Monetary Policy and Fiscal-led Inflation in Emerging Markets*

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January 30, 2024

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Abstract

I study monetary policy and inflation in emerging markets and the interaction with fiscal policy. I measure monetary policy shocks—unanticipated changes in monetary policy—using changes in exchange rates around monetary policy announcements. I validate this approach against existing monetary policy shocks. I find that in response to an unanticipated rise in interest rates—a monetary policy tightening—inflation increases and output falls in emerging markets. This inflation response is opposite the one generally found for advanced economies. I show the results are in line with high-frequency changes in inflation expectations. I develop a small open economy New Keynesian model with monetary and fiscal policy interactions. I show a fiscal-led policy mix, i.e., a weak fiscal policy reaction of taxes to changes in government debt and accommodative monetary policy, can explain the increase in inflation. The estimated quantitative model finds a fiscal-led policy mix in emerging markets. The fiscal-led policy mix is supported by the effect of U.S. monetary policy shocks on emerging markets. I also study optimal monetary policy conditional on a fiscal-led policy regime.

Keywords: Monetary policy, inflation, fiscal policy, emerging markets

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1. Introduction

A central goal of monetary policy is price stability. A large body of empirical evidence for advanced economies shows that tighter monetary policy, that is, increasing interest rates, reduces inflation. This finding comes from identifying high-frequency monetary policy shocks—unanticipated changes in monetary policy—and estimating their impact on the macroeconomy. However, the impact of domestic monetary policy in emerging-market economies is relatively less studied.

In this paper I examine the impact of monetary policy for emerging markets. I find a monetary policy tightening leads to an increase in inflation, the opposite response as generally found for advanced economies. I argue the interaction of monetary policy with fiscal policy is central to understanding the impact on inflation. In particular, I find evidence that the monetary and fiscal policy mix in determining inflation is *fiscal led* for emerging markets—i.e., a weak response of taxes to government debt and accommodative monetary policy—whereas *monetary led* for the U.S.[1] This suggests that while many emerging markets have established independent inflation-targeting central banks (Fraga, Goldfajn and Minella, 2003), the fiscal authority retains significant influence over inflation outcomes.

To examine the impact of monetary policy, I measure high-frequency monetary policy shocks for emerging markets using changes in exchange rates from the covered interest rate parity condition. I use this alternative to the conventional approach to measuring monetary policy shocks for advanced economies because of data limitations for emerging markets. I first validate this approach against existing monetary policy shocks. I then estimate the impact on inflation in emerging markets and find inflation increases for a monetary policy tightening, the opposite response to the U.S. I also examine high-frequency changes in market inflation

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[1] Specifically, in a *fiscal-led* policy mix, taxes respond by less than one-to-one with changes in government debt and monetary policy raises the nominal interest rate by less than the increase in inflation. In a *monetary-led* policy mix, taxes respond by more than one-to-one with changes in government debt and monetary policy responds aggressively by raising the nominal interest rate by more than the increase in inflation. Leeper (1991) uses the terminology "active" or "passive". I use *fiscal led* and *monetary led* following Bianchi and Melosi (2017), for example, my use of *fiscal led* corresponds to the Leeper (1991) "active" fiscal and "passive" monetary regime.

expectations for the emerging markets and find results consistent with those for inflation outcomes. I develop a small open economy model with monetary and fiscal policy and show a *fiscal-led* policy mix can explain an increase in inflation and fall in output to a monetary policy tightening. In this case, a monetary policy tightening raises the government debt burden and inflation increases to stabilize the level of government debt. I estimate the policy rule parameters for a quantitative version of the model, which support the presence of a *fiscal-led* regime in the emerging markets.

The first part of the paper provides the empirical analysis, outlining the measurement approach for monetary policy shocks, validation, and results for monetary policy in emerging markets. Since futures contracts for the monetary policy interest rate are unavailable for emerging markets, I cannot follow standard measurement approaches to identify monetary policy shocks for advanced economies. I use the change in the forward exchange rate premium (log difference between the forward and spot exchange rate against the U.S. dollar) to measure monetary policy shocks, which from the covered interest parity condition should equal unanticipated changes in the domestic interest rate.[2] I show for the U.S. and other advanced economies that using the forward premium is strongly correlated with existing measures of high-frequency monetary policy shocks, and find near identical macroeconomic effects when used as an external instrument in a VAR following Gertler and Karadi (2015). I also do so for Mexico and Brazil against other approaches to measuring monetary policy shocks. These validation exercises support using the forward premium measurement approach.

I then examine the impact of domestic monetary policy shocks for five emerging markets: Brazil, Chile, Colombia, Mexico, and South Africa from 2006 to February 2020.[3] I do so in a monthly panel VAR, using the high-frequency monetary policy shocks measured using the forward premium as an external instrument. I find that in response to an unanticipated monetary policy tightening, inflation increases and output falls for these emerging markets.[4]

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[2] My identification approach does not require that covered interest parity holds, as detailed in Section 2.

[3] I select these emerging markets because over this period I can calculate daily market inflation expectations from government bond prices. In addition, they all have inflation-targeting central banks and floating exchange rates.

[4] I include fiscal policy, measured by the level of government debt, and the exchange rate, which are both present in the model, as variables in the VAR.

This inflation response is the opposite to that generally found in advanced economies, where both inflation and output fall for a monetary policy tightening.

To further investigate this inflation response, I examine high-frequency changes in inflation expectations around monetary policy decisions for these emerging markets. I do so by calculating market inflation expectations from the difference in yields for nominal and inflation-indexed government bonds.[5] I find that for an unanticipated monetary policy tightening, inflation expectations increase, in line with higher realized inflation. These high-frequency expectations results provide further support for the VAR results for inflation.

