How should central banks respond to commodity price shocks? Optimal monetary and exchange rate frameworks for commodity-exposed economies *

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Abstract

This paper shows that the optimal monetary policy and exchange rate framework depend critically on the economy's commodity exposure. We develop a flexible but tractable model economy with commodity exports and imports, in which international financial conditions may vary with the commodity cycle. Stabilizing domestic prices is optimal for commodity exporters, in line with standard open-economy policy prescriptions. But for economies that use commodities as inputs in production, optimal policy largely 'looks through' the direct and indirect effects of commodity shocks on domestic prices; this contrasts with some earlier findings and policy practice (which only 'looks through' the direct effect). Exchange-rate pegs or strict CPI inflation targeting perform better for commodity importers because they stabilize wages and employment, though neither policy is robustly optimal. In emerging and developing economies, where financial conditions are more tied to the commodity cycle, trade-offs are starker and implementing the optimal policy may be challenging, since it requires enough credibility to keep inflation expectations anchored amidst greater volatility in some nominal variables.

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1 Introduction

How should monetary policy and exchange rate frameworks adapt to an era of volatile commodity prices? Recent geopolitical events – including the wars in Ukraine and the Middle East – have led to extreme fluctuations in the prices of energy and other commodities. Meanwhile, climate-related weather shocks are increasingly affecting global food prices. Both types of shock are likely to be more frequent in the years ahead. Commodity price shocks can create challenges for inflation-targeting central banks, as they often lead to trade-offs between different objectives. This raises questions about how monetary policy should respond, and whether existing inflation targeting frameworks are best suited for delivering such a response.[1]

Until recently, a loose consensus had formed on the appropriate monetary response to commodity price shocks, both in the literature and among policymakers. Since Aoki (2001), the literature has highlighted that optimal monetary policy involves minimising inflation in sticky-price sectors, with price adjustment to shocks occurring entirely in flexible-price sectors. Applied to commodities, which are priced flexibly in global markets, these insights suggested stabilising measures of core inflation, while permitting short-term volatility in headline CPI inflation. Similarly, the small open economy literature has generally found that stabilising measures of domestic inflation (e.g. producer price inflation) is optimal (Gali and Monacelli, 2005; Benigno and Benigno, 2006).[2] These findings were consistent with the strategies espoused by policymakers, which suggested 'looking through' the direct effects of commodity prices such as the impact of energy on CPI inflation.[3]

Recent episodes of commodity price volatility have called into question the previous consensus. Across advanced economies, the extraordinary increases in the prices of gas and oil beginning in 2022 precipitated large and persistent increases in measures of core and domestic inflation, not just headline CPI inflation. A large proportion of these increases can be attributed to the 'indirect effects' of energy prices via firms' input costs (Vlieghe, 2025). But the size and persistence of these effects suggest a departure from the typical policy strategy of leaning against indirect effects to stabilise core inflation.

Moreover, the findings in the literature are in stark contrast to policy frameworks and practice in many emerging and developing economies. Rather than focusing on stabilising domestic inflation supported by a freely floating exchange rate, many of these economies exhibit a 'fear of floating' (Calvo and Reinhart, 2002; Bianchi and Coulibaly, 2023), either

[1] For evidence on the quantitative importance of commodity shocks and terms-of-trade shocks more broadly, see, e.g., Schmitt-Grohe and Uribe (2017), Giovannini et al. (2019), Drechsel and Tenreyro (2018).

[2] These build on the new open economy macroeconomics tradition launched by Obstfeld and Rogoff (1995). See also Kollmann (2001), De Paoli (2009), and a comprehensive survey by Corsetti et al. (2010).

[3] Besides being consistent with optimal policy in New Keynesian models, these strategies were advocated on related practical grounds. Policy transmission lags made responding to temporary shocks in fast-reacting (flexible price) sectors counterproductive, if the impact of the shock occurred before policy had a chance to take effect. See Lagarde (2026) and Powell (2024) for examples, and Nelson (2025) for a discussion of the history of 'looking through' in policy circles.

implicitly or explicitly targeting the exchange rate.

In this paper, we revisit the perennial question of how monetary policy should optimally respond to commodity price shocks, and study how the appropriate policy framework depends on whether the economy in question is a commodity importer or a commodity exporter. In answering these normative questions, we also shed light on the positive questions of why policy responses and frameworks tend to differ between advanced economies and some emerging markets. We pinpoint the role of endogenous financial conditions, which tend to fluctuate with commodity prices in emerging and developing economies, as in Drechsel and Tenreyro (2018).

We present a small open economy model with roles for commodity imports and exports, and with endogenous risk premia in financial markets. We build on the models presented in Drechsel and Tenreyro (2018) and Drechsel, McLeay, and Tenreyro (2019) along various dimensions, while retaining the simplicity of a New Keynesian open economy framework à la Gali and Monacelli (2005). The model is tractable, but flexible enough to incorporate the various transmission channels from commodity prices in economies with varying commodity exposure.

Specifically, we include roles for different commodities (and commodity-like homogeneous goods) as export goods, as imports consumed directly by households, and as intermediate inputs in production.[4] Commodity import price increase have direct and indirect effects on inflation, while commodity export price increases lead to windfall income gains and increases in export production. We model commodity price shocks as relative price shocks of the relevant commodity compared to a global price index.

We incorporate wage and price rigidities, with sticky prices in domestic good production and monopolistic exports, but flexible prices of commodities and homogeneous goods, in line with the mixed-currency pricing in McLeay and Tenreyro (2026). Monopolistic exports are sticky in domestic currency (producer-currency pricing, as in Obstfeld and Rogoff, 1995), while commodities are nominally priced in dollars. Since these dollar prices are flexible and wages are sticky, exchange rates have allocative effects on exports, as under producer-currency pricing (McLeay and Tenreyro, 2026).[5]

A key contribution of our model is to include country-dependent constraints in global financial markets, with risk premia on external debt potentially depending on swings in international commodity prices. In line with empirical evidence (Drechsel and Tenreyro, 2018), we postulate that risk premia faced by developing or emerging commodity exporters are negatively related to the prices of those commodities. For commodity or energy importers, instead, we postulate a positive relationship. This captures the strong link between commodity prices and financial conditions in emerging and developing economies.

[4]These can also be interpreted as imported non-commodity intermediates, allowing our model to speak, at least to a simplified degree, to the relevance of global value chains for monetary policy. In a similar vein, Werning et al. (2025) show formally that tariffs act as cost-push shocks in a New Keynesian framework.

[5]This is different from the dollar-currency pricing model formulated by Gopinath et al. (2020), where dollar prices are sticky and the allocative role of exchange rates is muted.

A second contribution is to compute welfare-optimal policy in our model with commodity inputs, production, consumption and endogenous risk premia. Compared to a benevolent social planner, there is an externality in the competitive, flexible wage and price allocation, as agents do not take into account the impact of their decisions on the risk premium. Our results focus on the Cole-Obstfeld (Cole and Obstfeld, 1991) parametrisation in which there is no additional terms-of-trade externality, though we also explore the implications of relaxing this assumption.

We compare the benchmark optimal policy to three alternative rules: strict domestic inflation targeting; strict CPI inflation targeting; and an exchange-rate peg. We separately examine the responses to shocks facing commodity importers and commodity exporters, which helps delineate the different channels and policy responses arising from commodity exposure. In practice, commodity exporters also use energy and other commodities in production and consumption, so we also examine correlated shocks to the global prices of import and export commodities. We explore how the results change when the risk premium sensitivity is higher, matching the constraints faced by emerging and developing economies.[6] The applicability of our framework to a range of economies is a further contribution to the literature on commodities; this has typically focused on either emerging economies that export commodities, or advanced economies that import commodities, largely neglecting the link between commodity prices and risk premia.

We find that the ranking across the three different policy frameworks depends critically on the economy's commodity exposure. A first key result is that for commodity *exporters*, strict domestic inflation targeting is close to optimal after a commodity price shock, while exchange-rate pegs lead to substantially worse welfare outcomes. Stable domestic prices also simultaneously stabilise aggregate wages, minimising losses arising from price and wage dispersion. They also close the efficient output gap. An exchange-rate peg, in contrast, generates an inefficient boom in employment and consumption, causing above target domestic inflation and wage inflation, and a positive output gap. Strict CPI targeting, which can be seen as an average of the two alternatives, is quantitatively similar to an exchange-rate peg.

The key feature of the model driving these results is that commodity export prices are flexible, in line with the results and evidence presented in McLeay and Tenreyro (2026). With no nominal frictions, all commodity exporters can freely adjust to the new global price, so this creates no relative-price distortions. Commodity exports and production optimally expand after a price increase, constrained by supply capacity. This drives up the marginal cost of commodity production, until its marginal value product of labor falls back to that in the non-export sector. The efficient real producer wage is therefore unaffected, and so the

[6]These different calibrations allow us to differentiate between: advanced economies that are commodity exporters, such as Australia, Norway and Canada; emerging and developing economies that are commodity exporters, such as Argentina, Chile and Ghana; advanced economies that are commodity importers, such as Germany, Italy, and Japan; as well as emerging and developing economies that are commodity importers, such as India, Vietnam and Turkey.

efficient level of output can be achieved by stabilizing both domestic prices and wages.

However, our results also suggest reasons why some commodity exporters may wish to depart from the optimal policy. In the model, strict domestic inflation targeting clearly outperforms alternatives from a welfare perspective, but it does result in higher exchange-rate and CPI volatility. The peg performs badly because efficient terms of trade need to appreciate, via an appreciation of the nominal exchange rate. This causes an initial fall in import prices, leading to CPI deflation, followed by inflation as the commodity price and exchange rate fall back to trend. While this volatility is efficient in the model, it may be associated with other costs if central banks' credibility is closely tied to CPI inflation outcomes; or where private-sector balance sheets run a currency mismatch, making them vulnerable to exchange-rate volatility.

Our second key result is that for commodity *import* price shocks, which we refer to as energy imports, the policy ranking is reversed, with strict domestic inflation targeting performing significantly worse than either alternative. This appears to challenge received policymaker wisdom in response to such shocks. In principle, policy is able to lean against the indirect effects of energy on inflation via firms costs, and stabilise the domestic price level. But it can only do so by generating significantly negative wage inflation and a large negative output gap. The optimal policy therefore involves largely 'looking through' the domestic price movements induced by these indirect effects. Our result therefore extends the policymaker 'looking through' heuristic to the price of energy embodied in other goods and services, not just the price of energy directly in the consumption basket.

Why is complete stabilisation of domestic inflation a bad policy for energy importers, but not commodity exporters? The key to understanding this finding is the role of energy as a production input. An increase in the price of energy requires substituting into more labor intensive production, reducing its marginal product and the efficient real producer wage. While energy itself has flexible prices, it is incorporated into goods and services that do not. Nominal wages are also sticky, so in line with Erceg et al. (2000), the change in the real producer wage can only be delivered by domestic price inflation or nominal wage deflation, or a combination of both. Quantitatively, wage deflation requires generating a negative output gap, and it is hence optimal for most of the adjustment to come through higher domestic prices.

While we come to broadly similar normative conclusions for emerging markets, we find that variations in financial conditions amplify the trade-offs they face. Falls in risk premia as commodity export prices rise incentivise higher consumption, and require a larger exchange rate appreciation and greater fall in CPI inflation to prevent an inefficient large boom. Rises in risk premia as commodity import prices rise require enormous contractions in output to generate the appreciation needed to stabilise domestic prices, making this implausible. Procyclical fluctuations in risk premia therefore help explain the presence of different policies in emerging and developing economies.[7]

[7]Our model abstracts from a dollarised-liability channel, as emphasized for example by Cook (2004).

Our model suggests that exchange-rate pegs result in relatively low losses for energy importers, but this finding is not robust to different assumptions about the nature of these shocks. In practice, most energy importers also export some commodities or commodity-like homogenous goods, the prices of which are likely to rise at the same time. When we simulate a correlated import and export price shock in a commodity importer-exporter, the optimal policy is between the two extremes of strict domestic inflation targeting and an exchange-rate peg. For some shock realizations, strict CPI targeting performs well, but this is again not robust.

Our final key result is that across all of our different model variants, the optimal policy tends to be consistent with reasonably stable wage growth. Faced with commodity-price shocks, stable wage inflation is a better measure of the underlying level of inflation in the economy than measures of price inflation, which are affected by increases in imported commodity prices. But unlike exchange-rate pegs, stable wage inflation is reasonably close to the optimal policy irrespective of the economy's precise commodity exposure, or links with financial conditions.

While wage inflation is optimally stable in response to commodity price shocks, we stress that such an outcome can be achieved within current flexible inflation targeting frameworks.[8] Our results examine strict inflation targeting rules, but flexible inflation targeting frameworks permit policymakers to allow temporary deviations from their targets. Indeed, this is one interpretation of the responses of many central bankers to recent energy-price shocks. Policymakers at least partially 'looked through' impacts on CPI inflation, core inflation and proxies for domestic inflation (e.g. services inflation), but responded strongly to increases in wage inflation, as these suggest 'second round effects'. Through the lens of our model, this is close to optimal.

This policy recommendation again comes with caveats, particularly for emerging markets. Successful flexible inflation targeting requires policy credibility, often built up over decades. If the optimal strategy involves allowing a greater degree of volatility in both CPI inflation, and in core inflation, then this may risk the credibility of the framework. As a result, emerging market policymakers may not be able to use the flexibility required to implement the optimal policy (Drechsel, McLeay, and Tenreyro, 2019; Nakamura, Riblier, and Steinsson, 2025).

Relation to the literature. We contribute to a growing literature that incorporates commodity price fluctuations in macroeconomic models and studies implications for policy. Our main contribution is to develop a tractable framework that can be conveniently adapted to study both commodity importers and exporters and both advanced and emerging economies. This contrasts with previous work, which has typically focused on

Introducing such a channel could potentially imply a stronger benefit of lower exchange rate volatility, especially in emerging economies.

[8] To our knowledge, no central bank explicitly targets wage inflation, likely owing partly to greater measurement challenges and partly to potential political-economy constraints.

either emerging economies that export commodities or advanced economies that import commodities. Drechsel and Tenreyro (2018) build a real business cycle model with a commodity-*exporting* sector and quantifies the contribution of commodity price shocks, relative to other shocks, in driving macroeconomic fluctuations. Similar approaches are taken by Shousha (2016) and Fernández et al. (2018), while Giovannini et al. (2019) develop a multi-country modeling framework. Drechsel, McLeay, and Tenreyro (2019) develop a two-sector New Keynesian model to study optimal monetary policy in the presence of commodity price shocks, also for commodity-*exporting* countries. Related approaches include Catao and Chang (2013) and Ferrero and Seneca (2019). For recent work that instead focuses on the impact of energy prices in commodity-*importing* countries, see Guerrieri et al. (2024) and Auclert et al. (2024).[9] We generalize the framework of Drechsel, McLeay, and Tenreyro (2019) by allowing for both imported and exported economies, by introducing imperfect international risk sharing, by allowing for a more general formulation of preferences, and by specifying the economy's external debt premium to depend on commodity import prices and commodity export prices.[10]

Hevia and Nicolini (2013, 2015) also study models with two types of commodities, one produced by the home economy, the other one imported. A key difference is that they do not consider the connection between risk premia and commodity prices. Moreover, their analysis assumes perfect international risk sharing, an assumption that we relax in our framework.[11] Hamann et al. (2023) study emerging economies that are oil exporters and also link oil prices to risk premia; they analyze the long-term consequences of that link, including reserve management considerations that are specific to the oil market. Another related strand of the literature studies energy price shocks in New Keynesian models with nominal prices and wage rigidities, and compares core inflation and headline inflation targeting (Bodenstein, Erceg, and Guerrieri, 2008, 2011).

Methodologically, we follow the New Keynesian open economy literature in characterizing optimal policy and comparing different policy rules (Svensson, 2000; Gali and Monacelli, 2005; De Paoli, 2009). We enrich the New Keynesian framework with an explicit focus on commodities and also allow for some benefits of fixed exchange rates, inspired by the survey of Obstfeld (2020). Our work connects to business cycle models with terms-of-trade shocks more generally, with Mendoza (1995) as a classic reference.

Our framework captures different types of small open economies that take global prices as given. A given country's policy thus does not impact conditions in global commodity

[9] Earlier research on monetary policy for commodity *importers* has been conducted by Kormilitsina (2011), Natal (2012), and Catao and Chang (2015).

[10] Drechsel, McLeay, and Tenreyro (2019) study only one type of commodity that is exported, and focus on either perfect international risk sharing or autarky as the two polar cases for the international asset market structure. They specify a CES utility function with unitary elasticities as a special case of consumer preferences. Furthermore, they allow only domestic financial conditions to depend on commodity prices and not the international borrowing premium. We generalize all of these aspects of the framework.

[11] Amol et al. (2026) use a similar framework to Hevia and Nicolini (2013). Like us, they emphasize applicability to a range of countries, giving Chile and Ecuador as salient examples.

markets. Allowing for interactions between national policies and global prices, and a resulting scope for international coordination, is an interesting avenue for future research. Guerrieri, Lorenzoni, and Werning (2025) study international coordination of monetary policy in the face of global price shocks, in a framework that allows individual countries' policies to affect global price pressures.

Finally, our analysis of differently commodity-exposed economies is also loosely connected with studies that analyze macroeconomic outcomes and policy questions arising from international fragmentation, geopolitical tensions and trade wars. This literature is fast-growing, so we only include a few recent examples. Broadbent, Di Pace, Drechsel, Harrison, and Tenreyro (2024) study the consequences of the Brexit referendum for the UK economy. Ambrosino, Chan, and Tenreyro (2024) study if trade fragmentation leads to inflationary pressures and examine the optimal monetary policy response in a model with household heterogeneity. Bergin and Corsetti (2023), Auray, Devereux, and Eyquem (2024), Werning, Lorenzoni, and Guerrieri (2025), Bianchi and Coulibaly (2025), Itskhoki and Mukhin (2025), Kalemli-Özcan, Soylu, and Yildirim (2025), Monacelli (2025) and Auclert, Rognlie, and Straub (2025) all shed light on macroeconomic questions surrounding tariffs, from a variety of different angles.

