPLIED STANDARD DEVIATIONS ACROSS POLICIES - **EMERGING COMMODITY IMPORTER**, CONDITIONAL ON COMMODITY (ENERGY) IMPORT PRICE SHOCK

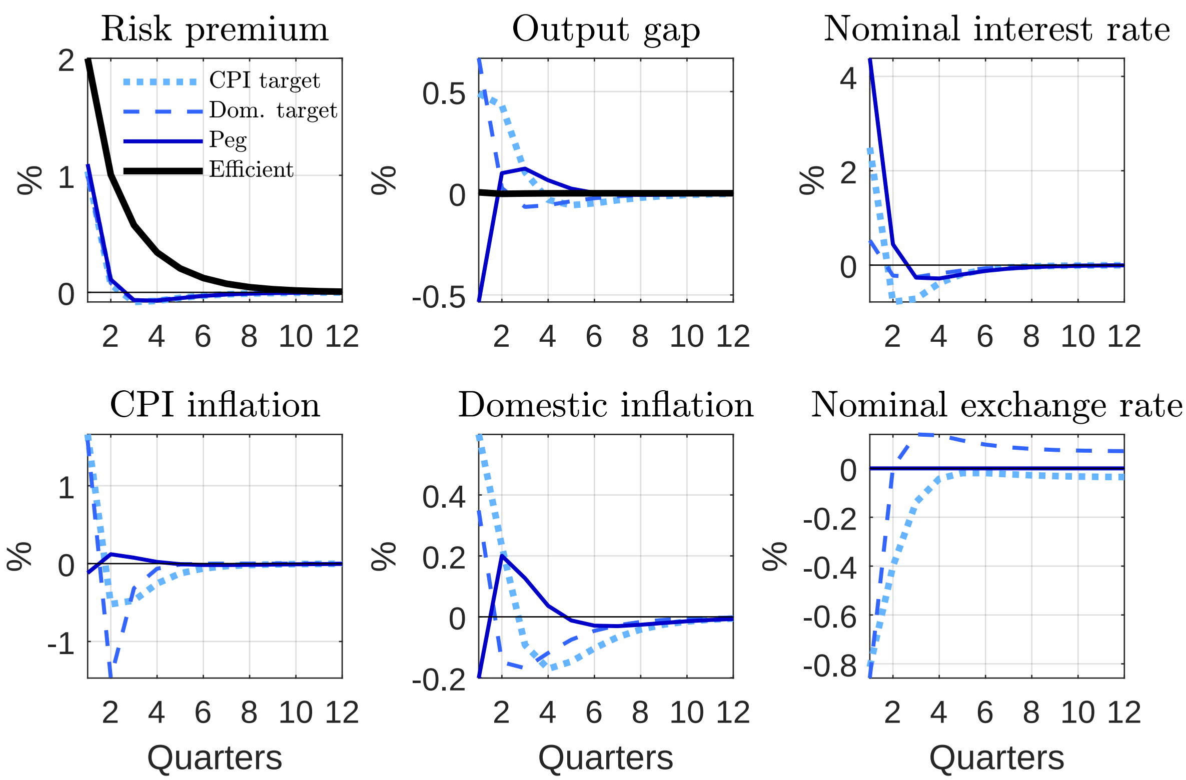
	CPI inf. target	**Dom. inf. target**	**Nominal peg**
CPI inflation	1.70	1.71	1.26
Domestic inflation	1.21	0.77	0.29
Efficient output gap	1.75	1.76	1.00

Figure 7: IRFS TO ENERGY IMPORT PRICE SHOCK IN EMERGING MARKET COMMODITY IMPORTER



Note: IRFs to a 10% positive commodity/energy import price shock under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $\hat{e}_t^{-1}$ and $\hat{s}_t^{-1}$ so that an increase corresponds to an appreciation.

Figure 8: IRFS TO RISK PREMIUM SHOCK IN EMERGING ECONOMY



Note: IRFs to a 3.3pp positive shock to the risk premium under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation and interest rates are shown in annualized percent. The nominal exchange rate is plotted as $\hat{e}_t^{-1}$ so that an increase corresponds to an appreciation.

5 The role of financial conditions

In this section, we explore the role of the risk premium and financial conditions in more detail. This also relates to recent work by (Itskhoki and Mukhin, 2021; Fukui, Nakamura, and Steinsson, 2023), which stresses the role of financial volatility in driving exchange-rate dynamics.

We find that for an emerging economy, facing a pure risk premium shock, exchange-rate pegs do relatively well at stabilising CPI inflation, since the volatility comes largely via the exchange rate.

There is a trade-off, however, as this is at the expense of greater volatility in the real economy. Overall, our results are consistent with active exchange-rate management being particularly costly in response to fundamentals-driven movements, but with some countervailing benefits for volatility driven by financial channels.

6 Conclusions

We set out a small open economy New Keynesian setting with commodity exports and imports to compare the performance of different monetary policy and exchange rate frameworks in response to commodity price shocks. To capture the marked procyclicality of credit in emerging and developing economies, we allow the risk premium faced by these economies to vary with commodity prices. After setting out the model, we characterise the behaviour of different types of economies when the policymaker seeks to implement a fixed exchange rate. We compare the volatility and performance of the economy under different inflation-targeting Taylor rules, and to the benchmark of the social planner's optimal policy.