In the second part of the paper I set out a small open economy model with monetary and fiscal policy, which together determine the response of inflation to a monetary policy shock. I extend the canonical small open New Keynesian economy with monetary policy of Galí and Monacelli (2005) to incorporate fiscal policy following Leeper (1991). Monetary policy follows a Taylor rule targeting inflation, and the fiscal policy rule adjusts taxes depending on the level of government debt as a share of output. I characterize the two policy regimes for this economy—*monetary led* and *fiscal led*—that lead to a unique stationary equilibrium and depend jointly on the policy rule parameters.[6]

Next, I show the response of inflation to a monetary policy shock depends on the policy regime. In the *monetary-led* policy mix, the central bank responds by increasing the interest rate by more than inflation, and fiscal policy raises taxes strongly in response to higher levels of government debt. In this case, a monetary policy tightening reduces inflation and decreases output, in line with the empirical evidence for advanced economies. In the *fiscal-led* policy mix, the fiscal authority adjusts taxes by a small amount to higher levels of government debt, and the central bank is accommodative of higher inflation.[7] In the *fiscal-led* regime, a monetary policy tightening increases inflation and decreases output, as in the empirics for emerging markets. The reason is output falls due to lower household demand, which raises

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[5] Inflation expectations are measured by break-even inflation, the rate of inflation that makes an investor indifferent between the returns on nominal and inflation-indexed government bonds with a similar maturity.

[6] This extends the results in Leeper (1991) to an open economy where monetary policy responds to inflation which includes domestic inflation and an exchange rate component. Llosa and Tuesta (2008) characterize the conditions for a unique stationary equilibrium in Galí and Monacelli (2005) with monetary policy only.

[7] As detailed in Section 3, in the *fiscal-led* policy mix the Taylor-rule coefficient on inflation is less than one, and fiscal rule for taxes coefficient on government debt to output is less than one.

government debt relative to output, and taxes adjust by little from the fiscal rule. Therefore, inflation rises to reduce the government debt burden and ensure it is stabilized, similar to monetization of public debt.[8] This higher inflation is accommodated by monetary policy.

The final part of the paper uses a quantitative version of the model, including features of emerging markets and allowing for a rich set of shocks, to estimate the monetary and fiscal policy mix. I do so using Bayesian methods, incorporating the high-frequency monetary policy shocks in the estimation, similar to Bianchi, Ludvigson and Ma (2022). The key moments to identify the policy regime and policy rule parameters are the relationship between the monetary policy rate and inflation, and the fiscal balance and government debt.

I find the emerging markets are characterized by a *fiscal-led* policy mix over the sample period, consistent with the estimated response of an increase in inflation to a monetary policy tightening. This is evidence of fiscal indiscipline, that when output falls and government debt is high there is limited government budget consolidation, similar to procyclical fiscal policy in emerging markets (Kaminsky, Reinhart and Végh, 2005). Estimating the model for the U.S., I instead find a *monetary-led* policy mix, rationalizing the opposite inflation response to a monetary policy shock.[9] The impulse responses for the estimated quantitative model are also similar to the empirical results.

I also examine the response in emerging markets to a U.S. monetary policy shock. I find a *fiscal-led* policy mix in the small open economy model is in line with the empirical findings in De Leo, Gopinath and Kalemli-Ozcan (2023) that a U.S. monetary tightening leads to a monetary policy easing in emerging markets, and reduces inflation and output growth.[10] Whereas the *monetary-led* policy mix leads to a monetary policy tightening in emerging markets and reduces inflation, which cannot rationalize the findings in De Leo *et al.* (2023).

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[8] I follow Galí and Monacelli (2005) and do not introduce money explicitly in the model, so the government receives no seigniorage revenue. Money can be thought of as a unit-of-account role, as in the New Keynesian literature, e.g. Woodford (2003), Galí (2008), which study the limit of the economy as it becomes cashless.

[9] The finding of a *monetary-led* policy mix for the U.S. in the post-Volcker period from 1979 is consistent with the estimates in Taylor (1998), Clarida, Galí and Gertler (2000), Cogley and Sargent (2001), Lubik and Schorfheide (2004), Favero and Monacelli (2005), Sims and Zha (2006), Davig and Leeper (2006), Fernández-Villaverde and Rubio-Ramírez (2007), and, more recently, Carvalho, Nechio and Tristao (2021).

[10] A large literature studies the effect of U.S. monetary policy shocks in emerging markets, such as Canova (2005), Kalemli-Ozcan (2019), Ilzetzki and Jin (2021), Vicondoa (2019), De Leo *et al.* (2023), as well as the global financial cycle (Rey, 2013; Miranda-Agrippino and Rey, 2020).

Finally, I study the welfare consequences of monetary policy in a *fiscal-led* regime. In particular, I examine the optimal monetary policy rule conditional on a *fiscal-led* policy mix and find that welfare is increased by reducing the monetary policy responsiveness to inflation.[11] This suggests the empirical estimates for the emerging markets monetary policy of little response to inflation are close to optimal given the *fiscal-led* regime. By contrast, in the *monetary-led* regime, the optimal policy rule responds more strongly to inflation. I also show that higher welfare can be achieved in a *monetary-led* regime than the *fiscal-led* regime, implying this shift in policy mix for emerging markets would be welfare improving.

1.1. Related Literature

This paper is related to several strands of literature. The main contribution is documenting the macroeconomic response to monetary policy shocks in emerging markets, and linking this to the behavior of fiscal policy in a small open economy New Keynesian model.