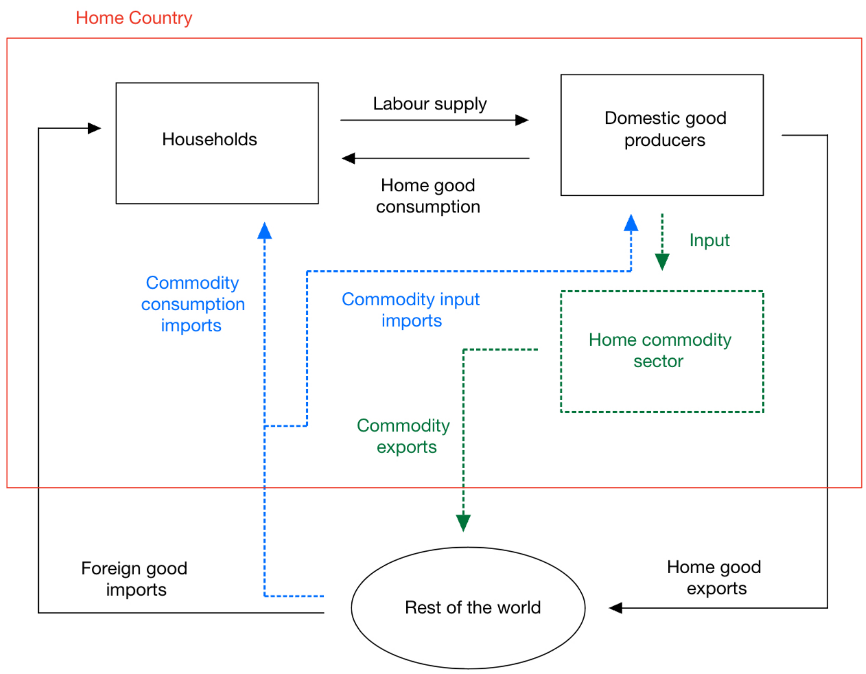
The applicability of our framework to a range of economies is a key contribution to the existing macroeconomic literature on commodities; this literature has typically focused on either emerging economies that export commodities, or advanced economies that import commodities, largely neglecting the link between commodity prices and risk premia.

2 Model

We first set out a general version of the model, for an economy which both exports and imports commodities. The model is flexible enough that we can then calibrate it to represent economies with different degrees of commodity exposure. In subsequent sections we focus separately on optimal policy for commodity importers and exporters.

Figure 1 summarizes the model structure. Households supply labor and consume a basket of goods containing: domestically produced goods; commodities imported from abroad, which we refer to as energy; and non-commodity differentiated import goods. Global commodity prices are exogenous from our small open economy's perspective. Domestic firms use commodities and labor as inputs to produce differentiated goods. These goods are consumed domestically, exported abroad, and also used as inputs into the domestic commodity sector. The commodity sector uses these goods as its only input, producing flexibly-priced commodities that are exported into competitive global markets.

Figure 1: MODEL OVERVIEW



2.1 Households

The economy is populated by a unit mass of households indexed by ι. Each household has lifetime expected utility given by

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

where C_t is total consumption, $N(\iota)_t$ is labor supply. β, σ and φ capture the discount factor, the inverse intertemporal elasticity of substitution, and the inverse Frisch elasticity.

As in Erceg et al. (2000), each household is a monopoly supplier of differentiated labor, at wage rate $W_t(\iota)$. Labor is bundled together as

$$N_t \equiv \left(\int_0^1 N_t(\iota)^{\frac{\chi-1}{\chi}} d\iota \right)^{\frac{\chi}{\chi-1}} \tag{2}$$

Cost minimization by firms or a labor aggregator, taking the wage rate as given, gives differentiated labor demand of:

$$N_t(\iota) = \left(\frac{W_t(\iota)}{W_t} \right)^{-\chi} N_t \tag{3}$$

where $W_t = \left(\int_0^1 W_t(\iota)^{1-\chi} d\iota \right)^{\frac{1}{1-\chi}}$ is the aggregate wage index. Households are subject to a Calvo (1983)–type friction in wage setting in domestic currency and may only change their wage each period with probability $1-\delta$. Households maximize utility 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

$$P_tC_t + Q_{t,t+1}D_{t+1} + Q^*_{t,t+1}\mathcal{E}_tB_{t+1} = W_tN_t + D_t + \mathcal{E}_tB_t\Phi(B_t, P^*_{\tilde{c},t-1}, P^*_{c,t-1}) + \Psi_t - T_t\ , \tag{4}$$

where $Q_{t,t+1}$ denotes the price of a domestic security, D_{t+1}; $Q^*_{t,t+1}$ is the price of an internationally traded bond, B_{t+1}; W_t is the wage rate, Ψ_t is a rebate of profits and T_t is lump-sum taxation.

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. The issuer pays back one unit of foreign currency multiplied by a risk premium, $\Phi(B_t, P^*_{\tilde{c},t-1}, P^*_{c,t-1})$. The risk premium depends on the level of external debt $(-B_t)$, as in Schmitt-Grohe and Uribe (2003). It is normalized to one in steady state and households do not internalize that the level of bond holdings affects it.

We also allow the risk premium to depend on global commodity prices $P^*_{\tilde{c},t}$ and $P^*_{c,t}$. P^*_c is the price of exported commodities, which may differ from that of imported commodities, $P^*_{\tilde{c}}$. The risk premium increases in the price of the imported commodity and decreases in the price of the exported commodity and the level of bond holdings.

The dependence of countries' risk premia on commodity price fluctuations has been highlighted by previous research. For the case of exported commodities, the connection is a key mechanism in the macroeconomic models of Shousha (2016), Drechsel and Tenreyro (2018), and Fernández et al. (2018). Empirical evidence is provided for a set of emerging economy bond market spreads by Bastourre et al. (2012) and for different debt instruments in Argentina by Drechsel and Tenreyro (2018).[12] Note also that Miranda-Agrippino and Rey (2020) measure the global financial cycle as a common factor in both corporate bond indices and commodity price series. When it comes to the distinction between exported and imported commodities, several papers find that they move sovereign spreads in different directions, in line with what we will assume. See Alturki and Hibbert (2021) and Cohen et al. (2025) for recent evidence. Juvenal and Petrella (2024) highlight broader connections between international commodity price cycles and the global financial cycle. Di Pace et al. (2025) show that terms trade shocks have very different effects depending on whether they primarily shift import or export prices.

Total consumption is a CES aggregate of domestic and foreign goods,

$$C_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}}C_{h,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}}C_{f,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{5}$$

[12] For example, Bastourre et al. (2012) document a correlation between a common factor of emerging economy bond returns and a common factor of commodity prices to be -0.81. Drechsel and Tenreyro (2018) find that a 10% deviation of commodity prices from their long-run mean moves Argentine real interest spread by almost 2 percentage points.

with corresponding price index $P_t = \left[(1-\alpha)P_{h,t}^{1-\eta} + \alpha P_{f,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}$. $C_{h,t}$ is a bundle of consumption goods produced in the domestic economy ('home'), given by

$$C_{h,t} \equiv \left(\int_0^1 C_{h,t}(i)^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{6}$$

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

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

$$C_{f,t} \equiv \left[(1-\alpha_{\tilde{c}})^{\frac{1}{\vartheta}} C_{nc,t}^{\frac{\vartheta-1}{\vartheta}} + \alpha_{\tilde{c}}^{\frac{1}{\vartheta}} C_{\tilde{c},t}^{\frac{\vartheta-1}{\vartheta}}\right]^{\frac{\vartheta}{\vartheta-1}}, \tag{7}$$

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.

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 applies 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.

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

$$\mathcal{T}_t \equiv \frac{P_{f,t}}{P_{h,t}}. \tag{8}$$

The demand functions for home and foreign goods can be derived from the usual expenditure minimization problems:

$$C_{h,t} = (1-\alpha)\left(\frac{P_{h,t}}{P_t}\right)^{-\eta} C_t\,, \qquad C_{f,t} = \alpha\left(\frac{P_{f,t}}{P_t}\right)^{-\eta} C_t \tag{9}$$

Demand for foreign goods can be split into the two subcategories as:

$$C_{nc,t} = (1-\alpha_{\tilde{c}})\left(\frac{P_{nc,t}}{P_{f,t}}\right)^{-\vartheta} C_{f,t}\,, \qquad C_{\tilde{c},t} = \alpha_{\tilde{c}}\left(\frac{P_{\tilde{c},t}}{P_{f,t}}\right)^{-\vartheta} C_{f,t} \tag{10}$$

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

$$C_{h,t}(i) = \left(\frac{P_{h,t}(i)}{P_{h,t}}\right)^{-\epsilon} C_{h,t}. \tag{11}$$

Defining $\mathcal{E}_t$ as the nominal exchange rate, then 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 $P_{h,t} = \mathcal{E}_t P_{h,t}^*$, where asterisks denote foreign prices. The law of one price also holds at the variety level. For our small open economy, we take the limit where $\alpha^* \to 0$. We also assume that the foreign price basket includes only the non-commodity good ($\alpha_{\tilde{c}}^* = 0$), following Catao and Chang (2015). The foreign price level is therefore $P_t^* = P_{nc,t}^*$, and the real exchange rate is given by

$$S_t \equiv \frac{\mathcal{E}_t P_t^*}{P_t} = \frac{\mathcal{E}_t P_{nc,t}^*}{P_t} = \frac{\mathcal{T}_t}{\left[(1-\alpha)+\alpha\mathcal{T}_t^{1-\eta}\right]^{\frac{1}{1-\eta}}} \frac{\mathcal{E}_t P_{nc,t}^*}{P_{f,t}}. \tag{12}$$

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

$$C_{h,t}^* = \alpha^* \left(\frac{P_{h,t}^*}{P_t^*}\right)^{-\eta} C_t^* = \alpha^* \left(\frac{P_{h,t}^*}{P_{nc,t}^*}\right)^{-\eta} C_t^*. \tag{13}$$

Foreign preferences across varieties are symmetric to those of home households:

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

In our quantitative results, we focus particularly on the special case of Cole-Obstfeld preferences (Cole and Obstfeld, 1991), with $\sigma = \eta = \vartheta = 1$ and $\sigma^* = \eta^* = \vartheta^* = 1$.[13]

The first order condition for D_{t+1} gives the Euler equation

$$Q_{t,t+1} = \mathbb{E}_t\left[\beta \frac{1}{\Pi_{t+1}}\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\right] \tag{15}$$

where $\Pi_{t+1} \equiv \frac{P_{t+1}}{P_t}$ denotes gross CPI inflation.[14] This can be combined with the first order condition for B_{t+1} to give the uncovered interest parity (UIP) condition:

$$\frac{1}{Q_{t,t+1}}\mathbb{E}_t\left[\frac{1}{\Pi_{t+1}}\frac{C_t}{C_{t+1}}\right] = \frac{\Phi\left(B_{t+1}, P_{\tilde{c},t}^*, P_{c,t}^*\right)}{Q_{t,t+1}^*}\mathbb{E}_t\left[\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}\frac{1}{\Pi_{t+1}}\frac{C_t}{C_{t+1}}\right] \,. \tag{16}$$

The UIP condition clearly reveals the role of the risk premium term Φ in the country's external borrowing decisions. Our model abstracts from a dollarized-liability channel, as emphasized for example by Cook (2004).[15]

The optimality condition for a wage setter at time t is

$$\sum_{T=t}^{\infty}(\beta\delta)^{T-t}C_T^{-\sigma}N_T(\iota)\left[\frac{W_t^\star(\iota)}{P_T} - \frac{\chi}{\chi-1}\frac{1}{1+\varsigma_w}\frac{N_T(\iota)^\varphi}{C_T^{-\sigma}}\right] = 0 \,, \tag{17}$$

[13] This gives log utility in consumption, $C_t \equiv \frac{C_{h,t}^{1-\alpha}C_{f,t}^{\alpha}}{\alpha^\alpha(1-\alpha)^{1-\alpha}}$, and $C_{f,t} \equiv \frac{C_{nc,t}^{1-\alpha_{\tilde{c}}}C_{\tilde{c},t}^{\alpha_{\tilde{c}}}}{\alpha_{\tilde{c}}^{\alpha_{\tilde{c}}}(1-\alpha_{\tilde{c}})^{1-\alpha_{\tilde{c}}}}$, so that $P_{f,t} \equiv P_{nc,t}^{1-\alpha_{\tilde{c}}}P_{\tilde{c},t}^{\alpha_{\tilde{c}}}$, with the home economy CPI given by $P_t \equiv P_{h,t}^{1-\alpha}P_{nc,t}^{\alpha(1-\alpha_{\tilde{c}})}P_{\tilde{c},t}^{\alpha\alpha_{\tilde{c}}}$.

[14] In addition, the household problem implies the standard transversality conditions for domestic and foreign assets: $\lim_{T\to\infty}\mathbb{E}_0\left[\beta^T\left(\frac{C_0}{C_T}\right)^{\sigma}\frac{D_T}{P_T}\right] = 0$ and $\lim_{T\to\infty}\mathbb{E}_0\left[\beta^T\left(\frac{C_0}{C_T}\right)^{\sigma}\frac{\mathcal{E}_T B_T}{P_T}\right] = 0$.

[15] The correlation between commodity prices and risk premia might make such a channel relevant especially in the presence of occasionally binding collateral constraints (Fornaro, 2015; Ottonello, 2021). In part, our assumption is motivated by a new trend among developing and emerging economies to move away from dollar liabilities (Du and Schreger, 2022; Engel and Park, 2022). Introducing such a channel might imply a stronger advantage of reducing exchange rate volatility.

where $W_t^\star(\iota)$ is the optimal reset wage in period t and ς_w is a government subsidy that offsets the mark up at steady state. We also denote $W_t^r \equiv \frac{W_t}{P_t}$ as the real consumption wage, $W_{h,t}^r \equiv \frac{W_t}{P_{h,t}}$ as the real producer wage and $\Omega_{t+1} \equiv \frac{W_{t+1}}{W_t}$ as nominal wage inflation.

2.2 Domestic good sector

Domestic good firms, indexed by i, produce with labor $N_t(i)$, and imported commodities $X_{\tilde{c},t}(i)$, which are used as inputs in production. They pay 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. Profits are rebated to households. The technology of firm i is given by the CRS production function

$$Y_{h,t}(i) = A_{h,t} N_t(i)^{1-\mu} X_{\tilde{c},t}(i)^{\mu} \,, \tag{18}$$

while demand is given by

$$Y_{h,t}(i) = \left(\frac{P_{h,t}(i)}{P_{h,t}} \right)^{-\epsilon} Y_{h,t} \,. \tag{19}$$

This follows from the consumer problem in the home country and abroad and from the demand from the commodity exporting sector described below.

The first order condition of firm i is

$$\mathbb{E}_t \left[\sum_{T=t}^{\infty} \theta^{T-t} Q_{t,T} Y_{h,t,T}(i) \left(P_{h,t}^\star(i) - \frac{\epsilon}{\epsilon - 1} MC_T(i) \right) \right] = 0. \tag{20}$$

where $P_{h,t}^\star(i)$ is the optimal reset price in period t, 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 minimization implies that marginal costs are equal across firms and given by:

$$MC_t(i) = \frac{1}{1+\varsigma} \frac{N_t(i) W_t}{(1-\mu) Y_{h,t}(i)} = \frac{1}{1+\varsigma} \frac{X_{\tilde{c},t}(i) P_{\tilde{c},t}}{\mu Y_{h,t}(i)} \tag{21}$$

where ς is a production subsidy given by the government, and combining with (18):

$$MC_t = \frac{1}{1+\varsigma} \frac{W_t^{(1-\mu)} P_{\tilde{c},t}^{\mu}}{(1-\mu)^{(1-\mu)} \mu^{\mu} A_{h,t}}. \tag{22}$$

The equality of marginal costs implies that all firms resetting prices at time t choose the same price, and hence the same level of production and inputs.

The aggregate production function is given by

$$Y_{h,t} = \frac{A_{h,t} N_t^{(1-\mu)} X_{\tilde{c},t}^{\mu}}{\Delta_t}, \tag{23}$$

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 in models with Calvo pricing $\Delta_t = \int_0^1 \left(\frac{P_{h,t}(i)}{P_{h,t}}\right)^{-\epsilon} di$.

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

$$Y_{c,t} = A_{c,t} M^{\nu}_{h,t}, \tag{24}$$

where $0 < \nu < 1$ reflects the presence of decreasing returns in the sector. This structure closely follows Drechsel, McLeay, and Tenreyro (2019). Profits from the commodity sector are rebated as a lump sum payment to the household. Profit maximization gives

$$P_{c,t} \nu A_{c,t} M^{\nu-1}_{h,t} = P_{h,t}. \tag{25}$$

Rearranging (25) gives

$$M_{h,t} = \left(\nu \frac{P_{c,t}}{P_{h,t}} A_{c,t}\right)^{\frac{1}{1-\nu}} = \left(\nu A_{c,t} \mathcal{T}_t \frac{P^*_{c,t}\mathcal{E}_t}{P_{f,t}}\right)^{\frac{1}{1-\nu}} . \tag{26}$$

Different varieties of final goods are used and demanded according to the same CES aggregator as for consumption so that $M_{h,t}(i) = \left(\frac{P_{h,t}(i)}{P_{h,t}}\right)^{-\epsilon} M_{h,t}$.

2.4 Market clearing and equilibrium

For all t, aggregate domestic goods market clearing gives

$$C_{h,t} + C^*_{h,t} = Y_{h,t} - M_{h,t} , \tag{27}$$

and domestic securities are in zero net supply

$$D_{t+1} = 0 , \tag{28}$$

while the foreign bond is in perfectly elastic supply at the world interest rate, up to the country-specific risk premium. The government uses lump-sum taxation to finance subsidies offsetting monopolistic distortions in wage and price setting and runs a balanced budget. We close the model using four alternative monetary policies: a strict domestic inflation targeting rule; a strict CPI targeting rule; an exchange rate peg; and the benchmark optimal commitment policy plan.

Given monetary policy determining the interest rate i_t (or equivalently the bond price $Q_{t,t+1}$), exogenous global prices $P^*_{c,t}$, $P^*_{\tilde{c},t}$ and $P^*_{nc,t}$, foreign interest rate i^*_t, (equivalently the foreign bond price $Q^*_{t,t+1}$), foreign aggregate consumption C^*_t, productivity in final good production $A_{h,t}$ and commodity exporting sector $A_{c,t}$, initial conditions on price dispersion and wage dispersion, and asset holdings, an equilibrium is given by a sequence of aggregate quantities, $\{C_t, C_{h,t}, C^*_{h,t}, C_{f,t}, C_{\tilde{c},t}, C_{nc,t}, N_t, D_{t+1}, B_{t+1}, Y_{h,t}, X_{\tilde{c},t}, Y_{c,t}, M_{h,t}, \Psi_t, T_t\}_{t=0}^{\infty}$, and prices, $\{P_t, P_{h,t}, P^*_{h,t}, P_{f,t}, P_{\tilde{c},t}, P_{nc,t}, W_t, Q_{t,t+1}, P_{c,t}, \mathcal{T}_t, S_t, \mathcal{E}_t, \Delta_t\}_{t=0}^{\infty}$ so that agents maximize their utility and profits, the government budget is balanced, prices satisfy the law of one price and aggregation conditions, and markets clear.

3 Model intuition and application

In this section, we highlight some of the intuition underlying our model mechanism and results and then turn to the model's application.

3.1 Intuition

To highlight the main intuition behind the model's mechanisms, we use the log-linearized version of the model.[16] The full model equations are listed in Appendix B.