We find that for advanced economies that are commodity exporters, inflation targeting policies consistently dominate over a peg, leading to lower volatility in the output gap and inflation. The advantages of inflation targeting over pegs are more striking in the case of commodity-exporting emerging or developing economies: in the face of commodity price shocks, exchange rate pegs create enormous volatility in inflation and output. A fall in commodity prices necessitates a domestic currency depreciation, and the peg sacrifices efficient internal adjustment for the sake of exchange rate stability. This volatility is amplified by an endogenous tightening of financial conditions, which leads to further pressure to loosen and depreciate.

For advanced economies that are commodity importers, there is less differentiation between inflation targeting and the peg. The efficient response involves little change in employment, with higher energy prices leading to lower import volumes, production and consumption. The exchange rate peg implements a looser monetary stance, limiting some of this efficient output volatility, as well as the exchange-rate related volatility in import prices. But it does so at the cost of greater volatility in the output gap and domestic inflation. When emerging economies face the same energy price shock, there are some more distinct advantages to the exchange rate peg. A rise in the risk premium leads to a more depreciated currency under inflation targeting rules, which the peg prevents. By doing so, the peg is able to limit the volatility in both domestic and CPI inflation, relative to Taylor rules targeting those variables. Further exploring the role of borrowing costs, we find that for an emerging economy, facing a pure risk premium shock, exchange-rate pegs do relatively well at stabilising CPI inflation, since the volatility comes largely via the exchange rate. There is a trade-off, however, as this comes at the expense of greater volatility in the real economy. Overall, our results are consistent with active exchange-rate management being particularly costly in response to fundamentals-driven movements, but with some countervailing benefits for volatility driven exclusively by financial channels.

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APPENDIX TO

Commodity shocks with diverse impacts: how can different central banks tailor their policies?

by Thomas Drechsel, Michael McLeay, Silvana Tenreyro and Enrico Turri

A Social planner

The social planner maximises household utility taking production, resource constraints and international prices as given.

We can write it as

$$\max_{\{C_{h,t},C_{f,t},M_{h,t},X_{\tilde{c},t},N_t,B_{t+1}\}_{t=0}^{\infty}} \quad \sum_{t=0}^{\infty}\beta^t\left((1-\alpha)\log C_{h,t}+\alpha\log C_{f,t}-\frac{N_t^{1+\phi}}{1+\phi}\right) \tag{34}$$

$$s.t. \quad A_{h,t}N_t^{1-\mu}X_{\tilde{c},t}^{\mu}=C_{h,t}+C_{h,t}^*+M_{h,t} \tag{35}$$

$$P_{f,t}^*C_{f,t}=P_{c,t}^*A_{c,t}M_{h,t}^{\nu}+P_{nc,t}^*\alpha^*C_t^*-P_{\tilde{c},t}^*X_{\tilde{c},t}+B_t\Phi_t(B_t)-B_{t+1}Q_{t,t+1}^* \tag{36}$$

$$C_{h,t}^*=\alpha^*C_t^*\frac{\alpha C_{h,t}}{(1-\alpha)C_{f,t}}\left(\frac{P_{nc}^*}{P_{\tilde{c}}^*}\right)^{\alpha_{\tilde{c}}} \tag{37}$$

We can then write the Lagrangian

$$\begin{aligned}\mathcal{L}=\sum_{t=0}^{\infty}\beta^t\Bigg(&(1-\alpha)\log C_{h,t}+\alpha\log C_{f,t}-\frac{N_t^{1+\phi}}{1+\phi}\Bigg)\\&+\lambda_t\left(-C_{h,t}-\alpha^*C_t^*\frac{\alpha C_{h,t}}{(1-\alpha)C_{f,t}}\left(\frac{P_{nc}^*}{P_{\tilde{c}}^*}\right)^{\alpha_{\tilde{c}}}-M_{h,t}+A_{h,t}N_t^{1-\mu}X_{\tilde{c},t}^{\mu}\right)\\&+\xi_t\left(-P_{f,t}^*C_{f,t}+P_{c,t}^*A_{c,t}M_{h,t}^{\nu}+P_{nc,t}^*\alpha^*C_t^*-P_{\tilde{c},t}^*X_{\tilde{c},t}+B_t\Phi_t(B_t)-B_{t+1}Q_{t,t+1}^*\right)\end{aligned} \tag{38}$$

The system of first order conditions and constraints is

$$\beta^t \frac{1-\alpha}{C_{h,t}} - \lambda_t (1 + \frac{\alpha\alpha^* C_t^*}{(1-\alpha)C_{f,t}} \left(\frac{P_{nc}^*}{P_{\tilde{c}}^*}\right)^{\alpha_{\tilde{c}}}) = 0 \tag{39}$$

$$\beta^t \frac{\alpha}{C_{f,t}} - \xi_t P_{f,t}^* + \lambda_t (\frac{\alpha\alpha^* C_t^* C_{h,t}}{(1-\alpha)C_{f,t}^2} \left(\frac{P_{nc}^*}{P_{\tilde{c}}^*}\right)^{\alpha_{\tilde{c}}}) = 0 \tag{40}$$

$$-\beta^t N_t^{\phi} + \lambda_t (1-\mu) \frac{A_{h,t} N_t^{1-\mu} X_{\tilde{c},t}^{\mu}}{N_t} = 0 \tag{41}$$