Monetary policy shocks and transmission. This paper is related to the literature on measuring and identifying high-frequency monetary policy shocks (see Cook and Hahn, 1989; Kuttner, 2001; Cochrane and Piazzesi, 2002, for early contributions).[12] Gürkaynak, Sack and Swanson (2005), Gertler and Karadi (2015), and Nakamura and Steinsson (2018) use changes in U.S. Fed funds futures in a 30-minute window around monetary policy announcements.[13] This research has generally focused on advanced economies.[14]

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[11] Benigno and Woodford (2003, 2007) and Schmitt-Grohé and Uribe (2007) study optimal monetary and fiscal policy, and alternative policy rules in closed-economy sticky price models.

[12] An alternative uses a narrative approach to identify monetary policy shocks as in Romer and Romer (2004) from U.S. Federal Reserve internal forecasts, and further examined in Coibion (2012).

[13] More recent refinements to measuring monetary policy shocks include removing the component correlated with economic and financial data as in Bauer and Swanson (2023a) and Miranda-Agrippino and Ricco (2023).

[14] See also, for example, Altavilla, Brugnolini, Gürkaynak, Motto and Ragusa (2019) and Jarociński and Karadi (2020) for the European Central Bank, Champagne and Sekkel (2018) for Canada, and Cesa-Bianchi, Thwaites and Vicondoa (2020) for the U.K. Two recent studies for emerging markets use futures contracts for other interest rates to measure monetary policy shocks, Solis (2023) for Mexico and Gomes, Iachan, Santos and Ruhe (2023) for Brazil, which I used to validate my measurement approach. These studies investigate the impact of monetary policy on economic variables other than inflation and output. Aruoba, Fernández, Guzmán, Pastén and Saffie (2021) measure monetary policy surprises for Chile based on a survey of expected monetary policy from financial market participants. Using a Bayesian VAR estimation for a longer sample period than this paper, they find a decrease in the CPI following a contractionary monetary policy shock, in contrast to the results in this paper. Earlier work by Kohlscheen (2014) using daily changes in market interest rates found an exchange rate depreciation for a monetary policy tightening in emerging markets.

Covered interest parity. Using currency forward contracts as a lens to study changes in interest rates is related to the international finance literature on covered interest parity (e.g., Du, Tepper and Verdelhan (2018b) for advanced economies, and Du and Schreger (2016) for emerging markets). Importantly, my forward premium identification approach does not require that covered interest parity holds exactly.[15] Bianchi, Gómez-Cram, Kind and Kung (2023b) use this method as a robustness exercise for the U.S. for President Trump's tweets that criticize the Federal Reserve, and find similar results to using Fed funds futures. I validate this measure and use it to study monetary policy decisions in emerging markets.

Monetary policy in open economies. This paper is related to the literature on business cycles in emerging markets, following Neumeyer and Perri (2005) and Aguiar and Gopinath (2007).[16] Focusing on the role of monetary policy, Galí and Monacelli (2005) extend the New Keynesian model (e.g., Clarida, Galí and Gertler, 1999; Galí, 2008) for a small open economy.[17] In this framework, I incorporate fiscal policy from the closed-economy literature following Leeper (1991) to study monetary and fiscal interactions.

De Leo *et al.* (2023) study monetary policy cyclicality in emerging markets and emphasize a complementary channel: the disconnect between monetary policy rates and short-term interest rates due to risk premia. My focus on fiscal policy is closely related.[18] An additional explanation for a monetary tightening leading to an increase in inflation is the persistence of monetary policy shocks (Schmitt-Grohé and Uribe, 2014; Cochrane, 2018). For example,

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[15] See also Baba, Packer and Nagano (2008), Avdjiev, Du, Koch and Shin (2019), Jiang, Krishnamurthy and Lustig (2021), Engel and Wu (2023) on deviations from covered interest parity since the global financial crisis, and Du and Schreger (2022) for a recent review.

[16] See Frankel (2010) for an overview of characteristics that distinguish monetary policy in emerging markets from advanced economies.

[17] The small open New Keynesian economy framework has been used to study the role of features such as the role of financial spillovers (Gourinchas, 2018), financial frictions (Akinci and Queralto, 2024), dominant currency pricing (Gopinath, Boz, Casas, Díez, Gourinchas and Plagborg-Møller, 2020), currency choice (Mukhin, 2022), sovereign default (Arellano, Bai and Mihalache, 2020), and household heterogeneity (Guo, Ottonello and Perez, 2023; Auclert, Rognlie, Souchier and Straub, 2021). Schmitt-Grohé and Uribe (2016) develop an open economy model to study the effect of downward nominal wage rigidity in emerging markets. Itskhoki and Mukhin (2021, 2022) study monetary policy in a model with segmented financial markets and international financial shocks.

[18] Hnatkovska, Lahiri and Végh (2016) examine the exchange-rate effect of monetary policy shocks and find the exchange rate depreciates and inflation increases for a monetary policy tightening in emerging markets, in line with my results. Hnatkovska *et al.* (2016) use a monthly VAR and estimated innovations to a policy rule. I use a high-frequency approach to identify monetary policy shocks.

Uribe (2022) uses a sign-restrictions approach to identify permanent and transitory monetary policy shocks for the U.S., and finds inflation and output increases for a permanent increase in the nominal interest rate.

Monetary and fiscal policy interactions. This paper is related to the literature on monetary and fiscal policy interactions following Sargent and Wallace (1981).[19] In a seminal paper for a closed economy, Leeper (1991) characterizes the conditions under which policy is either *monetary led* or *fiscal led*, depending jointly on the monetary and fiscal policy rules. The fiscal theory of the price level operates through similar mechanisms (see Cochrane, 2023). Bayesian methods to estimate monetary and fiscal policy rules have also been used to examine fiscal multipliers (Leeper, Traum and Walker, 2017), the role of the zero-lower bound (Bianchi and Melosi, 2017), and unfunded fiscal shocks for inflation dynamics (Bianchi, Faccini and Melosi, 2023a). Sargent, Williams and Zha (2009) study inflation in a regime-switching model of government budget financing in Latin America.