Inflation. The linearized equation for CPI inflation is given by:

$$\hat{\pi}_t = \frac{\alpha}{1-\alpha}\left[\Delta\hat{s}_t + \alpha_{\tilde{c}}(\Delta\hat{p}^*_{\tilde{c},t} - \hat{\pi}^*_t)\right] + \kappa\mathbb{E}_t\sum_{i=0}^{\infty}\beta^i \hat{m}c^r_{t+i}, \tag{29}$$

$$\hat{m}c^r_t = w^r_{h,t} + \mu(\hat{p}^*_{\tilde{c},t} - \hat{w}_t + \hat{e}_t) - \hat{a}_{h,t}, \tag{30}$$

where lowercase letters with hat represent percentage deviations from steady state.

This equation highlights the channels through which commodity prices, the exchange rate, and the labor market affect inflation:

1. For a commodity importer, there are **direct CPI effects** on the inflation basket, given by $\frac{\alpha\alpha_{\tilde{c}}}{1-\alpha}\Delta\hat{p}^*_{\tilde{c},t}$.
2. There are also **indirect effects**, via domestic production, as a higher path for $\mu\hat{p}^*_{\tilde{c},t}$ (relative to domestic wages, expressed in foreign currency) increases domestic inflation via higher real marginal costs.
3. For both commodity importers and exporters, there is an **exchange rate impact**, whereby a real depreciation increases import-price inflation.
4. There is a standard **labor market channel**, as higher real producer wages, $\hat{w}^r_{h,t}$ increase domestic inflation via higher real marginal costs.

[16] As discussed in the next section, we log-linearize the model around an efficient steady state with relative prices normalized to 1, and a zero initial net foreign asset position.

Trade balance. The linearized trade balance can be written as:[17]

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

where the parameter $s_{m,ss}$ denotes the steady state share of home production used as materials in commodity production; $s_{c*,ss}$ denotes the share exported directly to foreign consumers; and $s_{c,ss}$ denotes 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, generating a **windfall income channel**.
2. Given higher profit margins, competitive commodity exporting firms are incentivized 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 $\alpha_{\tilde{c}}\hat{p}^*_{\tilde{c},t}$, scaled up by steady state consumption of foreign good, worsening the trade balance.

Commodity exports are priced in a global currency (e.g. the dollar), and importantly, these exports are competitive, with high demand elasticities and flexible prices, so exports are also sensitive to the currency, as in McLeay and Tenreyro (2026). When $s_{c^*,ss} > 0$, the economy also exports monopolistic, sticky price goods priced in producer currency. There is also a **global demand channel**, captured by $\hat{c}^*_t$, independent 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 characterize consumption by solving forward households' Euler equation, and using the UIP condition, to give:

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

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 rise in the risk premium will be the source

[17] We linearize around a steady state with balanced trade and zero bond holdings. We define the deviations $\hat{tb}_t$ as trade balance at time t divided by steady state value of home final good production, $\hat{tb}_t = \frac{TB_t}{P^*_h Y_h}$ (here we define the trade balanced in terms of foreign prices), where values in capital letters without time subscripts denote steady state values.

of starker trade-offs for emerging markets: exporters following a commodity price fall; and importers after a commodity price increase.

3.2 Calibration

Our model is parsimonious enough that we can distinguish between four different types of economies: advanced economies that are commodity exporters, such as Australia, Norway, Canada; emerging and developing economies that are commodity exporters, such as Argentina, Chile, and Ghana; advanced economies that are commodity importers, such as Germany, Italy, and Japan; as well as emerging and developing economies that are commodity importers, such as India, Vietnam, Turkey, Eastern European countries. We distinguish between these alternative cases by just varying a few key parameters, which we summarize 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
$\alpha_{\tilde{c}}$	Consumption share of imp comm.	0.001	0.25

The risk premium sensitivity with respect to level debt ϕ_b is set with close reference to the literature. For emerging economies, the value of 2.8 corresponds to the estimate of García-Cicco et al. (2010), which is also used in the model calibration of Drechsel and Tenreyro (2018).[18] For advanced economies, ϕ_b needs to be minimally greater than zero to close the model, as discussed in Schmitt-Grohe and Uribe (2003). However, we want it to be small enough to not otherwise impact the model's dynamics. We choose a value that corresponds to the emerging economy case but is smaller by a factor of 1,000.

For the risk premium sensitivity with respect to commodity prices, we use empirical estimates provided by the literature. Drechsel and Tenreyro (2018) estimate the semi-elasticity of emerging economy interest rate spreads to price of export commodities to be around 0.2, which we set as the value for ϕ_c.[19] Again, we reduce the corresponding advanced

[18] To provide more detail, this is the posterior estimate from the estimation of a small open economy DSGE model on macroeconomic data from Argentina.

[19] To provide more detail, Drechsel and Tenreyro (2018) regress a number of Argentine interest rate spreads on an international commodity price index. Their lowest estimate in absolute value that is statistically significant corresponds to a semi-elasticity of 0.199, so roughly 0.2.

economy value by a factor of 1,000. The parameter for commodity imports $\phi_{\tilde{c}}$ is set to the same values, for symmetry.

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 (2026). The output share of monopolistic, sticky price export goods (i.e. $\frac{C_h^*}{Y_h}$) is set to a very low level. For advanced economies, this is set to 0.3, which ensures that around three-quarters of steady-state exports are monopolistic domestic goods.

For commodity exporters, we switch off commodity imports by setting the parameters governing these, μ and $\alpha_{\tilde{c}}$, to a low level. For commodity importers, these are set so that in steady state, 20% of intermediate inputs and 10% of direct consumption are of the imported commodity.The remaining, common parameters are given in Table 2 and take standard values used in the literature.

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	1	Galí (2008)
β	Discount factor	0.9963	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%
$1-\delta$	Wage re-set probability	0.25	Same as prices
χ	Labor elasticity of substitution	4	Erceg et al. (2000)
ν	Returns of scale in comm. prod.	0.6	Gives $s_{m,ss} = 0.4$ in EM Imp.
κ	Implied price setting slope	0.08426	
κ_w	Implied wage setting slope	0.01685	

4 Welfare

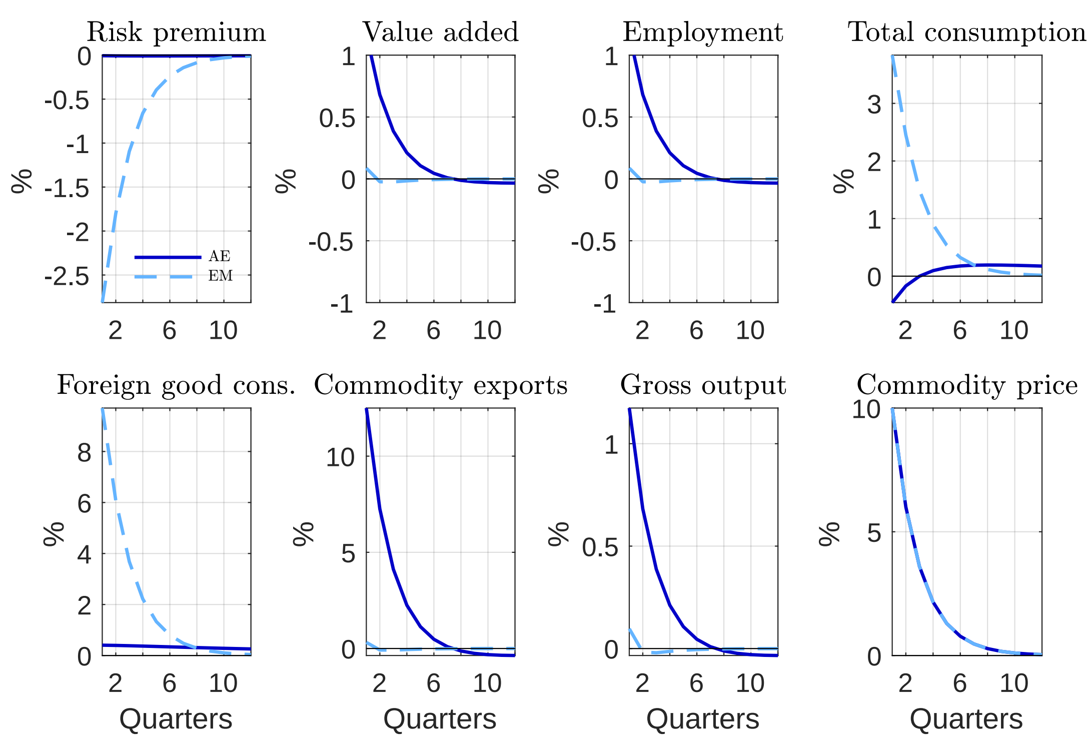
In this section of the paper we examine the welfare-optimal responses to commodity price shocks in our different economies. We first explore the efficient allocation that would obtain under a benevolent social planner. We then derive a quadratic second-order approximation to the representative household's utility, and use this to calculate the welfare-optimal commitment policy in each economy.

4.1 Social planner's allocation

We first calculate the social planner's solution assuming that the planner maximizes household utility taking production, resource constraints and international prices as given. We focus on the special case of Cole-Obstfeld preferences ($\sigma = \eta = \vartheta = 1$), but show variants for alternative substitution elasticities in Appendix D.1, and discuss their implications in Section 6. The social planner's solution is 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 internalize the impact of asset holdings on the premium. To build intuition, we discuss these benchmark allocations in each case. These allocations closely correspond with the natural allocations that arise under flexible prices and wages: the externality imposed by the risk premium is quantitatively small, even for a large risk premium.

Commodity exporter. Figure 2 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. A rise in commodity prices is equivalent to a positive productivity shock for its commodity output. At a given exchange rate, households can transform their labor into a greater amount of (foreign) consumption than before. With temporarily higher commodity prices (or productivity), it would be efficient for the economy to save more at unchanged international interest rates. The efficient response differs markedly between advanced and emerging economies, however, since the financial friction leads to different interest rates in each case.

Figure 2: SOCIAL PLANNER RESPONSE TO COMMODITY EXPORT PRICE SHOCK FOR COMMODITY EXPORTER



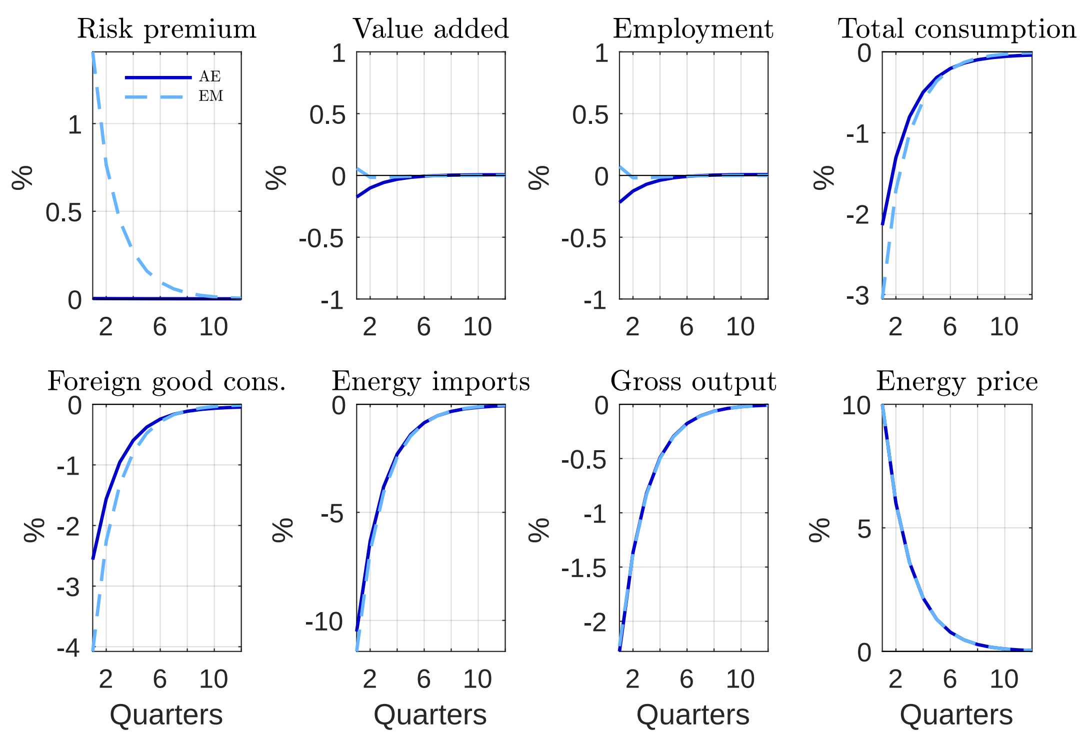
Note: IRFs to a 10% positive commodity export price shock with efficient or natural response. The results are generated under the calibration shown for a commodity exporter in Tables 1 and 2.

In the **advanced economy**, the interest rate is little changed. The planner therefore 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. Agents reap the benefits of this in future periods, as higher savings are used to fund greater foreign consumption (and reduced labor input).

In our **emerging economy**, in contrast, the risk premium co-moves strongly with the commodity price. With higher commodity prices, the risk premium faced by the small open economy falls sharply. From the planner's perspective, they face a lower effective path of interest rates. As a result it is efficient for agents to save less: employment and output are little changed, and it is efficient for some of the windfall income to be spent on greater consumption of foreign exports.

Commodity importer. Figure 3 shows the equivalent efficient responses in our commodity importing economies. In these cases, given unit elasticities of substitution, the planner's solution involves little change to employment or value-added production. Instead, commodity imports are cut such that expenditure on the commodity is unchanged. Given its dual use as a consumption good and intermediate input, this leads to falls in gross output and home good consumption, as well as to foreign good consumption imports.

Figure 3: SOCIAL PLANNER RESPONSE TO COMMODITY 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.

The size of the consumption response differs in each economy type, again owing to the financial friction. In the **advanced economy**, with an unchanged world interest rate, the planner requires consumption to fall by around 2% in response to a 10% commodity price increase. In the **emerging economy**, there is also a rise in the risk premium. Facing a higher effective interest rate, it is efficient for the emerging economy to cut consumption by more – around 3%. This extra saving also reduces the rise in the risk premium.

Discussion. A key feature of these results concerns the cyclical behavior of consumption. In emerging economies, it is efficient for consumption to respond significantly more pro-cyclically than in advanced economies in response to energy shocks, whether an importer or an exporter. Our model therefore rationalizes part of the observed consumption volatility in emerging economies as the efficient response of the economies to commodity price shocks. Crucial to this result is that the planner takes the financial friction as exogenous. When faced with higher commodity import prices/lower commodity export prices, the planner cannot offset the exogenous part of the risk premium increase, and the economy responds via a reduction in consumption.

4.2 Optimal monetary policy

We derive the optimal monetary policy under commitment using the linear-quadratic approximation method in Benigno and Woodford (2012). To do so, we first carry out a second-order approximation of utility, and then derive a quadratic expression with no linear terms that is equivalent to the second-order approximation of utility at the efficient level, under the constraints of the model. The presence of commodities as intermediate inputs in production precludes a compact representation of the loss function. We detail the full derivation in Appendix C.

As in related work (Gali and Monacelli, 2005; Erceg, Henderson, and Levin, 2000), the sources of welfare loss can be decomposed into (i) domestic good price dispersion from domestic price inflation, owing to sticky nominal prices; (ii) wage dispersion from wage inflation, owing to stick nominal wages; (iii) departures from the efficient levels of aggregate labor and consumption that would be achieved by a benevolent social planner. In the next section, we examine variability in the first two components, as well as the gap between output and its efficient level.

5 Commodity price shocks in different economies

In this section we use our model to compare the performance of different monetary policy and exchange rate frameworks in response to commodity price shocks.[20] We examine how the optimal response varies according to economies' commodity exposure (whether they

[20] The commodity price shock affects the economy on impact and wanes over time. For different shock profiles and their impact on inflationary pressures, see Ambrosino et al. 2024.

are exporters or importers or both); and how it is affected by the presence of endogenous financial conditions. In doing so, we also offer explanations for the different choices made by advanced and emerging economies.

We present results separately for the different cases set out in the previous section, which helps delineate the different commodity channels. To build intuition, we focus initially on the simpler case of advanced economies, not subject to varying financial conditions. We first study a commodity exporter in response to an increase in the prices of those commodities. Second, we examine the response of an energy importer, facing an increase in the price of energy. We then explore how these results change for emerging economies, where the main distinction is that commodity price swings affect their international borrowing conditions. In practice, there is unlikely to be such a clear separation between importers and exporters: commodity exporters also use energy and other commodities in consumption and production; while emerging markets tend to export commodity-like goods, even if they do not export commodities. We therefore discuss correlated shocks to the global prices of import and exports.

For each case, we examine four types of monetary policy settings. As our benchmark, we examine the optimal commitment policy derived in the previous section. While a useful benchmark, this policy is one that may be challenging for policymakers to implement in practice. It is not time consistent, so may not be credible. It may also require complex or extreme instrument reactions to achieve, which again, may not be credible (nor robust to uncertainty about the transmission mechanism).

We therefore compare our benchmark to three alternative simple policy rules, which approximate well the type of policy behaviors attempted by different central bank policymakers. Specifically, we study the economy when the policymaker seeks to implement a fixed exchange rate - a common strategy in many emerging and developing economies. We compare the volatility and performance of the key welfare-relevant variables with two strict inflation-targeting rules. The first targets zero CPI inflation, $\hat{\pi}_t = 0$, a strict version of the flexible inflation-targeting mandates that most central banks have as operational targets. The second restricts any volatility in domestic inflation, with $\hat{\pi}_{h,t} = 0$. This second rule approximates a common strategy for flexible inflation targeting central banks – which is to 'look through' the direct impact of energy-price shocks on CPI, while responding to their 'second-round' effects on domestic inflation.

Our main finding is that the welfare ranking across the three different frameworks is dependent on the economy's commodity exposure. Of our three simple rules, domestic price stability performs best in economies faced by pure commodity export price shocks, but worst following commodity import price shocks. Exchange-rate pegs can achieve higher welfare in the pure import price shock case, in line with earlier results by Hevia and Nicolini (2015). But this finding is not robust when global commodity export prices are positively correlated with commodity import prices. More robustly, across different cases and specifications, we find that the optimal policy allows relatively little variation in wage inflation. We discuss how this is consistent with the idea that credible flexible inflation targeting frameworks can achieve good outcomes by focusing on wage inflation, rather than domestic price inflation measures such as producer or services inflation, as these can still be strongly influenced by commodity prices.

5.1 Commodity exporters

Figure 4 shows our example advanced economy's response to a 10% increase in commodity export prices under different monetary rules. The optimal response (black dashed lines) to the temporary increase in commodity prices is to increase commodity export production. It is efficient to divert domestic goods to the commodity sector, which can more productively turn them into (foreign good) consumption. The constraint on the commodity expansion is supply capacity – decreasing returns to scale drive up the marginal cost of production, until the marginal value product of labor in the commodity sector falls back to its original level. This means that the efficient real producer wage is unaffected, and so the efficient level of output can be achieved by stabilizing both domestic prices and wages.