$$-\lambda_t + \xi_t \nu P_{c,t}^* A_{c,t} M_{h,t}^{\nu-1} = 0 \tag{42}$$

$$+\lambda_t \mu \frac{A_{h,t} N_t^{1-\mu} X_{\tilde{c},t}^{\mu}}{X_{\tilde{c},t}} - \xi_t P_{\tilde{c},t}^* = 0 \tag{43}$$

$$-\xi_t Q_{t,t+1}^* + \xi_{t+1} (\Phi_{t+1}(B_{t+1}) + B_{t+1} \partial_B \Phi_{t+1}(B_{t+1})) = 0 \tag{44}$$

$$A_{h,t} N_t^{1-\mu} X_{\tilde{c},t}^{\mu} = C_{h,t} + C_{h,t}^* + M_{h,t} \tag{45}$$

$$P_{f,t}^* C_{f,t} = P_{c,t}^* A_{c,t} M_{h,t}^{\nu} + P_{nc,t}^* \alpha^* C_t^* - P_{\tilde{c},t}^* X_{\tilde{c},t} + B_t \Phi_t(B_t) - B_{t+1} Q_{t,t+1}^* \tag{46}$$

We linearise the model around the steady state that satisfies these conditions, with zero net asset positions and relative prices normalised to one.

B Full linearised model

Relative price relations and resource constraint.

$$\hat{p}_t = \alpha \hat{p}_{f,t} + (1-\alpha)\hat{p}_{h,t} \tag{47}$$

$$\hat{p}_{f,t} = \alpha_{\tilde{c}} \hat{p}_{\tilde{c},t} + (1-\alpha_{\tilde{c}})\hat{p}_{nc,t} \tag{48}$$

$$\hat{\tau}_t = \hat{p}_{f,t} - \hat{p}_{h,t} \tag{49}$$

$$\hat{s}_t = (1-\alpha)\hat{\tau}_t - \alpha_{\tilde{c}} \hat{p}_{\tilde{c},t}^* \tag{50}$$

$$\Delta \hat{e}_t = \Delta \hat{s}_t + \hat{\pi}_t - \hat{\pi}_{f,t}^* \tag{51}$$

$$\hat{y}_{h,t} = s_{c,ss} \hat{c}_{h,t} + s_{c^*,ss} \hat{c}_{h,t}^* + s_{m,ss} \hat{m}_{h,t} \tag{52}$$

Households.

$$
\begin{aligned}
\hat{c}_{h,t} &= \alpha\hat{\tau}_t + \hat{c}_t && (53)\\
\hat{c}_{f,t} &= (\alpha-1)\hat{\tau}_t + \hat{c}_t && (54)\\
\hat{c}^*_{h,t} &= \hat{\tau}_t - \alpha_{\tilde{c}}\hat{p}^*_{\tilde{c},t} + \hat{c}^*_t && (55)\\
\hat{c}_{nc,t} &= \hat{p}_{f,t} - \hat{p}_{nc,t} + \hat{c}_{f,t} && (56)\\
\hat{c}_{\tilde{c},t} &= \hat{p}_{f,t} - \hat{p}_{\tilde{c},t} + \hat{c}_{f,t} && (57)\\
\varphi\hat{n}_t + \hat{c}_t &= \hat{w}_t - \hat{p}_t && (58)\\
&= \frac{1}{1-\mu}\left(\hat{mc}_t + \hat{a}_{h,t} - \alpha\hat{\tau}_t - \mu\hat{p}^*_{\tilde{c},t} - \mu\hat{s}_t\right) && (59)\\
\hat{c}_t &= -(i_t - \mathbb{E}_t\hat{\pi}_{t+1}) + \mathbb{E}_t\hat{c}_{t+1} && (60)\\
i_t - \mathbb{E}_t\hat{\pi}_{t+1} &= i^*_t - \mathbb{E}_t\hat{\pi}^*_{t+1} + \mathbb{E}_t\hat{s}_{t+1} - \hat{s}_t + \hat{\phi}_t && (61)\\
\hat{\phi}_t &= \phi_{\tilde{c}}\hat{p}_{\tilde{c},t} - \phi_c\hat{p}_{c,t} - \phi_B\hat{b}_t && (62)\\
\beta\hat{b}_t - \hat{b}_{t-1} &= \frac{s_{m,ss}}{\nu}(\hat{y}_{c,t} + \hat{p}^*_{c,t}) + s_{c^*,ss}\hat{c}^*_t - \mu(\hat{x}_{\tilde{c},t} + \hat{p}^*_{\tilde{c},t}) - \frac{\alpha s_{c,ss}}{1-\alpha}(\hat{c}_{f,t} + \alpha_{\tilde{c}}\hat{p}^*_{\tilde{c},t}) && (63)
\end{aligned}
$$

Domestic goods sector.

$$
\begin{aligned}
\hat{y}_{h,t} &= \hat{a}_{h,t} + (1-\mu)\hat{n}_t + \mu\hat{x}_{\tilde{c},t} && (64)\\
\hat{\pi}_{h,t} &= \beta\mathbb{E}_t\hat{\pi}_{h,t+1} + \kappa\hat{mc}_t && (65)\\
\hat{mc}_t &= (1-\mu)(\hat{w}_t - \hat{p}_t) + \mu(\hat{p}^*_{\tilde{c},t} + \hat{s}_t) + \alpha\hat{\tau}_t - \hat{a}_{h,t} && (66)\\
\hat{x}_{\tilde{c},t} &= \hat{n}_t + (\hat{w}_t - \hat{p}_t) - (\hat{p}^*_{\tilde{c},t} + \hat{s}_t) && (67)
\end{aligned}
$$