Procyclical fiscal policy in emerging markets. Finally, this paper is related to empirical work which finds that fiscal policy is procyclical in emerging markets, in contrast with advanced economies where it is countercyclical (Gavin and Perotti, 1997; Kaminsky *et al.*, 2005; Vegh and Vuletin, 2015).[20] Emerging market governments may be more subject and give in to political pressure to increase spending during booms (Tornell and Lane, 1999; Alesina, Campante and Tabellini, 2008).

The rest of the paper is organized as follows. Section 2 presents the empirical analysis. Section 3 presents the model. Section 4 provides the quantitative results. Section 5 examines U.S. monetary policy on emerging markets. Section 6 presents the welfare analysis, and Section 7 concludes.

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[19] Sargent (1982) examines the role of monetary and fiscal policy regimes in determining inflation and expectations. Aiyagari and Gertler (1985) show that how the government finances debt and the degree of monetary policy accommodation affect inflation and interest rates. Other significant contributions in this area include Drazen and Helpman (1987, 1990), Sims (1994), Woodford (1994), Cochrane (1999, 2001), Dupor (2000) and, more recently, Cochrane (2022).

[20] See also Tornell (1999), Talvi and Végh (2005), Mendoza and Oviedo (2006), Frankel, Vegh and Vuletin (2013).

2. Empirical Analysis

This section outlines the approach to measuring monetary policy shocks and the impact of monetary policy in emerging markets. Section 2.1 describes the measurement approach, data sources and validation exercises. Section 2.2 presents the results for the impact of monetary policy on inflation and output in emerging markets. Section 2.3 presents the additional results for monetary policy and high-frequency inflation expectations.

2.1. Measurement and validation of monetary policy shocks

I measure high-frequency monetary policy shocks for emerging markets using changes in forward and spot exchange rates. This is because futures contracts for the policy rate as used in advanced economies, e.g. Fed funds futures for the U.S., are unavailable in emerging markets so I cannot follow the same approach. The rationale for using exchange rates is the covered interest parity (CIP) condition

$$(1 + r^c_{t,t+1}) = (1 + r^\$_{t,t+1}) \frac{F_{t,t+1}}{\mathcal{E}_t}, \tag{1}$$

where $r^c_{t,t+1}$ is the one-period risk-free interest rate in currency c, $r^\$_{t,t+1}$ is the risk-free interest rate in U.S. dollars, $F_{t,t+1}$ is the forward exchange rate per USD at $t+1$, and $\mathcal{E}_t$ is the spot exchange rate per USD at t (where an increase in $\mathcal{E}_t$ is a depreciation of currency c). CIP is a well-known no-arbitrage condition which requires that the interest rate in currency c be equal to the implied interest rate in USD in the foreign exchange swap market.[21]

Since the global financial crisis, CIP deviations have opened up reflecting international financial frictions.[22] Taking logs of (1), and allowing for a deviation from CIP λ_t gives

$$r^c_t - r^\$_t - \lambda_t = \underbrace{f_{t,t+1} - e_t,}_{\text{forward premium} \equiv fp_{t,t+1}} \tag{2}$$

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[21] The forward exchange rate $F_{t,t+1}$ is locked in at time t and used to convert USD returns at $t+1$ into currency c.

[22] See Du and Schreger (2022) for a review on CIP deviations and Maggiori (2022) for a survey on imperfect financial markets in international macroeconomics.

where $f_{t,t+1}$ and e_t are the log forward and spot exchange rates, respectively. Equation (2) relates the interest rate spread with the U.S. to the forward premium. Other things being equal, if the risk-free interest rate in currency c increases, then currency must be expected to depreciate relative to the USD over the period, i.e. an increase in the forward premium.

I measure a monetary policy shock for country c under the following assumption.

ASSUMPTION 1. *Suppose $r_t^{\$}$ and any CIP wedge λ_t are constant within a narrow window around a monetary policy decision for country c.*

I test and show this holds for the emerging market episodes studied (see Appendix B1). Under Assumption 1, within a narrow window around a monetary policy decision

$$\Delta fp_{t,t+1} = \Delta r_t^c. \tag{3}$$

The change in the forward premium can be used to measure unanticipated changes in the one-period interest rate in country c as a result of the monetary policy announcement.[23]

Data sources. I examine the impact of domestic monetary policy using daily data for five emerging markets: Brazil, Chile, Colombia, Mexico, and South Africa from 2006 to February 2020.[24] These countries all have independent inflation-targeting central banks and floating exchange rates during this period.[25] I focus on the 1-year forward exchange rate against the USD, as this horizon most closely aligns with existing high-frequency monetary policy shocks. When measuring the change in the forward premium for the U.S., I use the USD average against the euro, yen, pound, and Swiss franc. I collect the monetary policy announcement dates from national central banks.[26] Appendix A provides more detail on the data, and Figure A2 provides the time series for the monetary policy shocks.

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[23] Bianchi *et al.* (2023b) use the same approach to measure monetary policy surprises for the U.S as a robustness exercise.