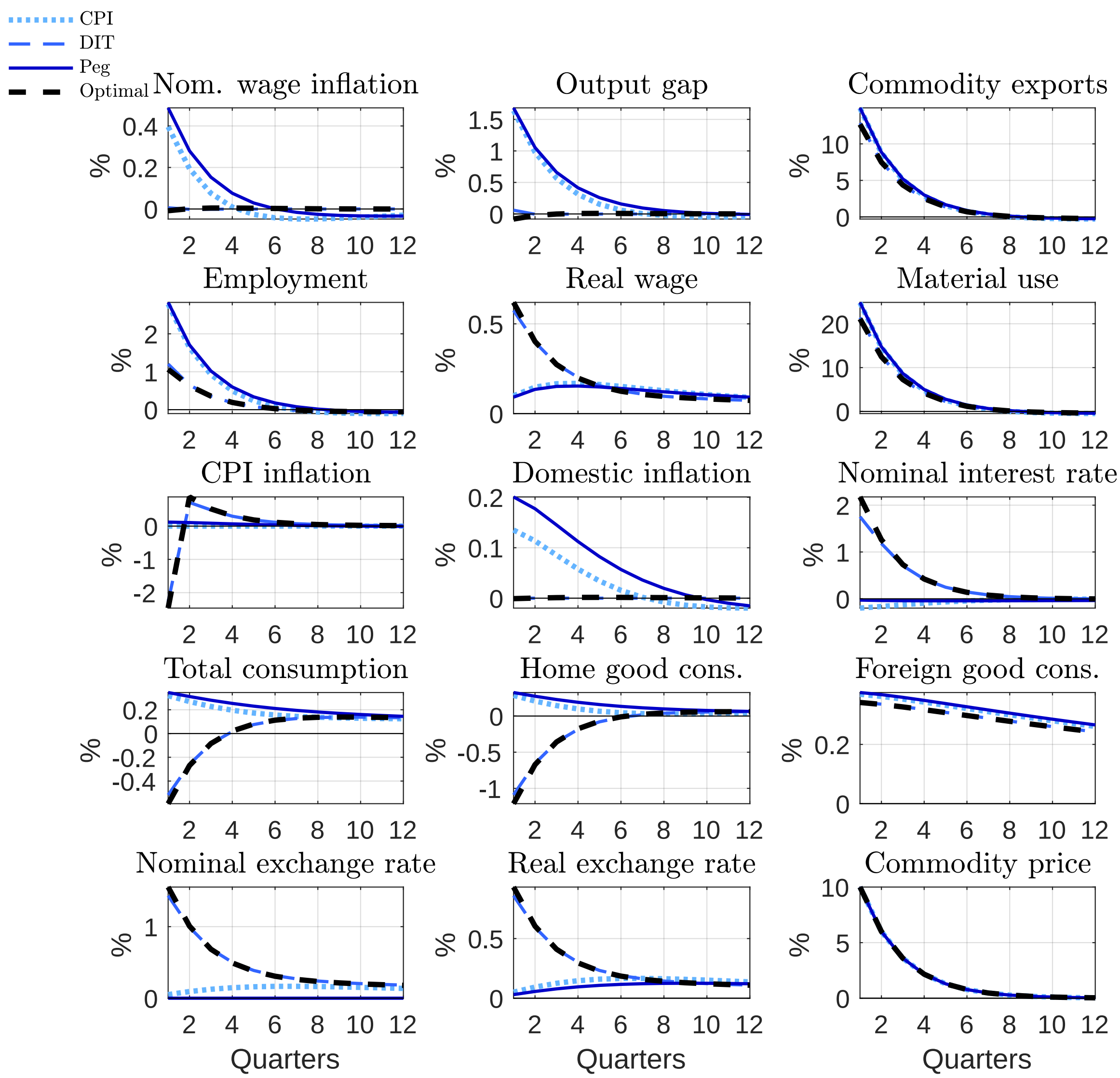
Comparing across policy rules, strict domestic inflation targeting is therefore approximately optimal, while strict CPI inflation targeting and exchange-rate pegs lead to worse welfare outcomes. Stable domestic prices can simultaneously stabilize aggregate wages, minimizing losses from price and wage dispersion, while also maintaining output and consumption at their efficient levels. The increase in commodity production results from a combination of higher employment and, since some home goods are substituted into commodity production, lower consumption. To achieve this, the real exchange rate optimally appreciates, leading to a sharp fall in CPI inflation.

The exchange-rate peg, in contrast, generates an inefficient boom in employment and consumption, causing above target domestic inflation and wage inflation, and a positive output gap. Rather than tightening policy to appreciate the nominal exchange rate, the peg requires keeping policy sub-optimally loose, such that the commodity price rise increases demand for domestic goods. Strict CPI targeting can be seen as an average of strict domestic inflation targeting and a peg. It also prevents the optimal appreciation (since this would feed through to CPI), and results in a similar inefficient boom to the exchange-rate peg. In either case, a smaller real appreciation occurs, owing to the price rise, rather than a significant nominal appreciation.

The optimality of stable domestic prices matches the standard result in Gali and Monacelli (2005). The addition of a commodity export sector to our model, under imperfect risk sharing, even with wage and price rigidities, does not change this. Key to this finding is that while wages and domestic good prices are sticky, commodity export prices are flexible, consistent with the Mixed Currency Pricing model and evidence supporting it in McLeay and Tenreyro (2026). With flexible prices, adjustments in the global price of commodities do not introduce any dispersion in prices across firms.

While stable domestic prices are optimal in the model, there are reasons why commodity

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 and Cole-Obstfeld preferences. The results are generated under the calibration shown in Tables 1 and 2. Wage and price inflation and interest rates are shown in annualized percent. The nominal exchange rate is plotted as $-\hat{e}_t$ so that an increase corresponds to an appreciation.

Table 3: IMPLIED STANDARD DEVIATIONS ACROSS POLICIES - COMM. EXPORT PRICE SHOCK IN AE

	CPI inf. target	Dom. inf. target	Nominal peg	Optimal
CPI inflation	0.00	0.62	0.05	0.68
Domestic inflation	0.05	0.00	0.09	0.00
Efficient output gap	1.99	0.15	2.11	0.17
Nom. wage inflation	0.12	0.00	0.15	0.00
Welfare loss vs. opt. (pp)	0.09	0.00	0.12	0.00

exporters may be less keen on the policy in practice. Table 3 shows that the volatility of CPI inflation is higher under strict domestic inflation targeting than the alternatives. While typical advanced-economy policy frameworks tend to target measures of inflation, with freely floating exchange rates, CPI inflation is the usual target. Even flexible inflation-targeting central banks may feel they are not able to fully ignore exchange-rate induced CPI volatility, without damaging their credibility. Similarly, to the extent there are additional costs (outside of the model) associated with exchange-rate volatility, these may make implementing a strict domestic inflation target less optimal. The last row in Table 3 reports the welfare loss from each policy rule with respect to optimal policy in percentage points, as derived in Appendix C. Stabilizing CPI or pegging may not be very costly after all in welfare terms since the the welfare loss compared to optimal policy is in both cases around one tenth of a percentage point.

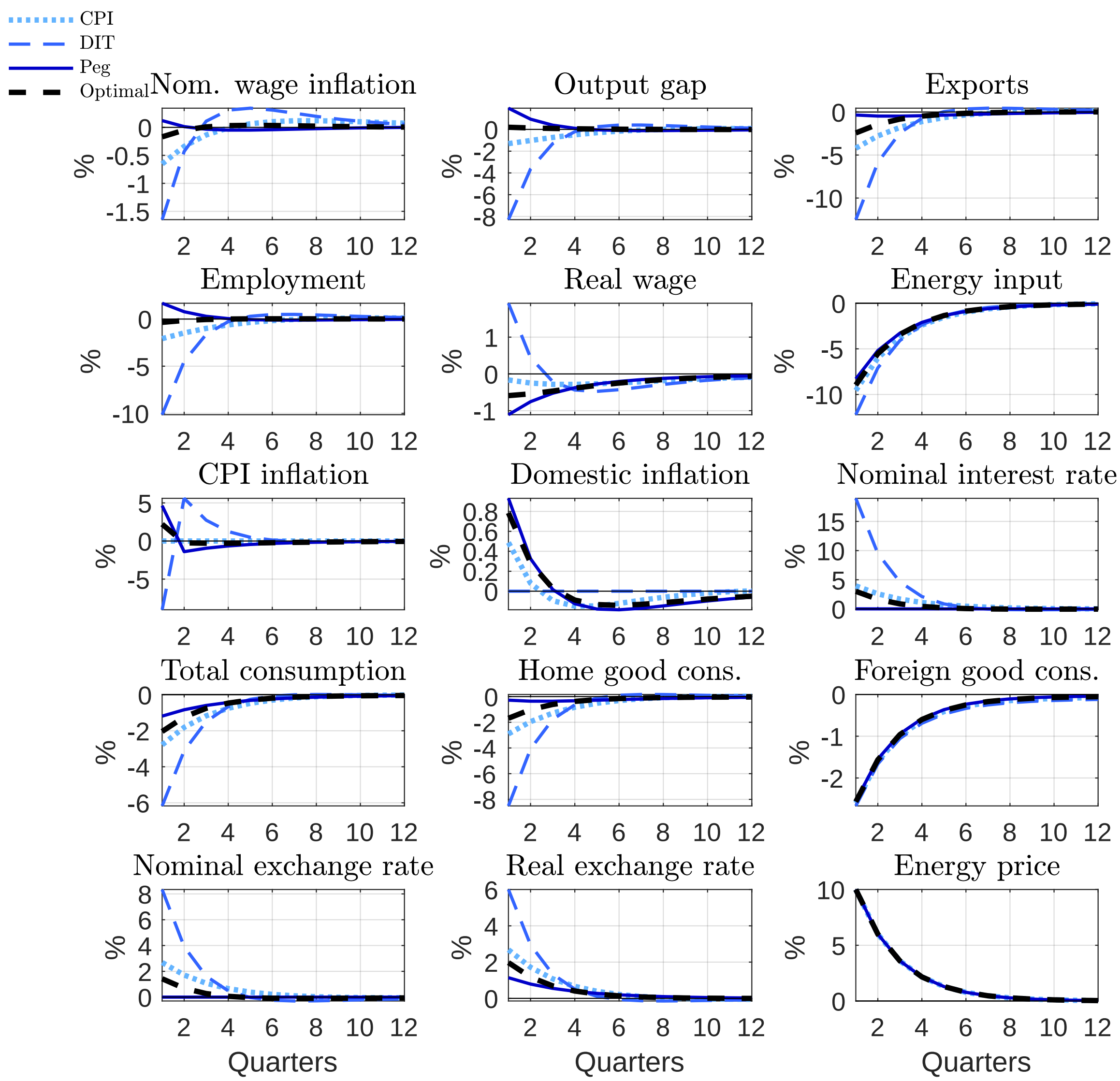
5.2 Energy importers

Figure 5 examines an example advanced economy energy *importer*, facing a 10% positive price shock. The energy price increase has a direct effect on CPI inflation, where it makes up 10% of the consumption basket, as well as an indirect effect via its effect on domestic good production, which has an energy intensity of 20%. This role of energy as an input in production drives a wedge between domestic price inflation and wage inflation, creating a trade-off for the policymaker that is not present for commodity export price shocks. This occurs because there are two sets of nominal rigidities (sticky prices and wages), and because the shock affects a sticky price sector, rather than only a flexible price one. The increase in input costs reduces the efficient real producer wage, requiring higher domestic prices or lower wages. The direct effects on CPI inflation coming from exogenously higher energy prices do not lead to the same difficulties, since they do not affect the sticky-price sector.

Faced with a choice of stabilizing domestic prices or wages, the benchmark optimal policy involves most of the adjustment taking place through higher domestic price inflation, with wage inflation only falling slightly. Quantitatively, more significant wage deflation requires a large reduction in employment below its efficient level, generating a large negative output gap. The policymaker optimally prefers to let the adjustment come through higher prices of energy-intensive goods, with little change in the level of employment or value-added. Consumption falls, both of energy and energy-intensive goods, in response to their higher price, and it is hence optimal for most of the adjustment to come through higher domestic prices. The fall in consumption is optimally delivered via a policy tightening that appreciates the real exchange rate. Given the direct impact of higher (relative) energy prices on the CPI, this only needs a small nominal appreciation and nominal interest rate rise.

Comparing across policy rules, strict domestic inflation targeting performs significantly worse than either alternative, generating a welfare loss of around one and a half percentage points. Strict stabilization of domestic prices in the face of such a shock to costs requires a sharp tightening in policy and a large exchange rate appreciation, which leads to large

Figure 5: IRFS TO ENERGY IMPORT PRICE SHOCK IN ADVANCED ECONOMY



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

Table 4: IMPLIED STANDARD DEVIATIONS ACROSS POLICIES - ENERGY IMPORT PRICE SHOCK IN AE

	CPI inf. target	**Dom. inf. target**	**Nominal peg**	**Optimal**
CPI inflation	0.00	2.81	1.24	0.62
Domestic inflation	0.14	0.00	0.27	0.23
Efficient output gap	1.91	9.18	2.23	0.48
Nom. wage inflation	0.20	0.46	0.04	0.04
Welfare loss vs. opt. (pp)	0.15	1.61	0.05	0.00

inefficient falls in employment and consumption, as well as negative wage inflation. This finding contrasts with policy practice, which typically recommends at least partially leaning against the indirect effects of an energy shock on inflation (Lagarde, 2026; Powell, 2024). The optimal policy instead involves largely accommodating both the direct and indirect CPI inflation channels of the shock. Our result therefore extends the 'looking through' idea to the price of energy embodied in other goods and services, in addition to changes in the price of energy directly.[21]

In contrast, the exchange rate peg does not tighten at all in response to the energy shock. This is slightly looser than the optimal policy. Table 4 shows that the peg achieves broadly similar outcomes for domestic inflation and wage inflation, but more volatility in the output gap, as it raises employment above its efficient level. Strict CPI inflation also delivers comparable results, though owing to the implicit weight on domestic inflation, it sets policy slightly tighter than is optimal, running a negative output gap, rather than a positive one under a peg.

5.3 EM and developing economies: risk premium link to commodities

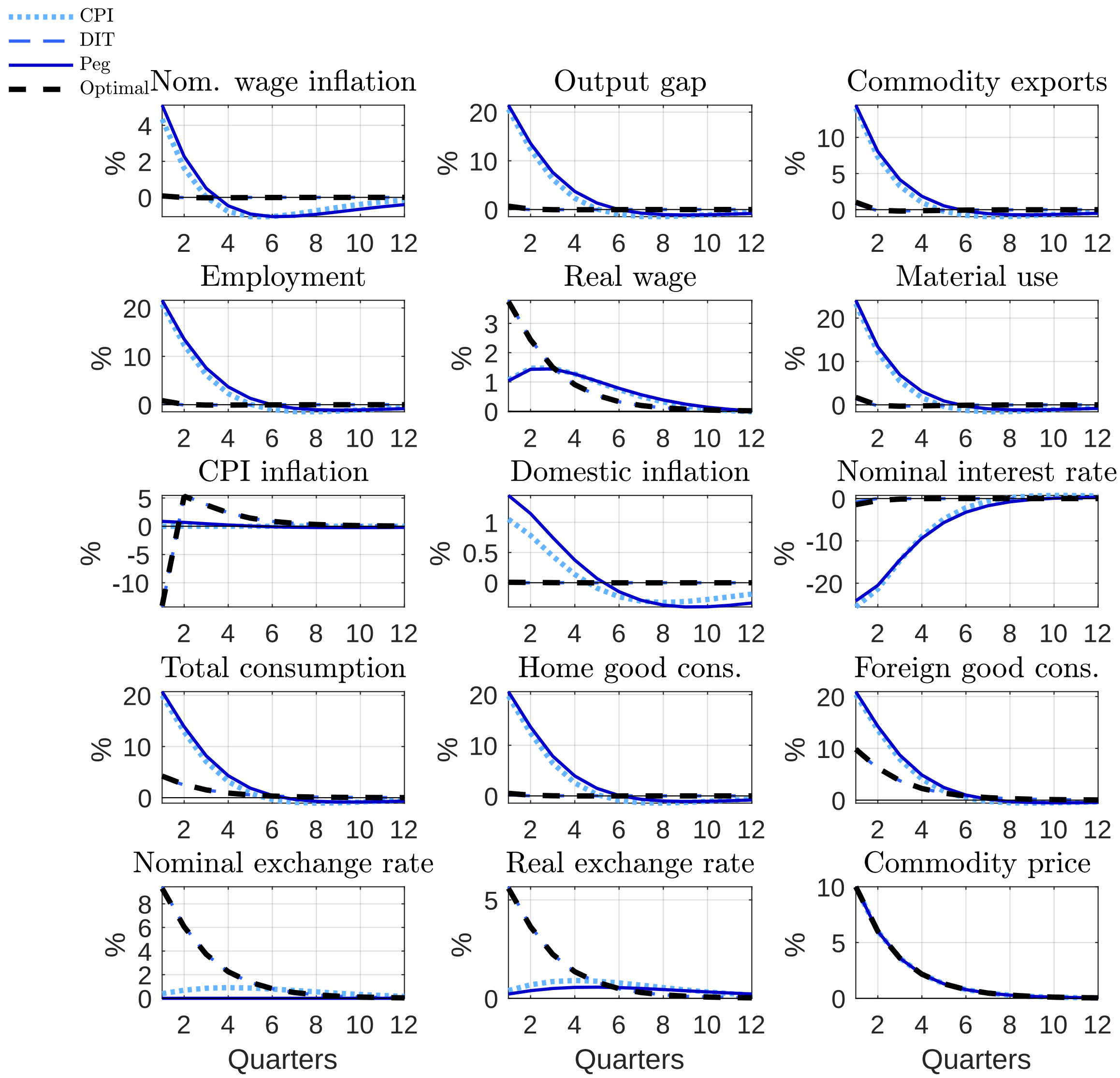
We now turn to examining differences in the response when economies face variations in financial conditions tied to the commodity cycle, as is the case for many emerging and developing economies. We find that these endogenous risk premia amplify the trade-offs they face. They increase the volatility in CPI inflation and exchange rates required to implement the optimal policy after export price shocks. And they worsen the trade-off between stabilizing domestic inflation and employment after an energy import price shock. Endogenous fluctuations in risk premia are therefore a new factor that can help explain why emerging and developing economies may be more likely than advanced economies to have exchange-rate targeting frameworks.

Export price shock. For *emerging or developing* economy commodity exporters, facing the same commodity price shock, the welfare ranking of different policies is even more clear-cut (Table 5). Figure 6 shows that exchange-rate pegs and strict CPI targeting create an enormous amount of inefficient volatility, by preventing the large required movements in the exchange rate, and cause welfare losses in excess of ten percent. In the presence of an endogenous risk premium, the increase in commodity export prices relaxes the financial friction and reduces the risk premium. As a result, a much larger real appreciation is required, even though consumption optimally rises. This is achieved through a large nominal appreciation of almost 10%, and a fall in annualized CPI inflation of close to 15%.