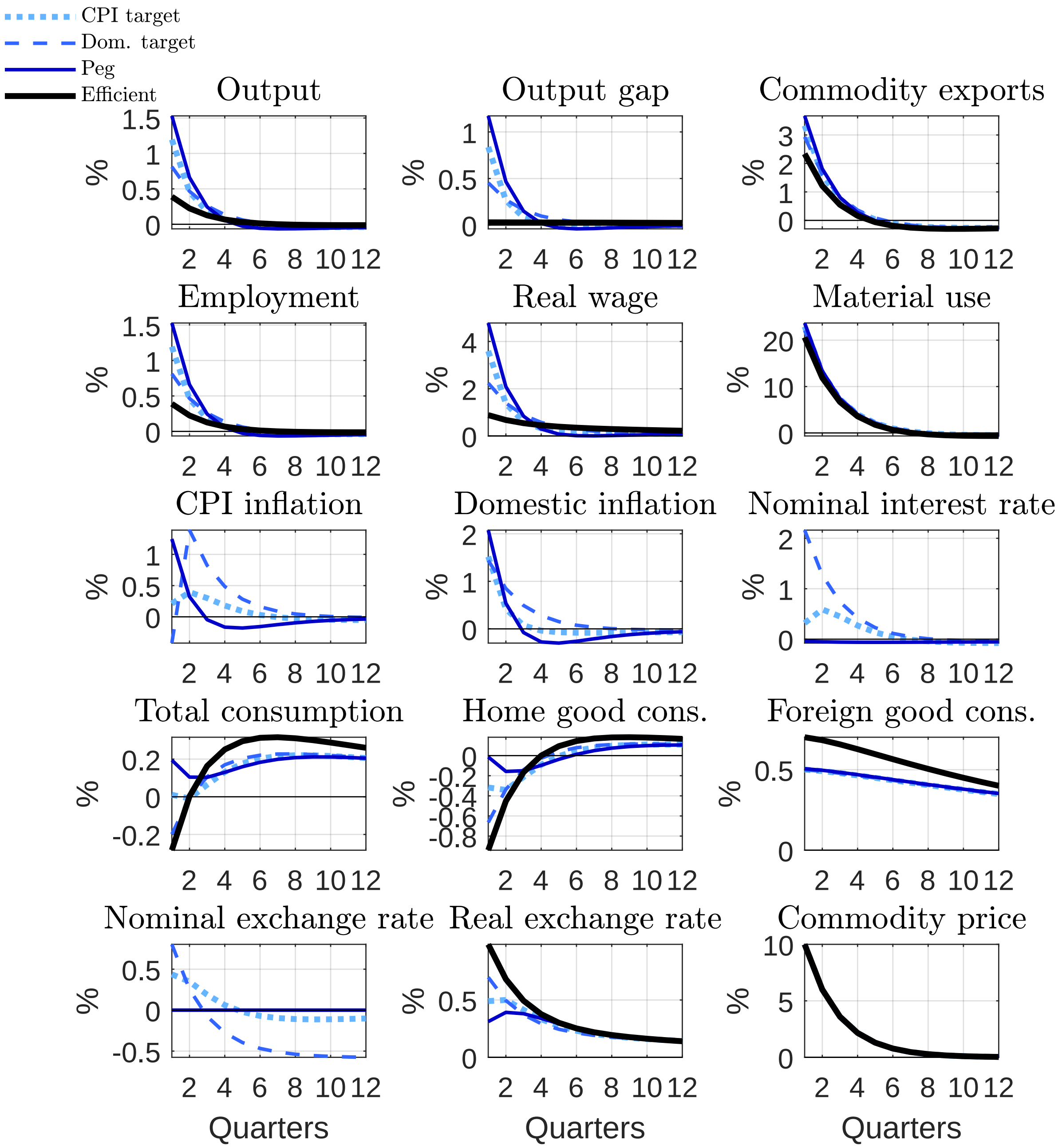
Commodity export sector.

$$
\begin{aligned}
\hat{y}_{c,t} &= \hat{a}_{c,t} + \nu\hat{m}_{h,t} && (68)\\
(1-\nu)\hat{m}_{h,t} &= \hat{p}^*_{c,t} + \alpha\hat{\tau}_t + \hat{s}_t + \hat{a}_{c,t} && (69)
\end{aligned}
$$

All hat variables are percentage deviations from steady state, except $\hat{b}_t \equiv \frac{B_t}{P_t \overline{Y_h}}$, $\hat{p}^*_{c,t} \equiv \frac{\frac{P^*_{c,t}}{P^*_t} - \frac{P^*_c}{P^*}}{\frac{P^*_c}{P^*}}$, $\hat{p}^*_{\tilde{c},t} \equiv \frac{\frac{P^*_{\tilde{c},t}}{P^*_t} - \frac{P^*_{\tilde{c}}}{P^*}}{\frac{P^*_{\tilde{c}}}{P^*}}$,