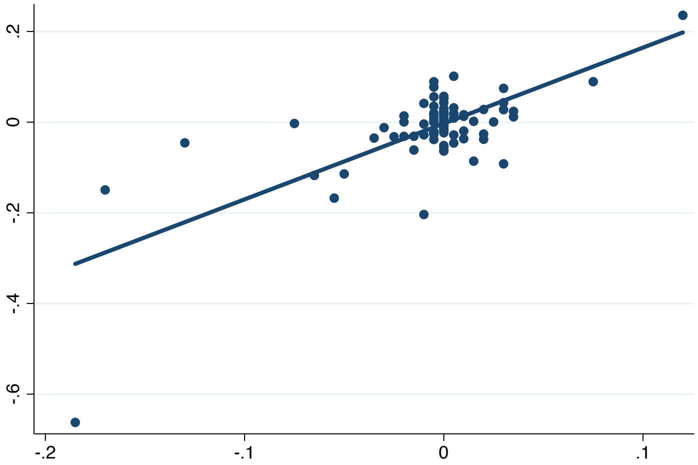
[24] I select these emerging markets because over this period I can calculate daily market inflation expectations from government bond prices (see Section 2.3).

[25] Figure A1 shows the monetary policy rate and inflation in each of the countries during the sample.

[26] Similar to the U.S. Federal Reserve, these emerging market central banks have a public, pre-set calendar of monetary policy meeting dates, with a small number of occasional ad-hoc meeting decisions.

Figure 1: U.S.: Forward Premium and Monetary Policy Shocks

Δfp (y-axis), Gertler Karadi MP shocks (x-axis)
% pts, 2005m9−2016



Notes: $R^2 = 0.45$. This figure plots the 1-day change in the 1-year forward premium and Gertler and Karadi (2015) monetary policy shocks, updated by Jarociński and Karadi (2020), on U.S. FOMC meeting dates.

Validation: High-frequency. I do validation exercises for the measure of a monetary policy shock using the forward premium against exisiting monetary policy shocks, both at a high-frequency and for the macroeconomic impact using a VAR. First, on a high-frequency basis, Figure 1 shows for U.S. monetary policy decision dates, that the change in the forward premium closely matches the Gertler and Karadi (2015) monetary policy shocks (where an increase in both variables is a monetary policy tightening).[27] This indicates the forward premium provides a good proxy for the monetary policy shock.

This significant relationship between the change in the forward premium and monetary policy shocks also holds for other U.S. measures from the literature (see Figures B1–B5 and Table B2).[28] Figures B6 and B7 show this also holds when using the 6-month and 3-month forward premium, and Figure B8 using a 2-day window around the monetary policy

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[27] Gertler and Karadi (2015) monetary policy shocks are from the 30-min change in 3-month ahead Fed funds futures.

[28] Specifically, the Nakamura and Steinsson (2018), Bauer and Swanson (2023b), Jarociński and Karadi (2020), Bu, Rogers and Wu (2021), and Gürkaynak *et al.* (2005) measures of U.S. monetary policy shocks.

decision.[29] Figures B10–B12 show the forward premium is strongly correlated with monetary policy shocks for the U.K., European Central Bank, and Canada. Figures B13 and B14 show this also for alternative approaches to measure monetary policy shocks for Mexico and Brazil, respectively, using futures contracts for other domestic interest rates.

Validation: Macroeconomic impact. I next use the high-frequency forward premium and existing monetary policy shocks in a structural VAR to compare the macroeconomic impact. First, for the U.S., I follow Gertler and Karadi (2015) by using a monthly VAR that includes the one-year government bond rate as the policy indicator, the log consumer price index, the log industrial production, and the excess bond premium measure of financial conditions (Gilchrist and Zakrajšek, 2012).[30] The high-frequency monetary policy shocks are used as an external instrument to identify a monetary policy shock.[31]

Figure 2 shows the impulse responses to a monetary policy shock which raises the government bond rate by one percentage point on impact, shown in the top left panel.[32] Following a monetary policy tightening, there is a decline in inflation shown by the consumer price index and a decrease in output shown by the fall in industrial production. The excess bond premium increases, indicating a tightening of financial conditions. The macroeconomic impact of the monetary policy shock is similarly estimated when using both the change in the forward premium and Gertler and Karadi (2015) monetary policy shocks. Figures B15-B16 show this close relationship also holds for alternative U.S. monetary policy shock measures, and Figure B18 for other monetary policy shocks for Mexico and Brazil. Taken together, these high-frequency and macroeconomic validation exercises support using the

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[29] In addition, Figure B9 shows that the forward premium is more closely related to the monetary policy shocks than the change in the U.S. Federal funds rate policy decision.

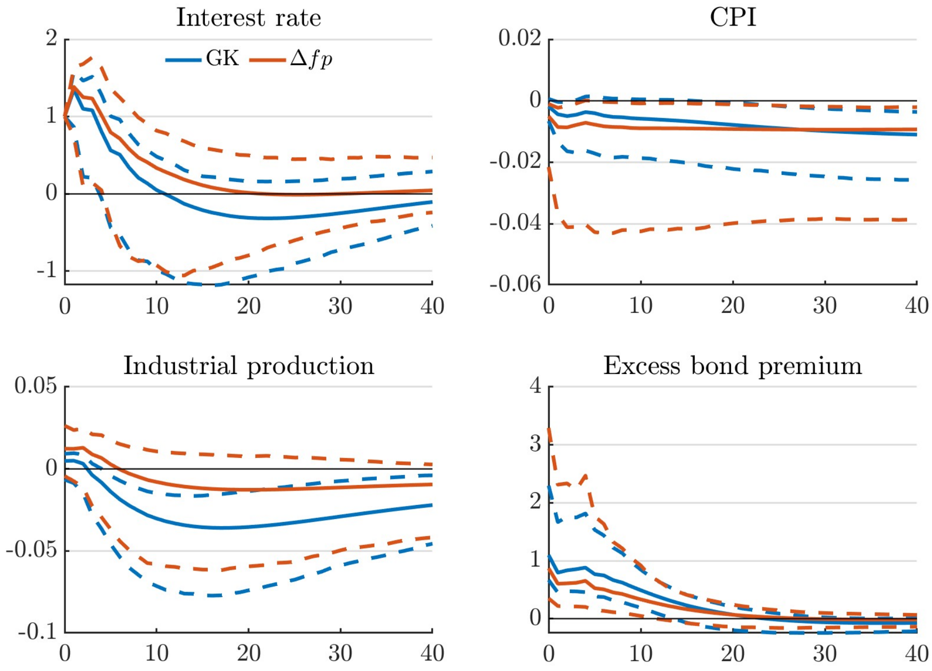
[30] The excess bond premium is the spread between the return on similar maturity corporate and government bonds, after removing the component due to default risk. Therefore, it can be interpreted as a measure of spreads due to financial market frictions.