Given the much larger required appreciation, the exchange-rate peg and strict CPI target create extreme volatility in real variables. To keep the exchange rate or CPI inflation stable requires a large loosening in monetary policy, leading to an extremely large inefficient boom

[21] See Vlieghe (2025) for a discussion of similar drawbacks of using core or services inflation as a measure.

Figure 6: 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 and Cole-Obstfeld preferences. The results are generated under the calibration shown in Tables 1 and 2. Wage and price inflation and interest rates are shown in annualized percent. The nominal exchange rates is plotted as $-\hat{e}_t$ so that an increase corresponds to an appreciation.

Table 5: IMPLIED STANDARD DEVIATIONS ACROSS POLICIES - COMM. EXPORT PRICE SHOCK IN EM

	CPI inf. target	**Dom. inf. target**	**Nominal peg**	**Optimal**
CPI inflation	0.00	4.19	0.34	4.12
Domestic inflation	0.39	0.00	0.57	0.00
Efficient output gap	25.16	0.46	26.95	0.77
Nom. wage inflation	1.27	0.01	1.51	0.02
Welfare loss vs. opt. (pp)	11.27	0.00	14.75	0.00

in employment and positive output gap. In the face of a similarly sized fall in commodity prices, the enormous recession would make the peg difficult to maintain. In contrast, the strict domestic inflation rule remains approximately welfare-optimal, stabilizing prices, wages and the output gap.

Given these results, how can we explain that many commodity-exporting emerging and developing economies do adopt exchange-rate pegs? As discussed earlier, one possible answer lies in the behavior of CPI inflation. By stabilizing the exchange rate, the peg avoids the volatility in import prices induced by the optimal appreciation. This leads to somewhat lower (though still significant) volatility in CPI inflation than strict domestic inflation targeting. If policymakers' remits are set as CPI targets, or if agents' expectations are formed based on CPI inflation, then the peg could still offer some benefits, but with large welfare costs.

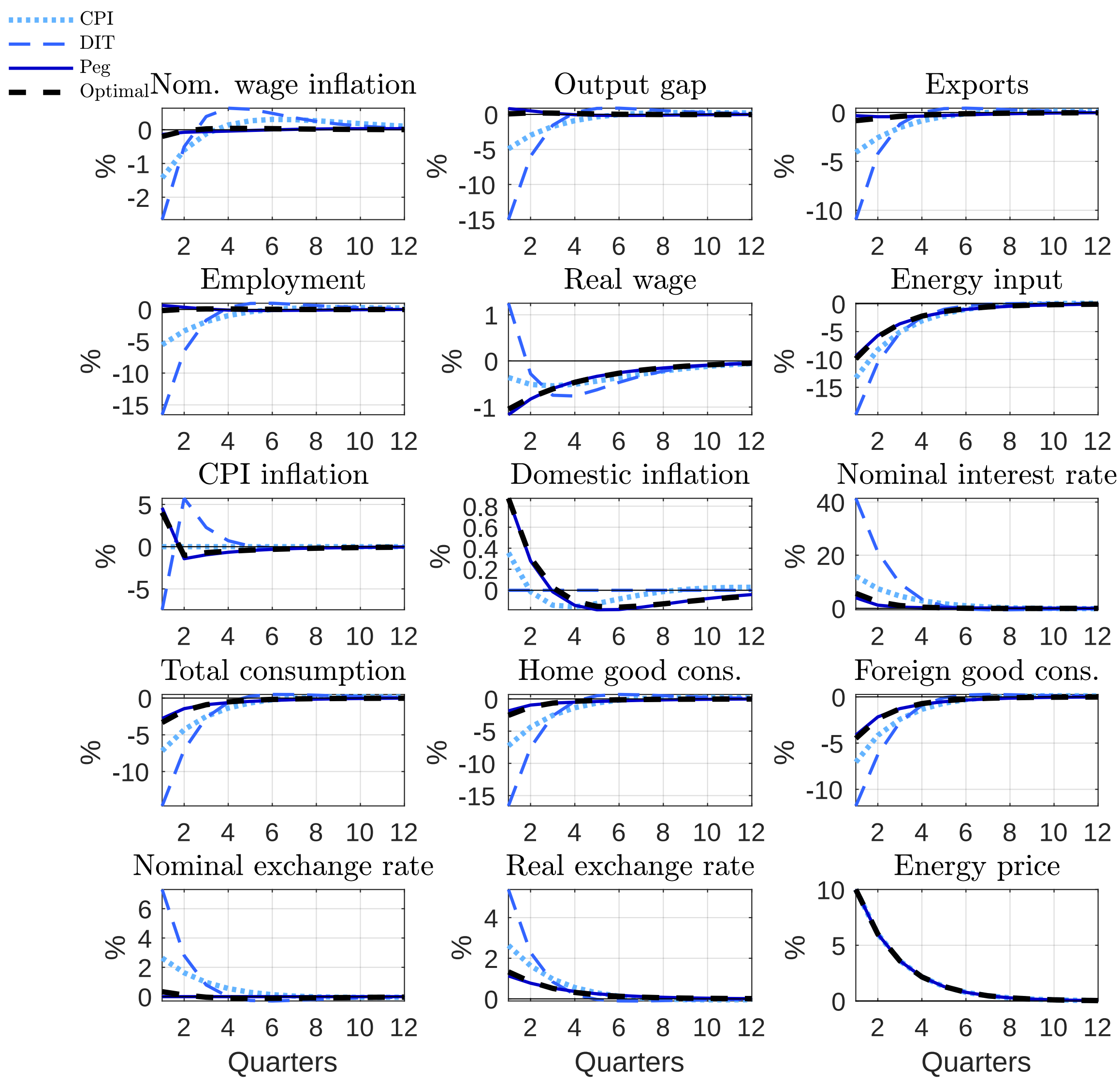
Energy import price shock. Similarly, when *emerging and developing economies* face the same energy price shock, there is a clear distinction in the welfare ranking across policies. The optimal response is qualitatively similar, but with the rise in the risk premium requiring a greater pro-cyclical fall in consumption, achieved with a smaller appreciation of the real and nominal exchange rate (Figure 7). This is best achieved by the exchange-rate peg (Table 6). The finding that an exchange-rate peg can perform well in response to a commodity import price shock, in the presence of sticky wages, is similar to Hevia and Nicolini (2015). The rise in the risk premium worsens the trade-off between domestic inflation and employment. To stabilize domestic inflation in this case requires an implausibly large increase in interest rates, and fall in employment.

Correlated commodity price shocks. Although we find that exchange-rate pegs can perform well when faced with an isolated commodity import price shock, this finding is not robust to examining other shock realisations, so is unlikely to explain the popularity of the framework in emerging markets.[22] Many emerging markets export commodities, or commodity-like products. And the global prices of these are likely to be positively correlated with the global price of commodity imports. In Figure 8 we therefore examine the optimal response (and the response of our policy rules) after a correlated shock to both prices. We calibrate the commodity export price shock so that the price increases by 5% on impact.

The optimal policy in this case is between the two extremes of strict domestic inflation targeting and an exchange rate peg, sitting relatively close to the outcome from strict CPI inflation targeting. Depending on shock realisations, one could have optimal policy closer to the exchange rate peg, to strict domestic inflation targeting, or somewhere in between. In the realistic case where an emerging and developing economy is subject to correlated swings in the global prices of both its commodity imports and exports, none of these simple policies

[22]The results also rely on the credibility and sustainability of the peg, which might not be granted in emerging economies. See for example, Mendoza and Uribe (2000).

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



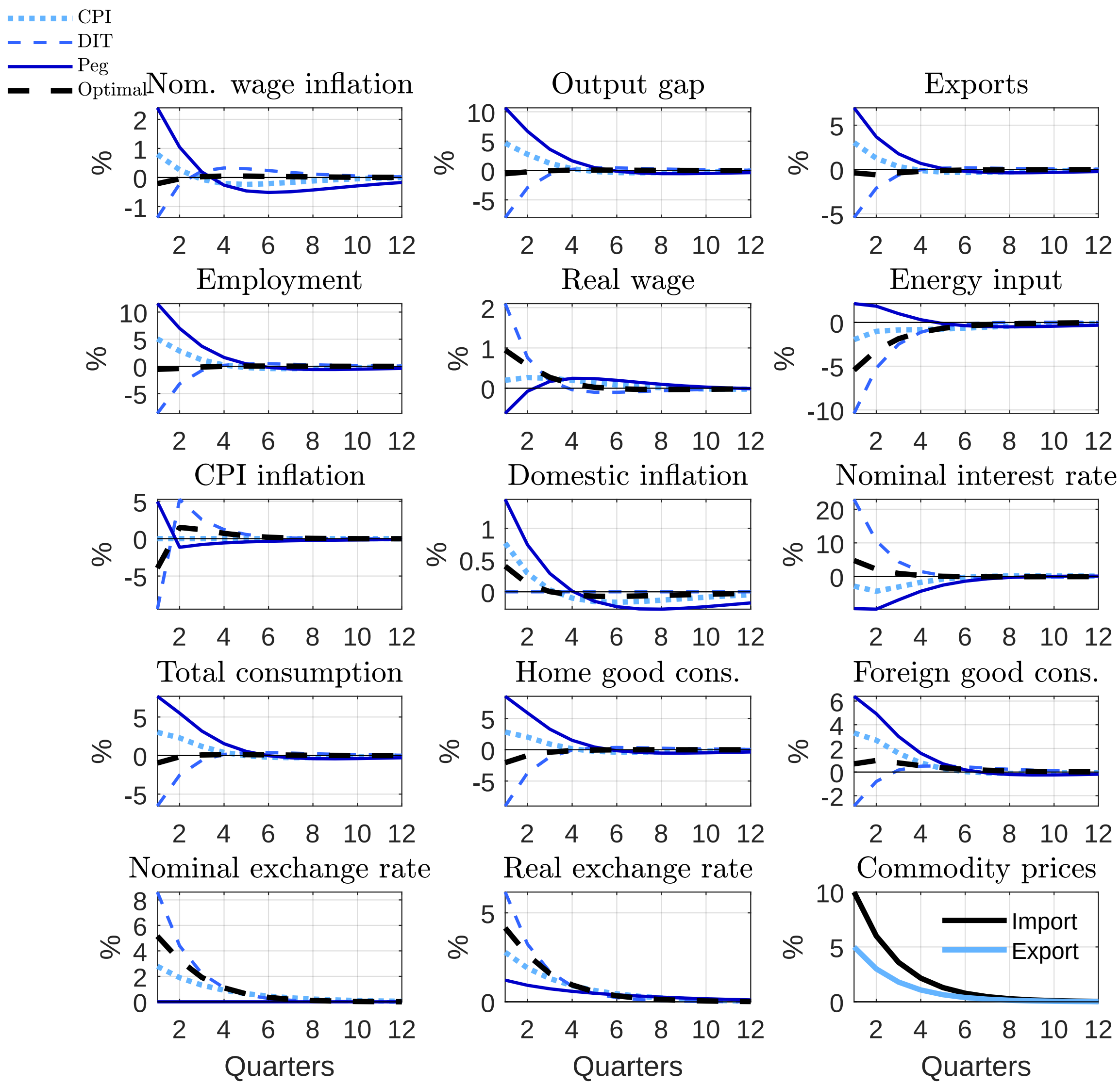
Note: IRFs to a 10% positive commodity/energy import price shock under alternative policy rules and Cole-Obstfeld preferences. The results are generated under the calibration shown in Tables 1 and 2. Wage and price inflation and interest rates are shown in annualized percent. The nominal and real exchange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

Table 6: IMPLIED STANDARD DEVIATIONS ACROSS POLICIES - ENERGY IMPORT PRICE SHOCK IN EM

	CPI inf. target	**Dom. inf. target**	**Nominal peg**	**Optimal**
CPI inflation	0.00	2.45	1.23	1.08
Domestic inflation	0.11	0.00	0.25	0.25
Efficient output gap	6.07	16.29	1.05	0.43
Nom. wage inflation	0.43	0.75	0.05	0.05
Welfare loss vs. opt. (pp)	0.90	4.20	0.01	0.00

is likely to be robustly optimal.

Figure 8: IRFS TO CORRELATED COMMODITY EXPORT AND IMPORT PRICE SHOCKS IN EMERGING MARKET



Note: IRFs to a 5% positive export price shock and 10% commodity import price shock under alternative policy rules and Cole-Obstfeld preferences. The results are generated under the calibration shown in Tables 1 and 2. Wage and price inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $-\hat{e}_t$ and $-\hat{s}_t$ so that an increase corresponds to an appreciation.

If possible to implement, the ideal policy would be shock dependent. This could still be consistent with typical flexible inflation targeting frameworks, which generally provide some leeway to policymakers to allow temporary deviations from their targets. Our results have examined strict inflation targeting rules, but it would be possible for flexible inflation targeting policymakers to make judgements on the type of commodity shock they are facing, before deciding how strongly to act. But this is likely to be more challenging for emerging markets, who are more likely to have a history of chronic inflation. They may not have built up sufficient credibility to depart significantly from stricter policy rules, as discussed in Drechsel, McLeay, and Tenreyro (2019).

Wage inflation. A final feature of our results suggests an alternative: across all model variants, stable wage inflation is optimal or near-optimal after commodity price shocks. In the face of commodity export shocks, stable wage inflation is isomorphic to stable domestic inflation, the best policy. In the face of commodity import shocks, wage inflation is unaffected, and stable wage inflation achieves stability in employment and the output gap. So stable wage inflation is reasonably close to the optimal policy irrespective of the economy's commodity exposure, or links with financial conditions. For many central banks, placing significant weight on wage inflation is consistent with current practice. In response to recent energy-price shocks, many policymakers responded particularly strongly once increases in wage inflation started to occur. It also fits with another common policymaker heuristic, to respond strongly to the 'second round effects' of energy price shocks.

6 Policy trade-offs and terms-of-trade externality

In this section of the paper we extend our analysis to discuss an additional externality that may affect the optimal monetary policy in response to commodity price shocks.

Our findings in the previous section examined the performance of different policies in models with Cole-Obstfeld preferences. In an extension of the logic in Gali and Monacelli (2005), the first-best policy was achieved by replicating the flexible price and wage equilibrium, as this eliminates fluctuations in the economy's monopolistic distortions.

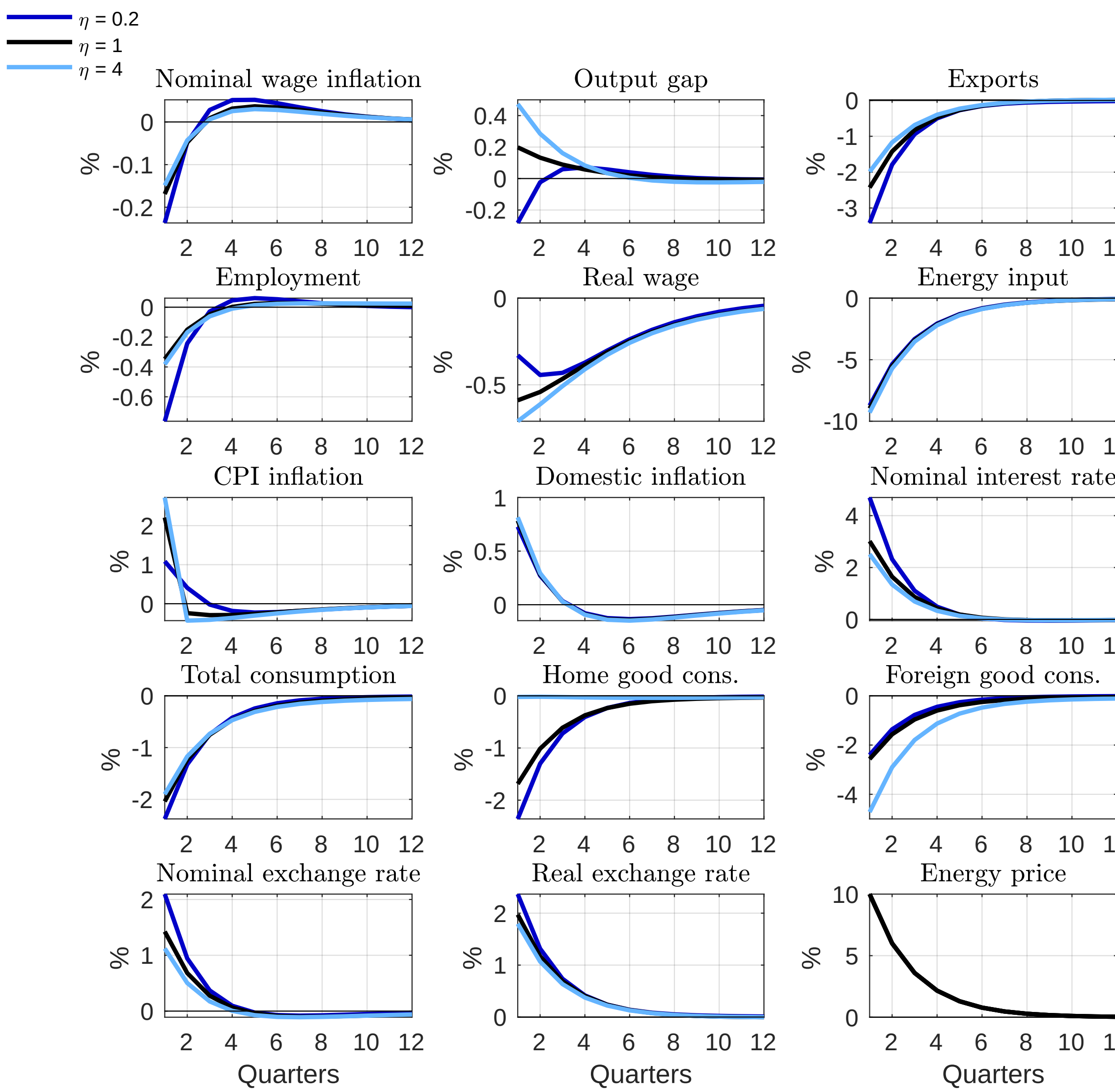
In models without commodity prices, departures from unitary elasticities are another way of creating meaningful trade-offs for policymakers. They do so as they can lead to a terms-of-trade externality, which implies a departure from domestic price stability in response to shocks. We next focus on these more general cases, by exploring the effect of varying the elasticity of substitution between home and foreign goods.

A terms-of-trade externality can arise when it is welfare-improving from the home economy's perspective to take advantage of its monopoly power over export prices. In our model, this externality appears only in our advanced economy calibrations, since emerging and developing economies export only commodity or commodity-like goods, without any pricing power. Moreover, even for advanced economies, the monopoly distortion is unaffected by shocks to commodity export prices, since our small open economy is a price-taker for commodity exports. We therefore focus on the influence of the substitution elasticity for advanced economy commodity (energy) importers, faced with a shock that increases energy prices by 10 percent.