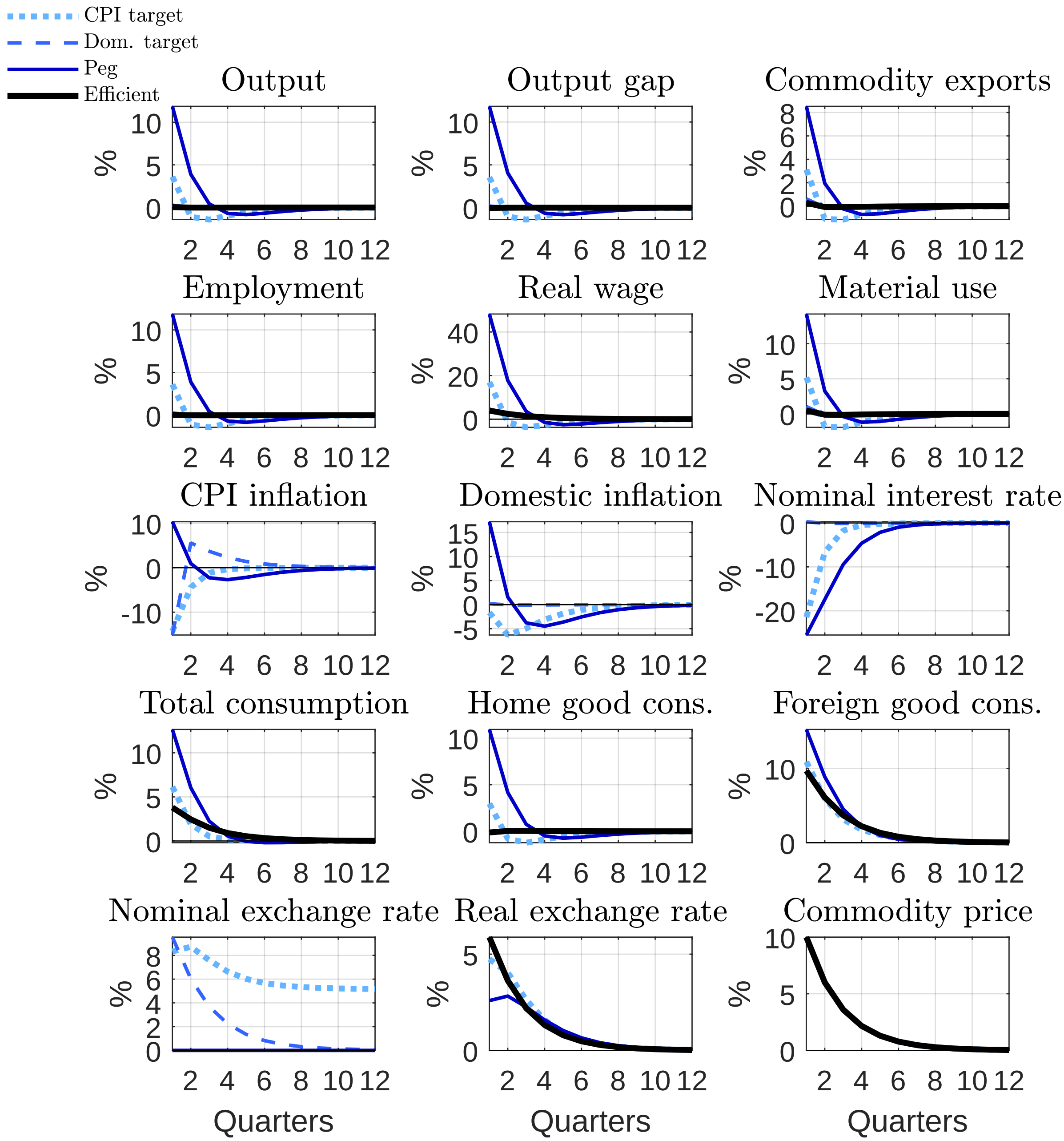
C Commodity price shocks

Figure C.1: IRFS TO COMMODITY EXPORT PRICE SHOCK IN DEVELOPED COMMODITY EXPORTER



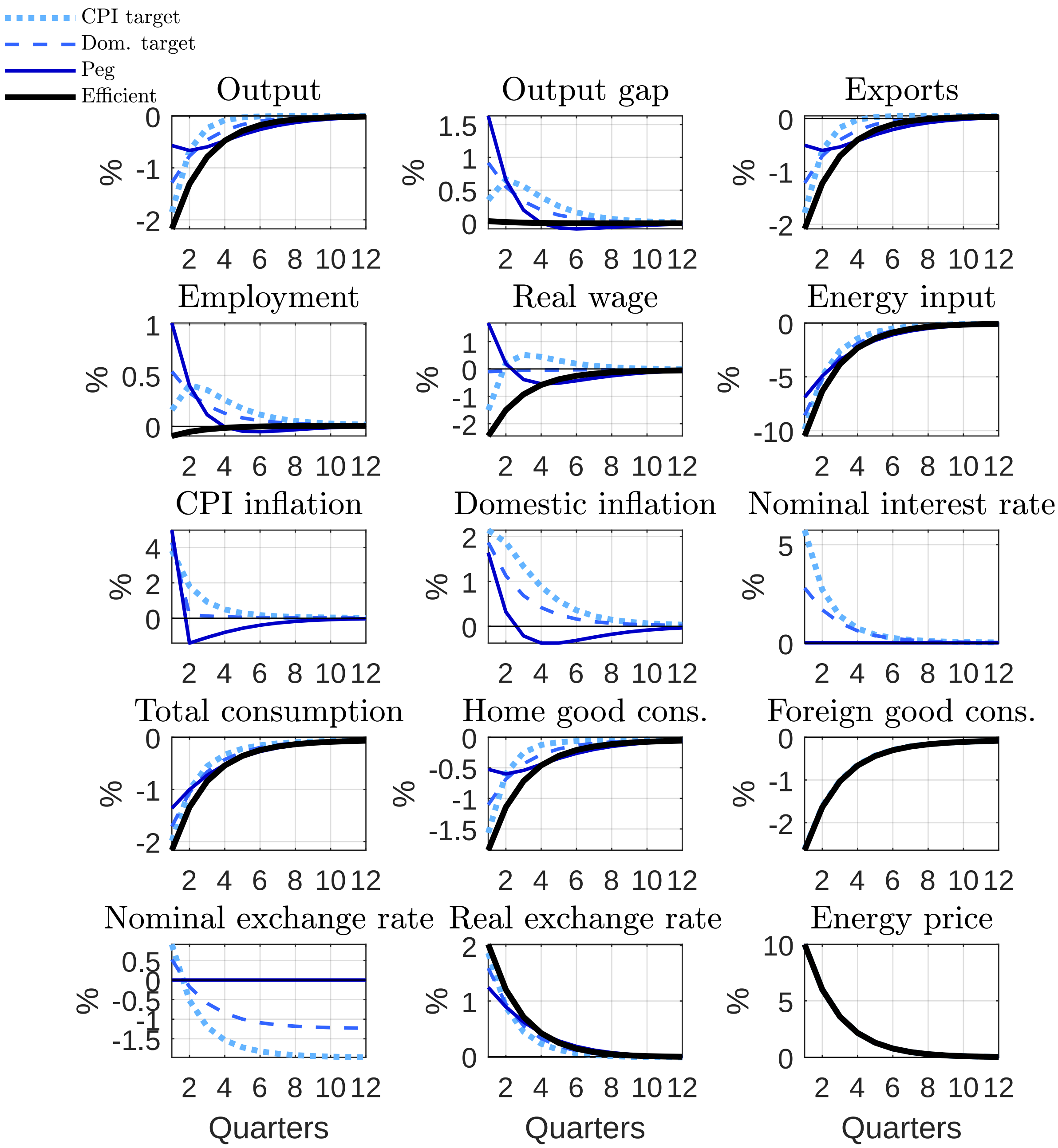
Note: IRFs to a 10% positive commodity export price shock under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $\hat{e}_t^{-1}$ and $\hat{s}_t^{-1}$ so that an increase corresponds to an appreciation.