[31] Following Bauer and Swanson (2023a), I also residualize the monetary policy shocks measured using the forward premium to remove any component correlated with economic and financial data and Figure B16 shows this also leads to very similar results. See Ramey (2016) for further detail on SVAR-IV estimation and Plagborg-Møller and Wolf (2021) on the equivalence with local projections impulse responses.

[32] The sample period for the VAR is July 1979 to December 2016. The sample period for the monetary policy shocks is October 2005 to December 2016, the longest period available for both Gertler and Karadi (2015) and the forward premium. Table B3 provides the first-stage regression results.

Figure 2: U.S. SVAR-IV: Forward Premium and Gertler Karadi MP Shocks

1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 1-day change in the 1-year forward premium and Gertler and Karadi (2015) monetary policy shocks, updated by Jarociński and Karadi (2020), as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

forward premium measurement approach.

2.2. Emerging markets monetary policy results

I now outline the estimation for the panel of emerging markets. I estimate a monthly VAR with country fixed effects, similar to Gertler and Karadi (2015), comprising five variables: the one-year government bond rate as the policy indicator, the log consumer price index, the log industrial production, government debt to output, and the nominal exchange rate. I include government debt relative to output as the fiscal policy measure, to incorporate any fiscal response to a monetary policy shock.[33] I also include the nominal exchange rate against

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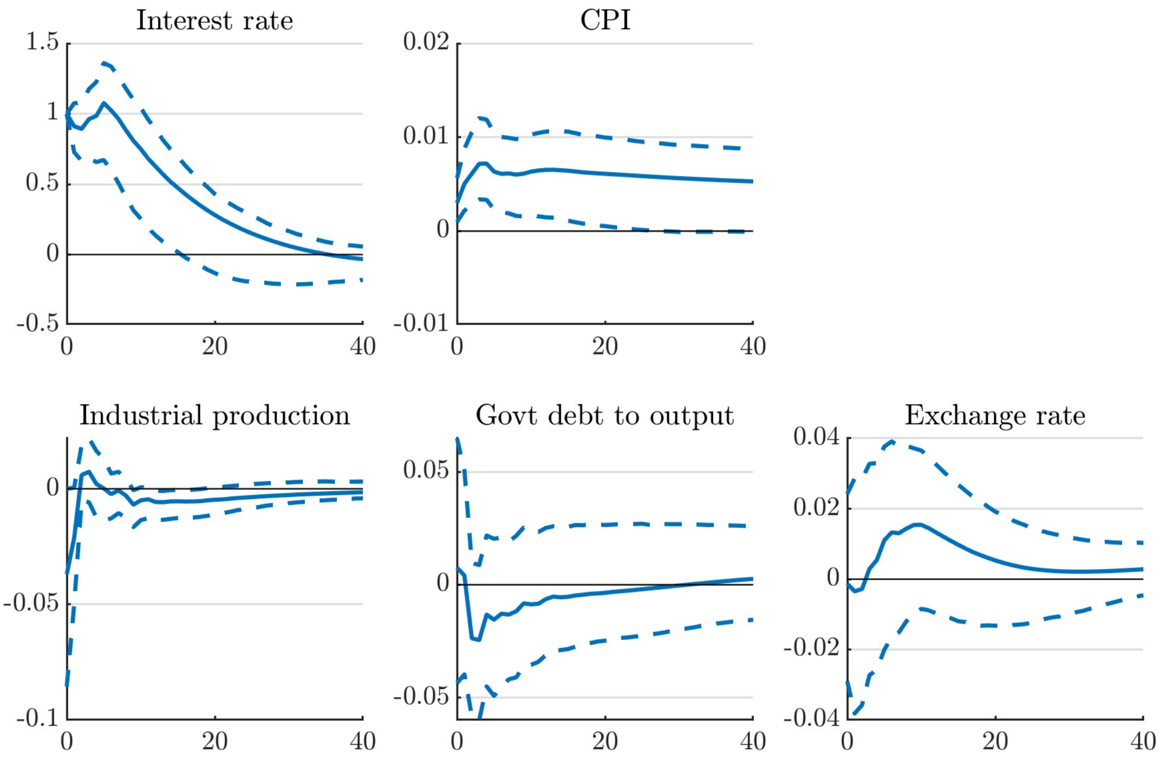
[33] Section 3 outlines the small open economy model with monetary and fiscal policy interactions.

Figure 3: Emerging Markets SVAR-IV: Forward Premium MP Shock

1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

the U.S. dollar to incorporate open economy channels of monetary policy.[34] I include 6 lags of all variables.[35] The high-frequency monetary policy shock measured using the forward premium is used as an external instrument.[36]

Figure 3 plots the impulse responses to a monetary policy shock which raises the government bond rate by one percentage point on impact, shown in the top left panel.[37] I find

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[34] See, for example, Hnatkovska *et al.* (2016) and Auclert *et al.* (2021) on the exchange rate and monetary policy.