6.1 Optimal policy with terms of trade externality

Figure 9 shows how optimal monetary policy varies in response to an energy price shock in an advanced-economy energy importer. The black lines repeat the responses for the Cole-Obstfeld case from the previous section; the dark blue lines show the response when home and foreign goods have low substitutability ($\eta = 0.2$); and the light blue lines show the more empirically relevant case of high substitutability ($\eta = 4$).

Figure 9: IRFS TO ENERGY IMPORT PRICE SHOCK IN ADVANCED ECONOMY



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

The key difference between these different variants is the presence of a terms of trade externality for the non Cole-Obstfeld cases. As in De Paoli (2009), when domestic and foreign goods are more substitutable, it is welfare improving to limit some volatility in the real exchange rate and terms of trade after an energy price change. This slightly alters the trade-off for the policymaker, as a more stable exchange rate implies more of the burden of higher costs should fall on domestic inflation. Conversely, when substitution elasticities are low, the terms of trade does not appreciate enough. The planner would like to restrict demand relative to its flexible price level. The optimal policy involves tighter policy and slightly lower domestic and CPI inflation.

6.2 Simple rules with different substitution elasticities

We can also compare the performance of our three monetary policy rules and strict wage inflation targeting (in which we close the model by setting nominal wage inflation $\hat{\omega}_t$ to zero) in each of our economies under different substitution elasticities. These are summarized in Table 7.

Table 7: WELFARE MAXIMIZING POLICY WITH DIFFERENT ELASTICITIES

	Best policy		
	$\eta = 0.2$	$\eta = 1$	$\eta = 4$
Commodity export price shock			
Advanced economy	DIT/WIT	DIT/WIT	DIT/WIT
Emerging economy	DIT/WIT	DIT/WIT	DIT/WIT
Commodity import price shock			
Advanced economy	WIT	WIT	WIT
Emerging economy	PEG	PEG	WIT

Note: the policies considered are a nominal exchange rate peg ($\hat{e}_t = 0$), strict CPI inflation targeting ($\hat{\pi}_t = 0$), strict domestic inflation targeting ($\hat{\pi}_{h,t} = 0$) and strict wage inflation targeting ($\hat{\omega}_t = 0$). When the loss from the two best rules differs by less than 0.01 percentage point, both are listed in the table.

In general, the ranking of simple policy rules is little affected by the elasticity of substitution and associated terms of trade externality. The strict domestic inflation and wage targeting rules always perform best for a pure commodity export price shock. For advanced importers, wage inflation targeting performs best, while the exchange rate peg generally performs best for emerging importers, apart from high substitution. Overall, as under Cole-Obstfeld preferences, strict wage inflation targeting performs well in all cases. It matches domestic inflation targeting following export-price shock, and performs similarly to or better than the peg for import-price shocks.

7 Conclusions

We develop 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, and to assess their desirability. 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. We characterize the behavior of different types of economies and compare the volatility and performance under different inflation-targeting rules and a fixed exchange rate to the optimal policy.

We find the desirability of different policy frameworks depends critically on the economy's commodity exposure. Five results stand out. First, for commodity *exporters*, strict domestic inflation targeting is close to optimal in the face of commodity price shocks, while exchange-rate pegs lead to substantially worse outcomes. Stable domestic prices simultaneously stabilise wages and close the efficient output gap. A peg, in contrast, generates an inefficient boom in activity, causing above target domestic inflation and wage inflation, and a positive output gap.

Second, for commodity *import* price shocks, strict domestic inflation targeting performs poorly when energy (or other imported commodities) are inputs into production. The optimal policy involves largely 'looking through' the domestic price movements induced by indirect effects. Our result therefore extends the policymaker 'looking through' heuristic to the price of energy embodied in other goods and services, not just the price of energy directly in the consumption basket.

Third, for emerging markets, the correlation between commodity prices and financial conditions amplifies the trade-offs they face. Falls in risk premia as commodity export prices rise incentivise higher consumption, and require a larger exchange rate appreciation and greater fall in CPI inflation to prevent an inefficient large boom. Rises in risk premia as commodity import prices rise require enormous contractions in output to generate the appreciation needed to stabilise domestic prices. Procyclical fluctuations in risk premia therefore help explain the presence of different policies in emerging economies.

Fourth, building on the practical observation that many energy importers also export some commodities or commodity-like homogeneous goods, whose prices are likely to rise at the same time, we find that the optimal policy is between the two extremes of strict domestic inflation targeting and an exchange-rate peg. For some shock realizations, strict CPI targeting performs well. But the results are sensitive to calibration, including, naturally, the weight that commodities have in export and import baskets.

Finally, across our different model variants, the optimal policy tends to be consistent with stable wage growth. Faced with commodity-price shocks, stable wage inflation is a better measure of the underlying level of inflation in the economy than measures of price inflation, which are affected by increases in imported commodity prices. But unlike exchange-rate pegs, stable wage inflation is reasonably close to the optimal policy irrespective of the economy's precise commodity exposure, or links with financial conditions.

We would stress stress that a form of wage stabilisation can be achieved within current flexible inflation targeting frameworks. Our results examine strict inflation targeting rules, but flexible inflation targeting frameworks permit policymakers to allow temporary deviations from their targets. Indeed, this is one interpretation of the responses of many central bankers to recent energy-price shocks. Policymakers at least partially 'looked through' impacts on CPI inflation, core inflation and proxies for domestic inflation (e.g. services inflation), but responded strongly to increases in wage inflation, as these suggest 'second round effects.' Through the lens of our model, this is close to the optimal policy. This policy recommendation again comes with caveats, particularly for emerging markets. Successful flexible inflation targeting requires policy credibility. If the optimal strategy involves allowing a greater degree of volatility in both CPI inflation, and in core inflation, then this may risk the credibility of the framework. As a result, emerging market policymakers may not be able to use the flexibility required to implement the optimal policy.

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APPENDIX NOT FOR PUBLICATION

How should central banks respond to commodity price shocks? Optimal monetary and exchange rate frameworks for commodity-exposed economies

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

A Social planner

Planner's problem and FOC The social planner maximizes household utility taking production, resource constraints and international prices as given.

The problem is given by:

$$\max \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left[(1-\alpha)^{\frac{1}{\eta}} C_{h,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{f,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}(1-\sigma)} - 1}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right\} \quad s.t. \tag{33}$$

$$Y_{h,t} = C_{h,t} + M_{h,t} + C_{h,t}^* \,, \tag{34}$$

$$Y_{h,t} = A_{h,t} N_t^{1-\mu} X_{\tilde{c},t}^{\mu} \tag{35}$$

$$Y_{c,t} = A_{c,t} M_{h,t}^{\nu} \tag{36}$$

$$P_{f,t}^* C_{f,t} = P_{c,t}^* A_{c,t} M_{h,t}^{\nu} + P_{h,t}^* C_{h,t}^* - P_{\tilde{c},t}^* X_{\tilde{c},t} + B_t \Phi_{t-1}(B_t) - Q_{t,t+1}^* B_{t+1} \tag{37}$$

$$C_{h,t}^* = \left(\frac{P_{h,t}^*}{P_t^*}\right)^{-\eta} \alpha^* C_t^* \,, \qquad \mathcal{T}_t^{\eta} = \frac{\alpha}{1-\alpha} \frac{C_{h,t}}{C_{f,t}} \,, \qquad \mathcal{T}_t = \frac{P_{f,t}^*}{P_{h,t}^*} \tag{38}$$

We can then write the current-value Lagrangian of the problem and take first order conditions, which, once we substitute out the multipliers give the following system of first order conditions

$$(1-\alpha)^{\frac{1}{\eta}} C_{h,t}^{-\frac{1}{\eta}} \left[(1-\alpha)^{\frac{1}{\eta}} C_{h,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{f,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}(1-\sigma)-1} = \frac{N_t^{\varphi+1}}{Y_{h,t}} \frac{1}{1-\mu} \frac{C_{h,t} + C_{h,t}^*}{C_{h,t}} \tag{39}$$

$$\alpha^{\frac{1}{\eta}} C_{f,t}^{-\frac{1}{\eta}} \left[(1-\alpha)^{\frac{1}{\eta}} C_{h,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{f,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}(1-\sigma)-1} = \frac{N_t^{\varphi+1}}{1-\mu} \left(\frac{P_{f,t}^*}{P_{\tilde{c},t}^* X_{\tilde{c},t}} \mu - \frac{C_{h,t}^*}{C_{f,t} Y_{h,t}}\right) \tag{40}$$

$$\frac{N_t^{\varphi+1}}{Y_{h,t}} \frac{1}{1-\mu} = A_{c,t} \nu M_{h,t}^{\nu-1} \frac{P_{c,t}^* N_t^{\varphi+1}}{P_{\tilde{c},1}^* X_{\tilde{c},t}} \frac{\mu}{1-\mu} \tag{41}$$

$$Q_{t,t+1}^* \frac{N_t^{\varphi+1}}{P_{\tilde{c},1}^* X_{\tilde{c},t}} = \beta(\Phi_{t-1}(B_t) + B_t \partial_B \Phi_{t-1}(B_t)) \frac{N_{t+1}^{\varphi+1}}{P_{\tilde{c},t+1}^* X_{\tilde{c},t+1}} \tag{42}$$

in addition to the constraints of the planner's problem.

Steady state values and share parameters We linearize the model around the steady state that satisfies these conditions and with relative prices and terms of trade normalized to one.

We choose an initial steady state with zero net asset positions. With $Q^* = \beta$ this implies the normalization that the risk premium at the steady state level of bond holdings (zero) equals one. We introduce share parameters that denote the steady state allocation of final good production in commodity production, consumption and exports,

$$s_{m,ss} = \frac{M_h}{Y_h} , \quad s_{c,ss} = \frac{C_h}{Y_h} , \quad s_{c^*,ss} = \frac{C_h^*}{Y_h} . \tag{43}$$

These substitute the parameters A_c and $\alpha^* C^*$, so only one of these can be a free parameter, and we choose $s_{c^*,ss}$. The other two steady state shares are determined by

$$s_{m,ss} + s_{c,ss} + s_{c^*,ss} = 1 \tag{44}$$

$$s_{c,ss}^2 - s_{c,ss} \left[\frac{(1-\mu\nu)(1-\alpha)}{1-\alpha(1-\nu)} - s_{c^*,ss} \right] - \frac{1-\alpha}{\alpha} \frac{\nu}{1-\alpha(1-\nu)} s_{c^*,ss}^2 = 0 \tag{45}$$

where for the second equation the unique positive solution for $s_{c,ss}$ is considered.

At steady state it is also true that

$$N^{\sigma+\varphi} = (1-\mu)(1-\alpha)^\sigma \frac{s_c^{1-\sigma}}{1-s_m} \left(\frac{\alpha s_c}{\alpha s_c + s_c^*} \mu \right)^{\frac{\mu}{1-\mu}(1-\sigma)} A_h^{1-\sigma} , \tag{46}$$

which for $s_{c^*,ss} = \mu = 0$ and $\sigma = \eta = 1$ gives the same level of employment as the autarky economy with commodity exports in Drechsel et al. (2019). In our simulations, we also normalize the level of productivity to one, $A_h = 1$.

Finally, the steady state currency values are

$$\frac{P_h^* C_h^*}{P_h^* Y_h^*} = s_c^* , \quad \frac{P_f^* C_f^*}{P_h^* Y_h^*} = \frac{\alpha}{1-\alpha} s_c , \quad \frac{P_{\tilde{c}}^* X_{\tilde{c}}}{P_h^* Y_h^*} = \mu \frac{\alpha s_c}{\alpha s_c + s_c^*} , \quad \frac{P_c^* Y_c}{P_h^* Y_h^*} = \frac{s_m}{\nu} \frac{\alpha s_c}{\alpha s_c + s_c^*} \tag{47}$$

that are used in the expression of the trade balance and the current account.

Linearized planner solution We also simulate the response of the planner to import and export price shocks. To do so we use a linearized version of the first order conditions that delivers the following system (in addition to the constraints which are also part of the full linearized model below).

$$-\hat{y}_{h,t} + (1+\varphi)\hat{n}_t + \frac{s_{c,ss}\hat{c}_{h,t} + s_{c^*,ss}\hat{c}^*_{h,t}}{s_{c,ss} + s_{c^*,ss}} = \frac{\eta-1}{\eta}\hat{c}_{h,t} + \left(1-\sigma-\frac{\eta-1}{\eta}\right)((1-\alpha)\hat{c}_{h,t} + \alpha\hat{c}_{f,t}) \tag{48}$$

$$\frac{\eta-1}{\eta}\hat{c}_{f,t} + \left(1-\sigma-\frac{\eta-1}{\eta}\right)((1-\alpha)\hat{c}_{h,t} + \alpha\hat{c}_{f,t}) = \tag{49}$$

$$= (\varphi+1)\hat{n}_t + \frac{\alpha s_{c,ss} + s_{c^*,ss}}{\alpha(s_{c,ss} + s_{c^*,ss})}(\hat{p}^*_{f,t} - \hat{p}^*_{\tilde{c}} + \hat{c}_{f,t} - \hat{x}_{\tilde{c},t}) - \frac{1-\alpha}{\alpha}\frac{s_{c^*,ss}}{s_{c,ss} + s_{c^*,ss}}(\hat{c}^*_{h,t} - \hat{y}_{h,t}) \tag{50}$$

$$\hat{p}^*_{\tilde{c},t} + \hat{x}_{\tilde{c},t} - \hat{y}_{h,t} = \hat{p}^*_{c,t} + \hat{a}_{c,t} + (\nu-1)\hat{m}_{h,t} \tag{51}$$

$$-\hat{i}^*_t + (\varphi+1)\hat{n}_t - \hat{x}_{\tilde{c},t} - p^*_{\tilde{c},t} = (\varphi+1)\hat{n}_{t+1} - \hat{x}_{\tilde{c},t+1} - p^*_{\tilde{c},t+1} + \phi_{\tilde{c}}\hat{p}^*_{\tilde{c},t} - \phi_c\hat{p}^*_{c,t} - 2\phi_B\hat{b}_t; \tag{52}$$

B Full linearized model

Relative price relations and resource constraint.

$$\hat{p}_t = \alpha\hat{p}_{f,t} + (1-\alpha)\hat{p}_{h,t} \tag{53}$$

$$\hat{p}_{f,t} = \alpha_{\tilde{c}}\hat{p}_{\tilde{c},t} + (1-\alpha_{\tilde{c}})\hat{p}_{nc,t} \tag{54}$$

$$\hat{p}_{\tilde{c},t} = \hat{e}_t + \hat{p}^*_{\tilde{c},t}\ , \quad \hat{p}_{nc,t} = \hat{e}_t + \hat{p}^*_{nc,t}\ , \quad \hat{p}_{c,t} = \hat{e}_t + \hat{p}^*_{c,t}\ , \quad \hat{p}_{h,t} = \hat{e}_t + \hat{p}^*_{h,t} \tag{55}$$

$$\hat{p}^*_t = \hat{p}^*_{nc,t} \tag{56}$$

$$\hat{\tau}_t = \hat{p}_{f,t} - \hat{p}_{h,t} \tag{57}$$

$$\hat{s}_t = \hat{e}_t + \hat{p}^*_t - \hat{p}_t = (1-\alpha)\hat{\tau}_t + \alpha_{\tilde{c}}(\hat{p}^*_{nc,t} - \hat{p}^*_{\tilde{c},t}) \tag{58}$$

$$\hat{y}_{h,t} = s_{c,ss}\hat{c}_{h,t} + s_{c^*,ss}\hat{c}^*_{h,t} + s_{m,ss}\hat{m}_{h,t} \tag{59}$$

$$\hat{\pi}_{t+1} = \hat{p}_{t+1} - \hat{p}_t\ , \quad \hat{\pi}_{h,t+1} = \hat{p}_{h,t+1} - \hat{p}_{h,t}\ , \quad \hat{\pi}^*_{t+1} = \hat{p}^*_{t+1} - \hat{p}^*_t \tag{60}$$

$$\hat{\omega}_{t+1} = \hat{w}_{t+1} - \hat{w}_t \tag{61}$$

$$\hat{w}^r_t = \hat{w}_t - \hat{p}_t \tag{62}$$

$$\hat{w}^r_{t+1} - \hat{w}^r_t = \hat{\omega}_{t+1} - \hat{\pi}_{t+1} \tag{63}$$

Households.

$$
\begin{aligned}
\hat{c}_{h,t} &= -\eta(\hat{p}_{h,t} - \hat{p}_t) + \hat{c}_t && (64)\\
\hat{c}_{f,t} &= -\eta(\hat{p}_{f,t} - \hat{p}_t) + \hat{c}_t && (65)\\
\hat{c}^*_{h,t} &= -\eta(\hat{p}^*_{h,t} - \hat{p}^*_t) + \hat{c}^*_t && (66)\\
\hat{c}_{nc,t} &= -\vartheta(\hat{p}_{nc,t} - \hat{p}_{f,t}) + \hat{c}_{f,t} && (67)\\
\hat{c}_{\tilde{c},t} &= -\vartheta(\hat{p}_{\tilde{c},t} - \hat{p}_{f,t}) + \sigma\hat{c}_{f,t} && (68)\\
\hat{\omega}_t &= \kappa^w(\hat{mrs}_t - \hat{w}^r_t) + \beta\mathbb{E}_t[\hat{\omega}_{t+1}] && (69)\\
\hat{mrs}_t &= \varphi\hat{n}_t + \sigma\hat{c}_t && (70)\\
\sigma\hat{c}_t &= -(i_t - \mathbb{E}_t\hat{\pi}_{t+1}) + \sigma\mathbb{E}_t\hat{c}_{t+1} && (71)\\
i_t - \mathbb{E}_t\hat{\pi}_{t+1} &= i^*_t - \mathbb{E}_t\hat{\pi}^*_{t+1} + \mathbb{E}_t\hat{s}_{t+1} - \hat{s}_t + \hat{\phi}_t && (72)\\
\hat{\phi}_t &= \phi_{\tilde{c}}\hat{p}^*_{\tilde{c},t} - \phi_c\hat{p}^*_{c,t} - \phi_B\hat{b}_t && (73)\\
\beta\hat{b}_t - \hat{b}_{t-1} &= \frac{s_{m,ss}}{\nu}\frac{\alpha s_c}{\alpha s_c + s^*_c}(\hat{y}_{c,t} + \hat{p}^*_{c,t}) + s_{c^*,ss}(\hat{c}^*_{h,t} + \hat{p}^*_{h,t}) + \\
&\quad -\mu\frac{\alpha s_c}{\alpha s_c + s^*_c}(\hat{x}_{\tilde{c},t} + \hat{p}^*_{\tilde{c},t}) - \frac{\alpha s_{c,ss}}{1-\alpha}(\hat{c}_{f,t} + \hat{p}^*_{f,t}) && (74)
\end{aligned}
$$

Domestic goods sector.

$$
\begin{aligned}
\hat{y}_{h,t} &= \hat{a}_{h,t} + (1-\mu)\hat{n}_t + \mu\hat{x}_{\tilde{c},t} && (75)\\
\hat{\pi}_{h,t} &= \kappa\hat{mc}^r_t + \beta\mathbb{E}_t\hat{\pi}_{h,t+1} && (76)\\
\hat{mc}^r_t &= (1-\mu)\hat{w}_t + \mu\hat{p}_{\tilde{c},t} - \hat{a}_{h,t} - \hat{p}_{h,t} && (77)\\
\hat{x}_{\tilde{c},t} + \hat{p}_{\tilde{c},t} &= \hat{n}_t + \hat{w}_t && (78)
\end{aligned}
$$

Commodity export sector.

$$
\begin{aligned}
\hat{y}_{c,t} &= \hat{a}_{c,t} + \nu\hat{m}_{h,t} && (79)\\
(1-\nu)\hat{m}_{h,t} &= \hat{a}_{c,t} + \hat{p}_{c,t} - \hat{p}_{h,t} && (80)
\end{aligned}
$$

All hat variables are log deviations from steady state, except $\hat{b}_t \equiv \frac{B_{t+1}}{P^*_h Y_h}$, which denotes foreign bond holdings as a share of the value of home output in foreign prices (since steady state bond holdings are equal to zero). As usual, $\kappa = \frac{(1-\beta\theta)(1-\theta)}{\theta}$ and $\kappa^w = \frac{(1-\beta\delta)(1-\delta)}{\delta}\frac{1}{1+\varphi\chi}$.