Figure C.2: IRFS TO COMMODITY EXPORT PRICE SHOCK IN EMERGING MARKET COMMODITY EXPORTER



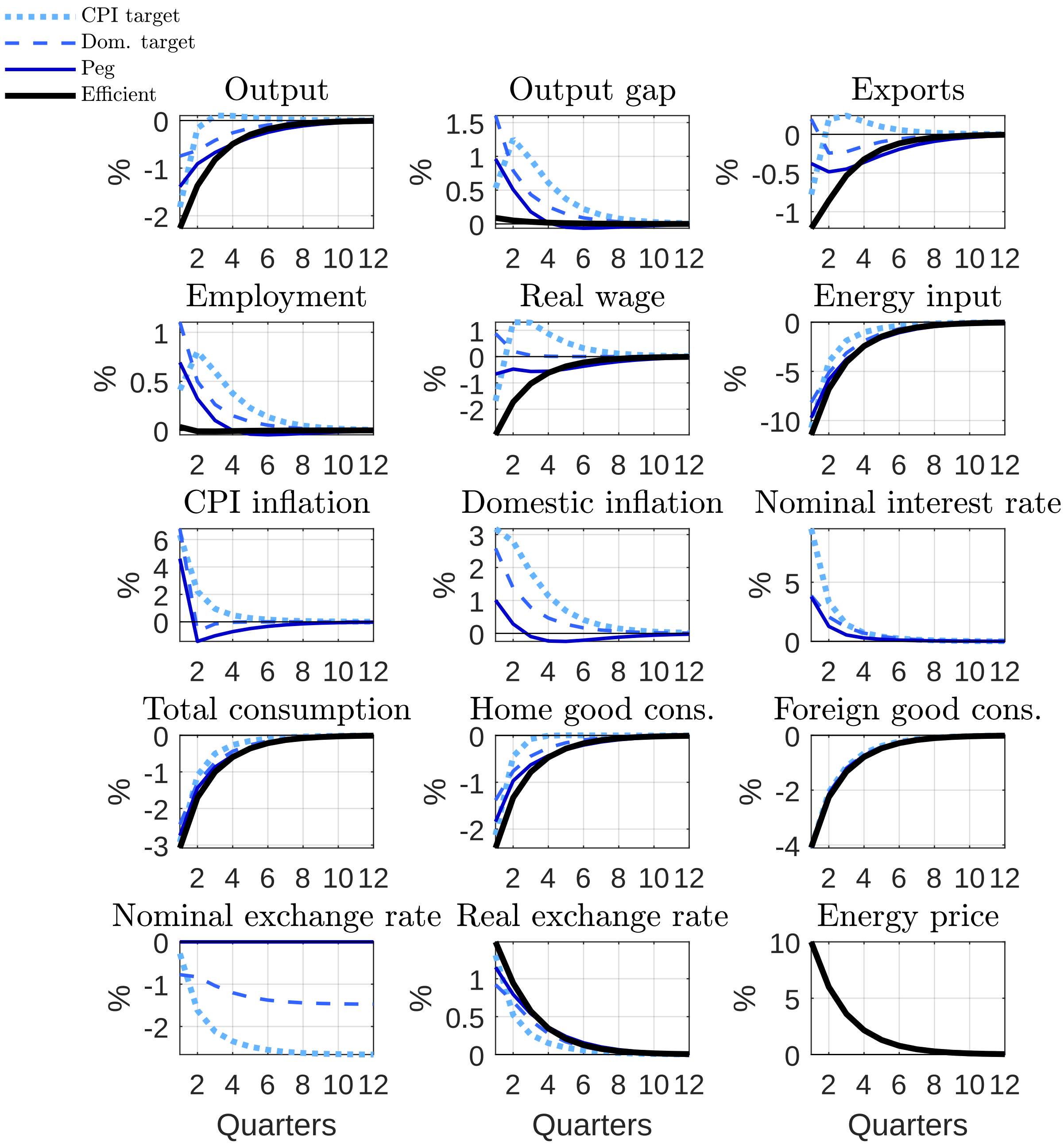
Note: IRFs to a 10% positive commodity export price shock under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $\hat{e}_t^{-1}$ and $\hat{s}_t^{-1}$ so that an increase corresponds to an appreciation.