[35] Figures B24–B26 show similar results when varying the lag length between 4 and 12 months.

[36] The sample period for the emerging markets VAR is January 2006 to February 2020, and for the monetary policy shocks is July 2011 to February 2020, the longest period available for all variables and countries. The results are robust to restricting to the post-Great Recession period.

[37] Table B3 provides the first-stage panel regression results, showing values above the threshold value of 10 recommended by Stock, Wright and Yogo (2002) to reasonably rule out a weak instruments problem.

that in response to a monetary policy tightening, the consumer price index increases (top middle panel) and industrial production falls (bottom left panel). This is the opposite inflation response as the U.S. in the previous section, where both inflation and output declined.[38] The change in government debt to output (bottom middle panel) and the nominal exchange rate (bottom right panel) are not significant. The latter may reflect both an increase in the domestic interest rate, which would lead the exchange rate to appreciate, other things being equal, and an increase in inflation, which would lead the exchange rate to depreciate.

These results for inflation and output to a monetary tightening in emerging markets are robust and of similar magnitude in alternative specifications. Figure B19 shows the impulse responses adding time fixed effects to control for any common global factors. Figure B20 estimates a small-scale VAR with the interest rate, consumer price index, and industrial production, without the government debt and exchange rate variables.[39] Figures B24–B26 show the impulse responses when varying the lag length of all variables between 4 and 12 months. The results are also robust to including additional variables, including the local stockmarket (Figure B27), sovereign spreads (Figure B28), exports (Figure B29), and capital flows (Figure B30), and controlling for U.S. interest rates (Figure B31).

Another concern may be that this inflation response finding reflects the "price puzzle". However, that result generally occurs when using the Cholesky identification scheme, rather than SVAR-IV with high-frequency external instrument (Rusnák, Havranek and Horváth, 2013; Gertler and Karadi, 2015). The increase in inflation is also found when checking other solutions to the price puzzle from the literature of including commodity prices (Figure B32) and using a measure of the output gap (Figure B33). Finally, I use the same VAR and forward premium measure of monetary policy shocks for the advanced small open economies Canada and the U.K. (Figure B34). I find that for a monetary policy tightening inflation decreases, in line with other advanced economies estimates, supporting that the emerging markets results are not due to the measurement approach.[40]

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[38] Figure B17 shows that this also holds for the U.S. using this EMs VAR specification, and similar results when using the forward premium and Gertler and Karadi (2015) monetary policy shocks.

[39] Figures B21 and B22 include only government debt to output or the exchange rate, respectively, and Figure B23 estimates the baseline VAR with government debt in levels.

[40] This is in line with the results in Champagne and Sekkel (2018) for Canada, and Cesa-Bianchi *et al.*

2.3. Inflation expectations and monetary policy shocks

Given the finding that inflation increases for a monetary policy tightenting, this section presents the additional results for high-frequency inflation expectations around monetary policy announcements. For the five emerging markets both nominal and inflation-indexed government bonds are traded, enabling market inflation expectations to be calculated at a daily frequency. Inflation expectations are measured by break-even inflation (BE_t): the level of inflation that leaves an investor indifferent between a nominal and an inflation-indexed bond. It is calculated by: $BE_t = Yield_t^{Nom} - Yield_t^{IIB}$, where $Yield_t^{Nom}$ is the yield on a nominal government bond, and $Yield_t^{IIB}$ is the yield on an inflation-indexed government bond with similar maturity.[41] Break-even inflation contains the expectations for future realized inflation and, therefore, any effect of monetary policy.

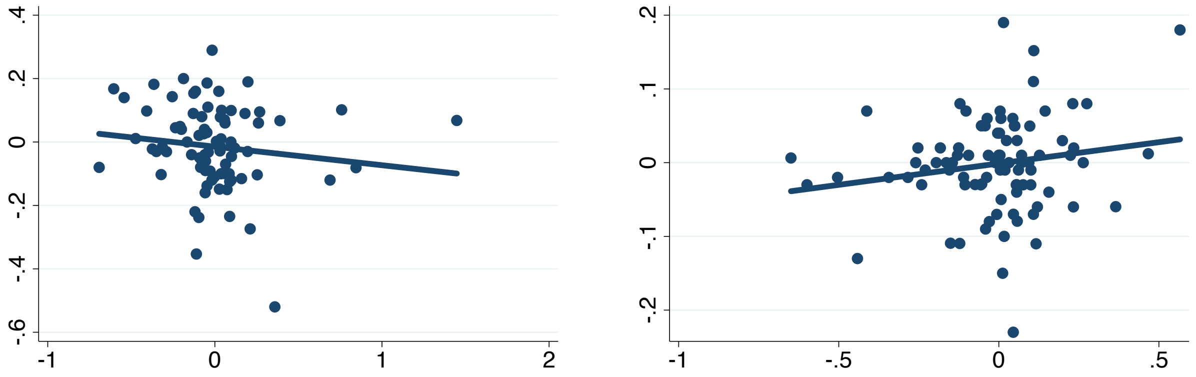
Figure 4 plots the relationship between the change in break-even inflation and the monetary policy shock measured using the forward premium around monetary policy decision dates. A positive relationship indicates that a monetary policy tightening is associated with an increase in inflation expectations. The results are positive and significant relationship for each emerging market, with the exception of Brazil in panel (a) where it is not significant (see Table B4 for regression results). This provides evidence that for these emerging markets, inflation expectations increase, in line with the increase in inflation outcomes following a monetary tightening in Section 2.2. Further, for the U.S. in panel (f), there is a negative and significant relationship, indicating a monetary policy tightening reduces inflation expectations, in line with the decrease in inflation as in Figure 2.[42] These high-frequency inflation expectations results also support the different inflation response to a monetary policy shock in emerging markets and the U.S.