C Optimal monetary policy

The second order approximation of utility is

$$
\sum_{t=0}^{\infty}\beta^t\left(\overline{C}^{1-\sigma}\left(\hat{c}_t + \frac{1}{2}(1-\sigma)\hat{c}^2_t\right) - \overline{N}^{1+\varphi}\left(\hat{n}_t + \frac{1+\varphi}{2}\hat{n}^2_t\right) - \frac{(1+\varphi)^2\chi}{2\kappa_w}\overline{N}^{1+\varphi}\hat{\omega}^2_t\right) + t.i.p. + o(|\xi|^2) \tag{81}
$$

where $\overline{N}^{1+\varphi}$ depends on the steady state value of labor supply and is specified in Appendix, $t.i.p.$ denotes terms that are independent of policy, and ξ is vector of shocks. As standard, we let hat lower case letters denote deviations from steady state.

As discussed by Benigno and Woodford (2012), maximizing the above expression subject to first-order log-linear approximations of the model equations leads to an incorrect solution. Before maximizing welfare, it is necessary to use the second-order approximations of model equations to substitute out the linear part of approximation to welfare, as we describe in the remainder of this section. Notice that all our model equations are exactly log linear (and hence exact to any order) apart from six key equations: the home good market clearing (aggregate demand), the aggregate production equation (because of the presence of price dispersion), the current account, the New Keynesian Phillips curve, the relationship between terms of trade and real exchange rate (unless $\eta = 1$), and the wage Phillips curve.

Since all but six of our equations are exact to the second order, we can express all real variables in our model in terms of six real variables of our choice,

$$\mathbf{Y}_t = (\hat{y}_{h,t}, \hat{\tau}_t, \hat{c}_t, \hat{n}_t, \hat{s}_t, \hat{w}^r_t)' \,, \tag{82}$$

while shocks are collected in the vector

$$\xi_t = (\hat{p}^*_{c,t}, \hat{p}^*_{\tilde{c},t}, \hat{p}^*_{nc,t}, \hat{a}_{h,t}, \hat{a}_{c,t}, \hat{c}^*_t)' \,. \tag{83}$$

With this notation, we can rewrite the second-order approximation in matrix notation as follows

$$\sum_{t=0}^{\infty} \beta^t \left\{ w'_{\mathbf{Y}} \mathbf{Y}_t + \frac{1}{2} \mathbf{Y}'_t W_{\mathbf{Y}} \mathbf{Y}_t + w_\omega \hat{\omega}_t^2 \right\} + t.i.p. + o(|\xi|^2) \tag{84}$$

where

$$w'_{\mathbf{Y}} = \left(0, 0, \overline{C}^{1-\sigma}, -\overline{N}^{1+\varphi}, 0, 0\right) \tag{85}$$

$$W_{\mathbf{Y}} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \overline{C}^{1-\sigma}(1-\sigma) & 0 & 0 & 0 \\ 0 & 0 & 0 & -\overline{N}^{1+\varphi}(1+\varphi) & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \tag{86}$$

$$w_\omega = -\frac{(1+\varphi)^2 \chi}{2\kappa_w} \overline{N}^{1+\varphi} \tag{87}$$

We then express the six equations that need to be approximated to the second order in the matrix form

$$\sum_{t=0}^{\infty} \beta^t \{ f^{\ell\prime}_{\mathbf{Y}} \mathbf{Y}_t + \frac{1}{2} \mathbf{Y}'_t F^{\ell}_{\mathbf{Y}} \mathbf{Y}_t + \mathbf{Y}'_t F^{\ell}_{\xi} \xi_t + f^{\ell}_{\pi} \hat{\pi}^2_{h,t} + f^{\ell}_{\omega} \hat{\omega}^2_t \} + t.i.p. + o(|\xi|^2) = 0 \,, \tag{88}$$

for labels $\ell \in \{AD, AS, CA, PC, TT, W{-}PC\}$, where $f^{\ell}_{\mathbf{Y}} \in \mathbb{R}^6$ is a column vector of dimension six representing the linear part of the equation, $F^{\ell}_{\mathbf{Y}} \in \mathbb{R}^{6,6}$ is a six-by-six matrix for the quadratic part and $F^{\ell}_{\xi} \in \mathbb{R}^{6,6}$ captures interactions between endogenous variables and shocks.

We solve for $L \in \mathbb{R}^6$ such that

$$\left(f^{AD}_{\mathbf{Y}} \mid f^{AS}_{\mathbf{Y}} \mid f^{CA}_{\mathbf{Y}} \mid f^{PC}_{\mathbf{Y}} \mid f^{TT}_{\mathbf{Y}} \mid f^{W-PC}_{\mathbf{Y}} \right) L = w_{\mathbf{Y}} \tag{89}$$

and express welfare as

$$\sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{2} \mathbf{Y}_t' M_{\mathbf{Y}} \mathbf{Y}_t + \mathbf{Y}_t' M_{\xi} \xi_t + m_{\pi} \hat{\pi}_{h,t}^2 + m_{\omega} \hat{\omega}_t^2 \right\} + t.i.p. + o(|\xi|^2) \tag{90}$$

for

$$M_{\mathbf{Y}} = W_{\mathbf{Y}} - \sum_{\ell} L_{\ell} F_{\mathbf{Y}}^{\ell} \,, \quad M_{\xi} = - \sum_{\ell} L_{\ell} F_{\xi}^{\ell} \,, \quad m_{\pi} = - \sum_{\ell} L_{\ell} f_{\pi}^{\ell} \,, \quad m_{\omega} = w_{\omega} - \sum_{\ell} L_{\ell} f_{\omega}^{\ell} \,, \tag{91}$$

which we maximize subject to the model equations approximated to first order. In practice, we again reduce the number of constraints to the six equations that are not exactly log-linear, the Euler equation and the relationship between nominal and real wage and price inflations, all expressed as a function of $\mathbf{Y}_t$ plus $\hat{b}_t$, $\hat{\pi}_{h,t}$ and $\hat{\omega}_t$.[1]

In general, it is not possible to substitute out the Lagrange multipliers of the constraints. Thus, we code them as additional variables (there are eight of them in our code) and add the nine first-order conditions to the model simulations. Since in total we are adding one equation, this closes the model.

To quantify the welfare implications of alternative monetary policy frameworks, we compute the consumption-equivalent welfare loss under each policy regime. The consumption-equivalent welfare loss (in percentage points) under a given policy regime is then

$$\lambda = - \left[\frac{1}{2} \operatorname{tr}(M_{\mathbf{Y}} \Sigma_{\mathbf{YY}}) + \sum_{i,j} (M_{\xi})_{ij} (\Sigma_{\mathbf{Y}\xi})_{ij} + m_{\pi} \operatorname{Var}(\hat{\pi}_{h,t}) + m_{\omega} \operatorname{Var}(\hat{\omega}_t) \right] \times 100,$$

where $\Sigma_{\mathbf{YY}}$ and $\Sigma_{\mathbf{Y}\xi}$ denote the unconditional variance-covariance matrices of endogenous variables and their covariances with shocks, computed from the first-order solution of the model under each policy.

C.1 Second order approximated equations

The second order approximations of equations that are not exactly approximated at at first order are given below. All other model equation, real variables and relative prices can be expressed as exact products of the five variables $Y_{h,t}, \mathcal{T}_t, C_t, N_t, S_t$.

[1] We could also reduce the number of constraints further since, aggregate demand, aggregate supply and terms of trade equation are intratemporal conditions.

$$AS \quad \hat{y}_{h,t} = (1-\mu)\hat{n}_t + \mu\hat{x}_{\tilde{c},t} - \frac{\epsilon}{2\kappa}\hat{\pi}^2_{h,t} \tag{92}$$

$$AD \quad \hat{y}_{h,t} + \frac{1}{2}\hat{y}^2_{h,t} = s_{c,ss}\left(\hat{c}_{h,t} + \frac{1}{2}\hat{c}^2_{h,t}\right) + s_{m,ss}\left(\hat{m}_{h,t} + \frac{1}{2}\hat{m}^2_{h,t}\right) + s_{c^*,ss}\left(\hat{c}^*_{h,t} + \frac{1}{2}(\hat{c}^*_{h,t})^2\right) \tag{93}$$

$$\begin{aligned} CA \quad b_{t-1} = {} & \beta b_t - \frac{s_{m,ss}}{\nu}\frac{\alpha s_c}{\alpha s_c + s^*_c}\left[(\hat{y}_{c,t} + \hat{p}^*_{c,t})(1 - \sigma\hat{c}_t - \hat{p}^*_t + \hat{s}_t) + \frac{1}{2}(\hat{y}^2_{c,t} + (\hat{p}^*_{c,t})^2 + 2\hat{y}_{c,t}\hat{p}^*_{c,t})\right] + \\ & - s_{c^*,ss}\left[(\hat{c}^*_{h,t} + \hat{p}^*_{h,t})(1 - \sigma\hat{c}_t - \hat{p}^*_t + \hat{s}_t) + \frac{1}{2}((\hat{c}^*_{h,t})^2 + (\hat{p}^*_{h,t})^2 + 2\hat{c}^*_{h,t}\hat{p}^*_{h,t})\right] + \\ & + \mu\frac{\alpha s_c}{\alpha s_c + s^*_c}\left[(\hat{x}_{\tilde{c},t} + \hat{p}^*_{\tilde{c},t})(1 - \sigma\hat{c}_t - \hat{p}^*_t + \hat{s}_t) + \frac{1}{2}(\hat{x}^2_{\tilde{c},t} + (\hat{p}^*_{\tilde{c},t})^2 + 2\hat{x}_{\tilde{c},t}\hat{p}^*_{\tilde{c},t})\right] + \\ & + \frac{\alpha s_{c,ss}}{1-\alpha}\left[(\hat{c}_{f,t} + \hat{p}^*_{f,t})(1 - \sigma\hat{c}_t - \hat{p}^*_t + \hat{s}_t) + \frac{1}{2}(\hat{c}^2_{f,t} + (\hat{p}^*_{f,t})^2 + 2\hat{c}_{f,t}\hat{p}^*_{f,t})\right] \end{aligned} \tag{94}$$

$$PC \quad V_t = \kappa\hat{mc}^r_t + \frac{\kappa}{2}\hat{mc}^r_t(\hat{mc}^r_t - 2\sigma\hat{c}_t + 2y_{h,t} + 2\hat{s}_t - 2\hat{\tau}_t + 2\hat{p}^*_{f,t} - 2\hat{p}^*_t) - \frac{\epsilon}{2}\hat{\pi}_{h,t} + \beta\mathbb{E}_t[V_{t+1}] \tag{95}$$

$$V_t = \hat{\pi}_{h,t} + \text{second order terms} \tag{96}$$

$$TT \quad \hat{s}_t = \hat{p}^*_t - \hat{p}^*_{f,t} + (1-\alpha)\hat{\tau}_t + \frac{1}{2}(\eta - 1)\alpha(1-\alpha)\hat{\tau}_t \tag{97}$$

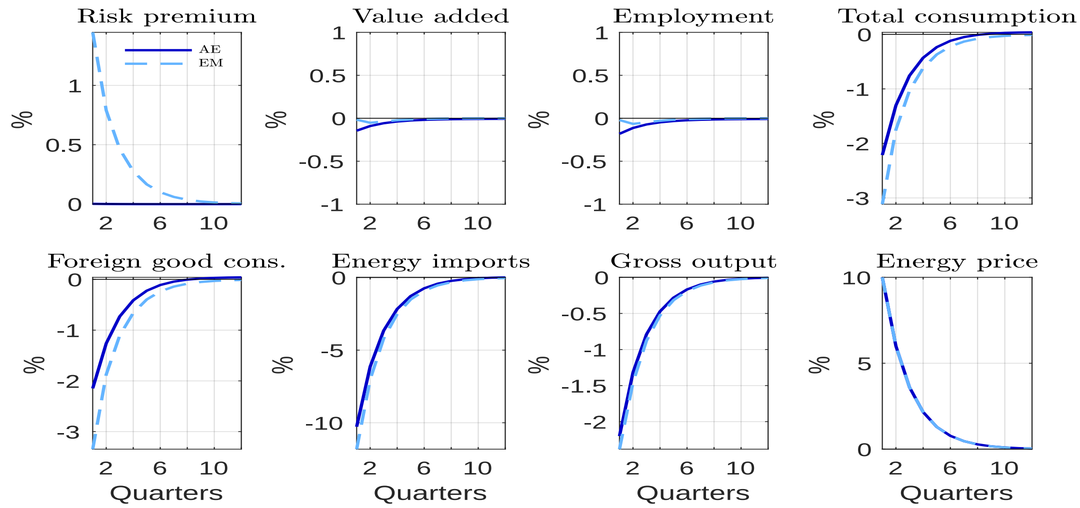
$$W\!-\!PC \quad V^w_t = \beta\mathbb{E}_t[V^w_{t+1}] + \frac{(1+\varphi)\chi}{2}\hat{\omega}^2_t + \frac{(1-\beta\delta)(1-\delta)}{\delta}\frac{1}{1+\varphi\chi}\left[m\hat{r}s_t\left(1 + \frac{1}{2}(m\hat{r}s_t + (2+\varphi)\hat{n}_t\right)\right] \tag{98}$$

$$V^w_t = \hat{\omega}_t + \text{second order terms} \tag{99}$$

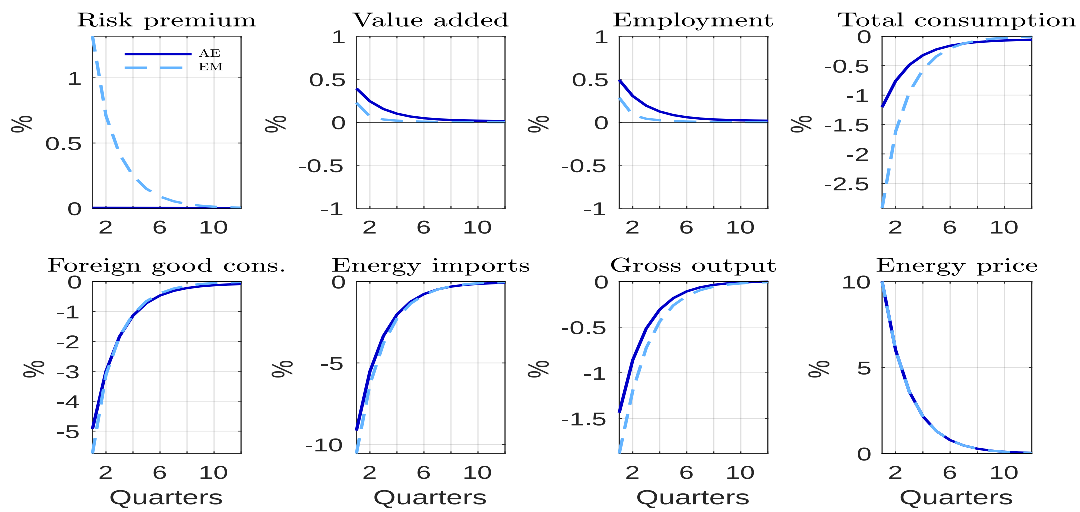
D Additional figures

D.1 Planner response with non-Cole-Obstfeld preferences

Figure D.1: SOCIAL PLANNER RESPONSE TO COMMODITY/ENERGY IMPORT PRICE SHOCK FOR COMMODITY IMPORTER: DIFFERENT ELASTICITIES



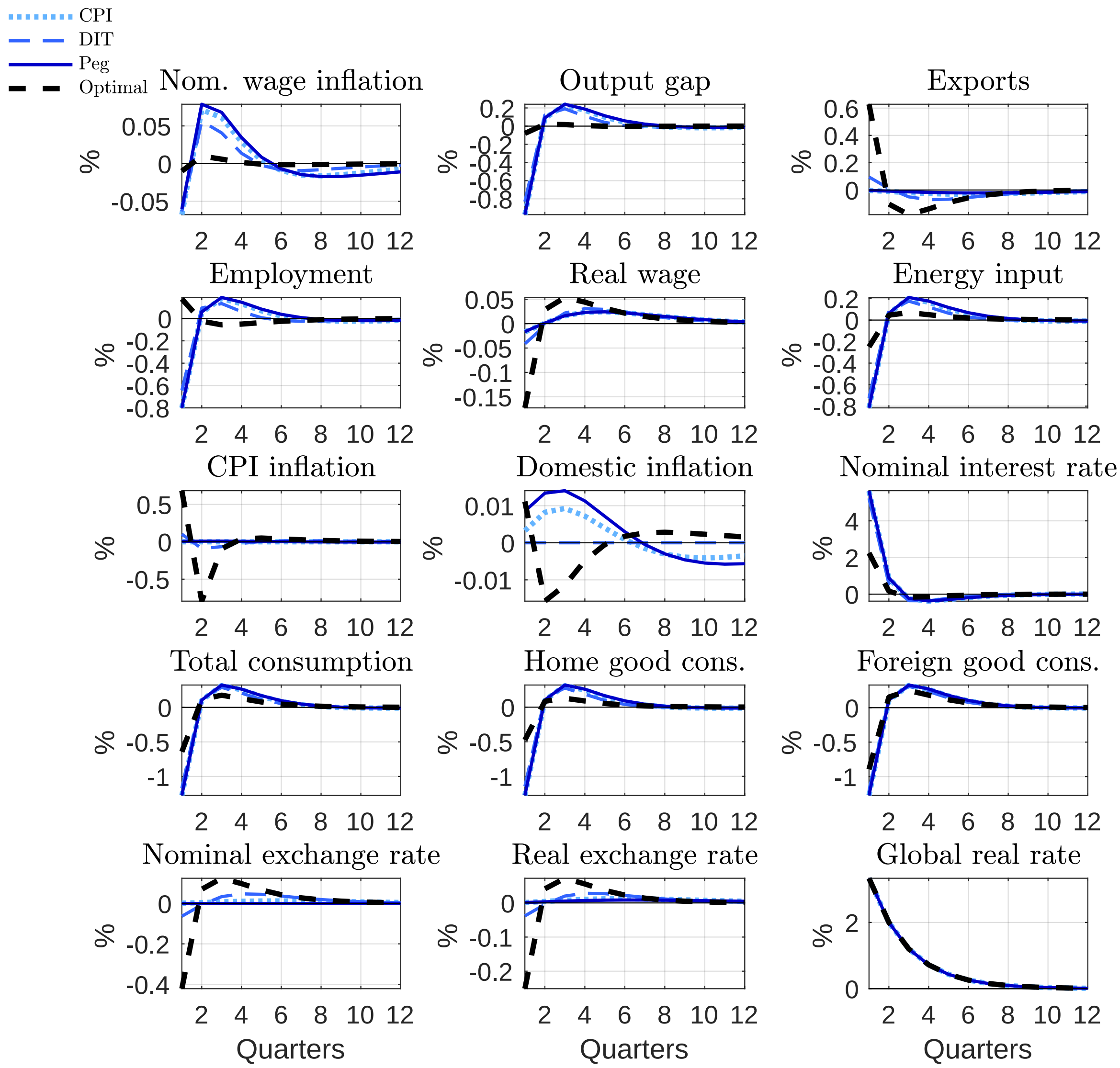
Note: IRFs to a 10% positive commodity import price shock with efficient or natural response. The results are generated under the calibration shown for a commodity importer in Tables 1 and 2, for $\eta = 0.2$.