Figure C.3: IRFS TO ENERGY IMPORT PRICE SHOCK IN DEVELOPED ECONOMY COMMODITY IMPORTER



Note: IRFs to a 10% positive commodity/energy import price shock under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $\hat{e}_t^{-1}$ and $\hat{s}_t^{-1}$ so that an increase corresponds to an appreciation.

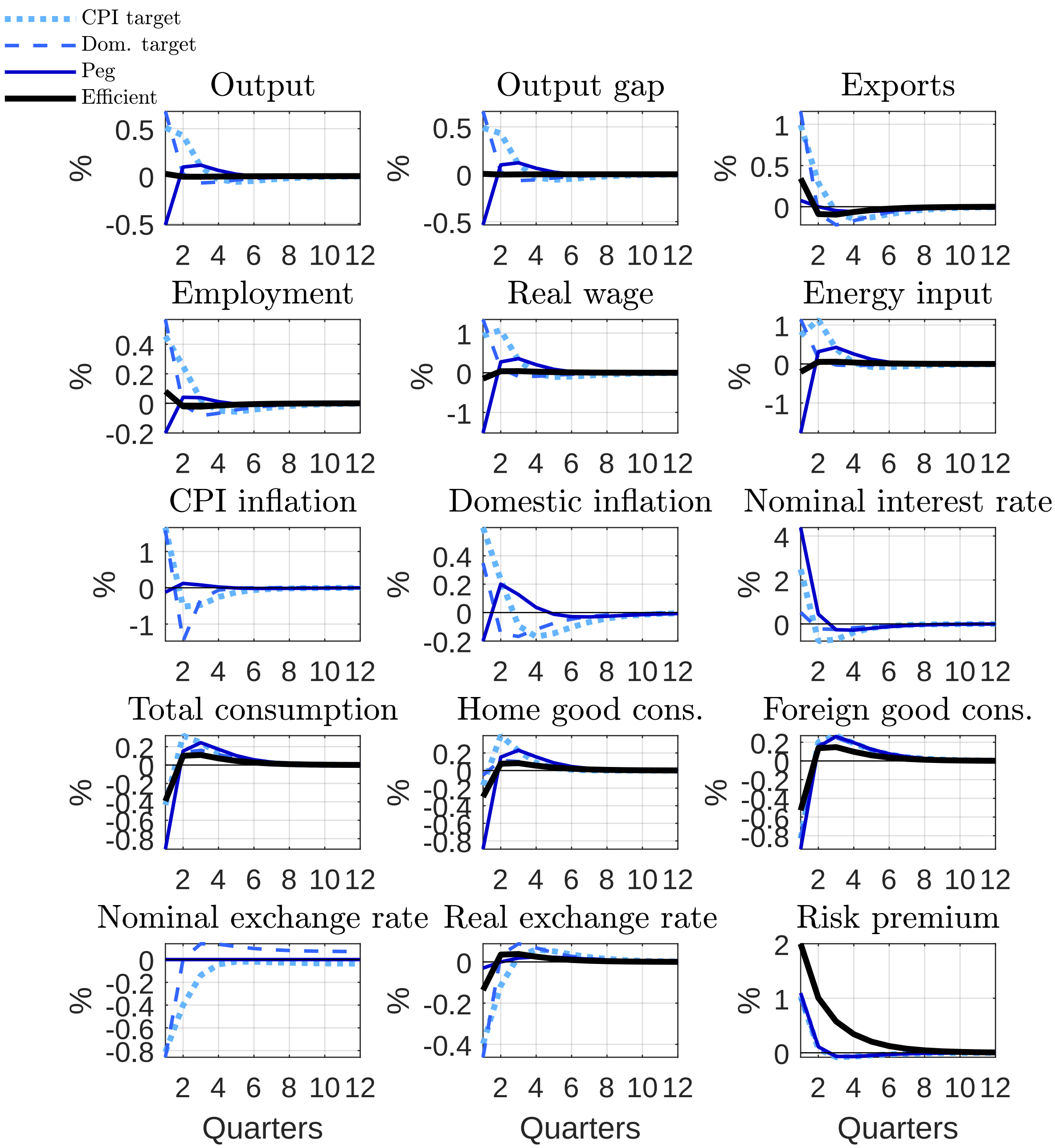
Figure C.4: IRFS TO ENERGY IMPORT PRICE SHOCK IN EMERGING MARKET COMMODITY IMPORTER



Note: IRFs to a 10% positive commodity/energy import price shock under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $\hat{e}_t^{-1}$ and $\hat{s}_t^{-1}$ so that an increase corresponds to an appreciation.