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, for $\eta = 4$.

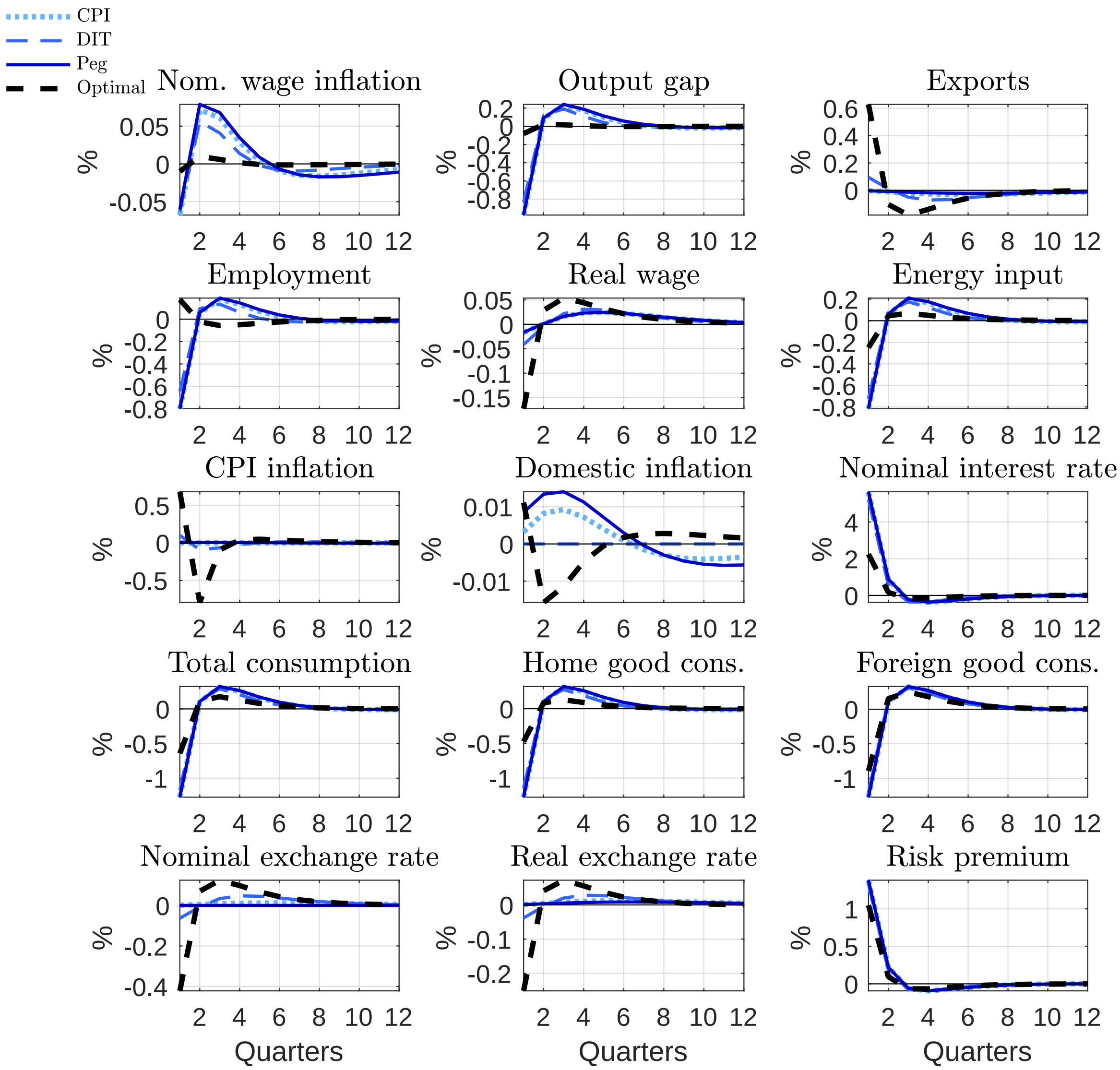
D.2 Interest rate shock

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 and Cole-Obstfeld preferences. The results are generated under the calibration shown in Tables 1 and 2. Wage and price inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are plotted as $-\hat{e}_t$ and $-\hat{s}_t$ so that an increase corresponds to an appreciation.

Figure D.3: IRFS TO RISK PREMIUM SHOCK IN EMERGING ECONOMY

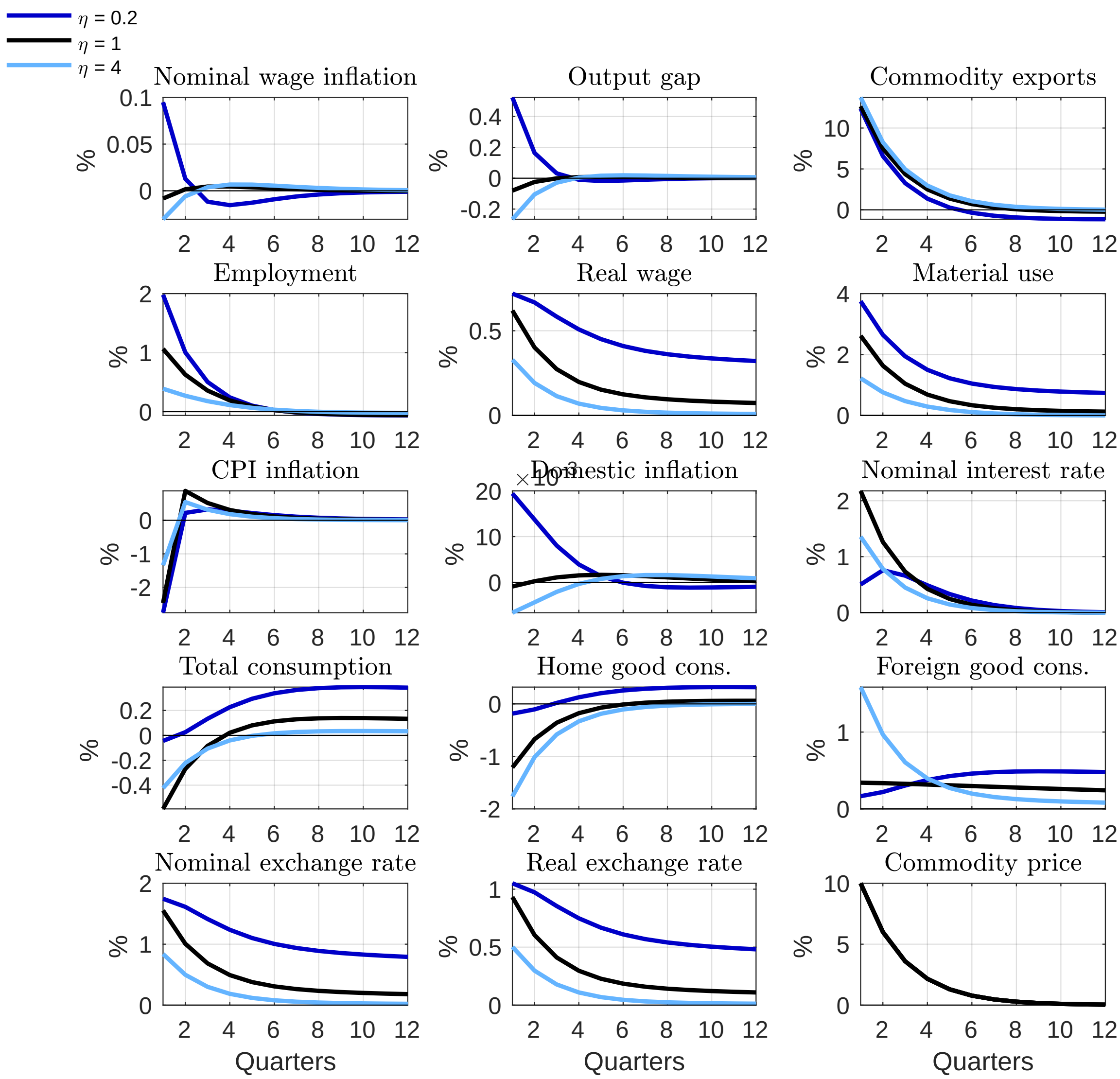


Note: IRFs to a 3.3pp positive shock to the risk premium under alternative policy rules and Cole-Obstfeld preferences. The results are generated under the calibration shown in Tables 1 and 2. Wage and price inflation and interest rates are shown in annualized percent. The nominal exchange rate is plotted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

D.3 Risk premium shock

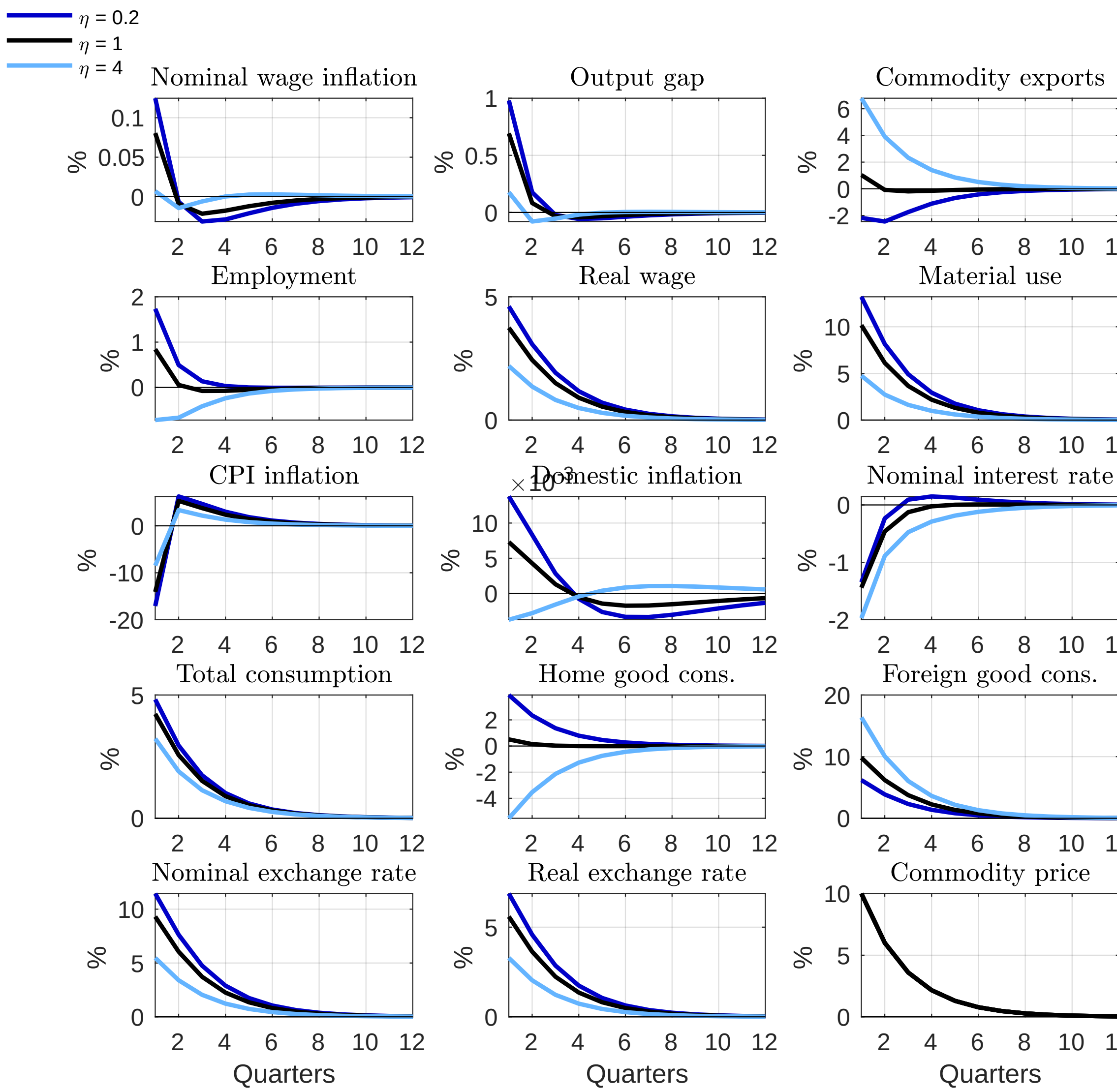
D.4 Optimal policy with non-Cole-Obstfeld preferences

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



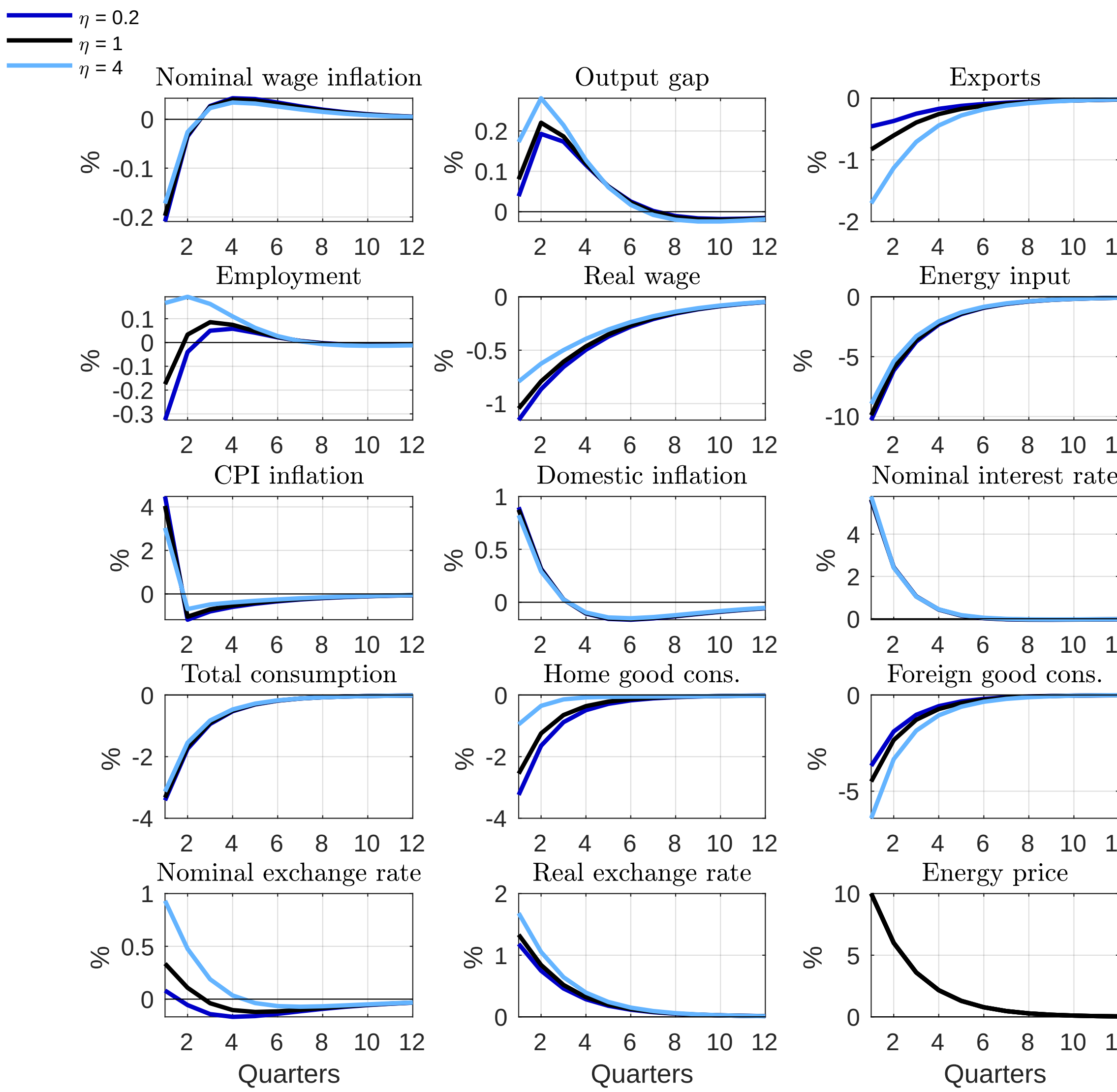
Note: Optimal policy IRFs to a 10% positive commodity/energy import price shock under alternative elasticities. The results are generated under the calibration shown in Tables 1 and 2. Wage and price inflation and interest rates are shown in annualized percent. The nominal and real exchange rates are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

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



Note: Optimal policy IRFs to a 10% positive commodity/energy import price shock under alternative elasticities. 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 $-\hat{e}_t$ and $-\hat{s}_t$ so that an increase corresponds to an appreciation.

Figure D.6: IRFS TO ENERGY IMPORT PRICE SHOCK IN EMERGING MARKET COMMODITY IMPORTER



Note: Optimal policy IRFs to a 10% positive commodity/energy import price shock under alternative elasticities. 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 $-\hat{e}_t$ and $-\hat{s}_t$ so that an increase corresponds to an appreciation.