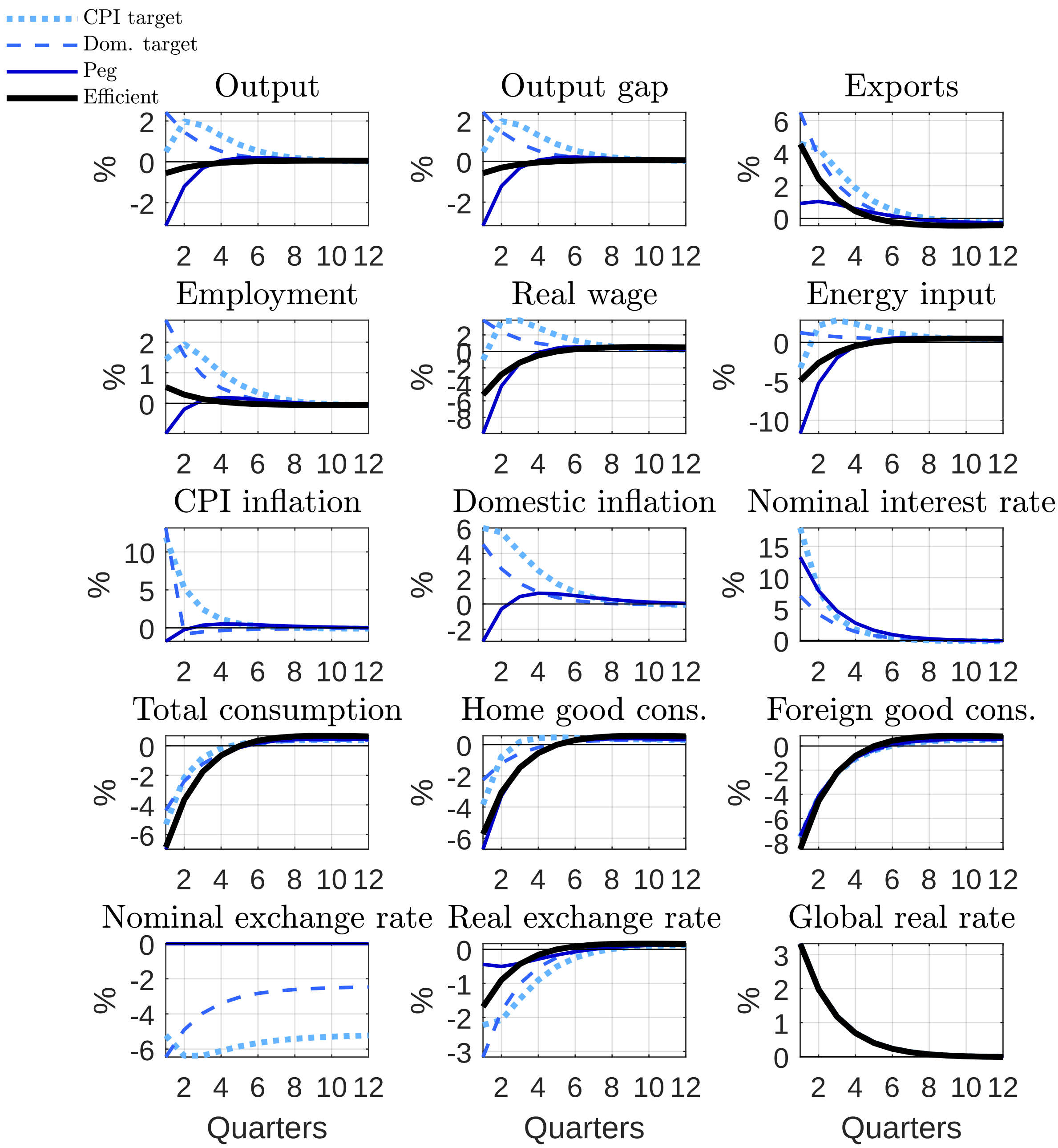
D Interest rate shocks

Figure D.1: IRFS TO RISK PREMIUM SHOCK IN EMERGING ECONOMY



Note: IRFs to a 3.3pp positive shock to the risk premium under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $\hat{e}_t^{-1}$ and $\hat{s}_t^{-1}$ so that an increase corresponds to an appreciation.

Figure D.2: IRFS TO GLOBAL INTEREST RATE SHOCK IN ADVANCED ECONOMY



Note: IRFs to a 3.3pp positive shock to the world interest rate under alternative policy rules. The results are generated under the calibration shown in Tables 1 and 2. Inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $\hat{e}_t^{-1}$ and $\hat{s}_t^{-1}$ so that an increase corresponds to an appreciation.