(2020) for the U.K.

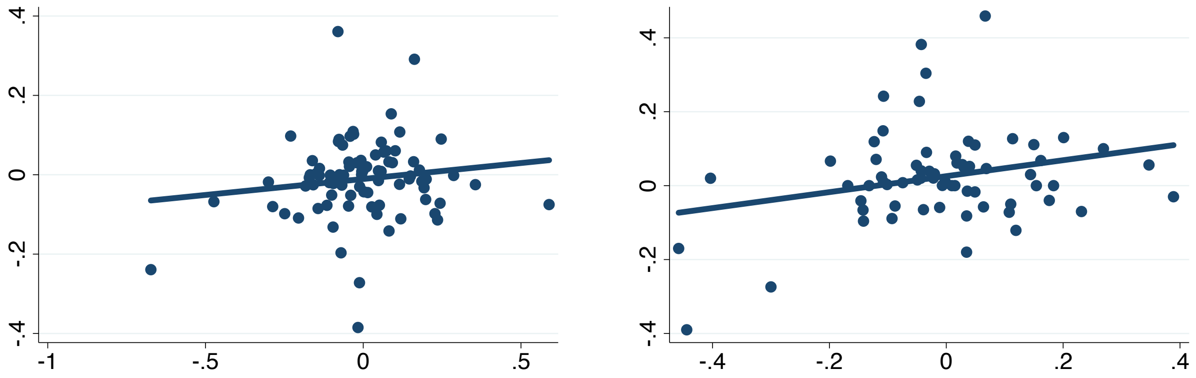
[41] Appendix A provides detail on the bonds used to calculate break-even inflation for each emerging market. For the U.S., I use the shortest horizon available, 5-year break-even inflation, from the Federal Reserve following Gürkaynak, Sack and Wright (2010).

[42] I find similar results for the U.S. when using the Gertler and Karadi (2015) and other measures of monetary policy shocks, and for other monetary policy shocks for Mexico and Brazil.

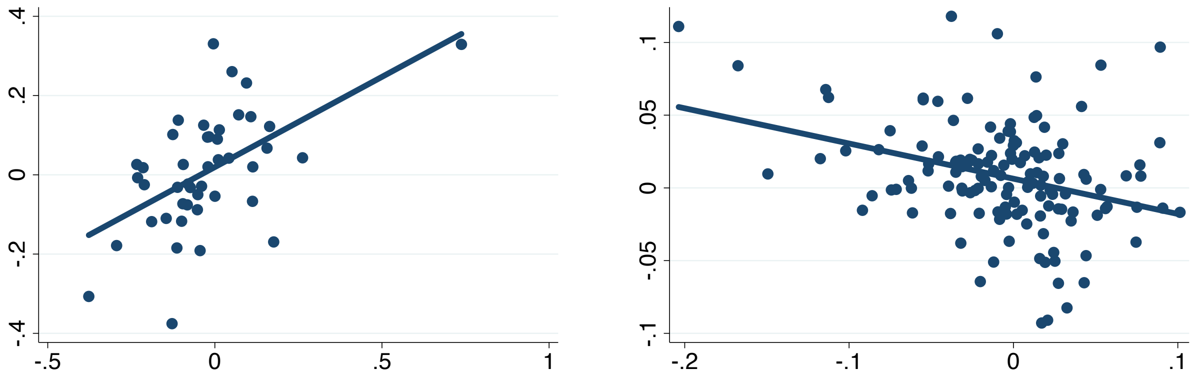
Figure 4: Inflation Expectations and Monetary Policy Shocks


(a) Brazil

(b) Chile


(c) Colombia

(d) Mexico


(e) South Africa

(f) U.S.

Notes: This figure shows the 2-day change in the 1-year forward premium for each country on monetary policy decision dates. The U.S. is the 1-day change. See Table B4 for the regression results and Appendix A2 for further detail. Data sources: Refinitiv Datastream, U.S. Federal Reserve, national central banks.

3. Theoretical Framework

This section outlines a small open economy model with monetary and fiscal policy, which jointly determine the response of inflation to a monetary policy shock. I extend the canonical small open New Keynesian economy with monetary policy of Galí and Monacelli (2005) to incorporate fiscal policy following Leeper (1991). In Section 3.2 I formally characterize the two policy regimes: *monetary led* and *fiscal led*, which lead to unique stationary equilibrium. In Section 3.3 I show that the *fiscal-led* policy regime can explain the increase in inflation in response to a monetary policy tightening in emerging markets found in Section 2. I extend this simple model in Section 4 in the quantitative analysis.

3.1. Model

The environment is a small open economy made up of households, firms, a monetary authority, and a fiscal authority. Time is infinite and discrete, denoted by $t = 0, 1, \ldots$. The representative household consumes home and foreign goods, and can save in local and foreign currency bonds. Domestic firms produce varieties of the home good using labor. The rest of the world exchanges home and foreign goods, and local and foreign currency bonds with the domestic economy. The monetary authority sets the local currency interest rate. The fiscal authority borrows in local currency and adjusts its budget to the level of government debt.

Households. The representative household has preferences given by lifetime utility

$$\sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \phi \frac{L_t^{1+\nu}}{1+\nu} \right], \tag{4}$$

where C_t is consumption and L_t is labor supply in period t. $\beta \in (0,1)$ is the discount factor. Consumption C_t is a CES aggregate of home c_{Ht} and foreign c_{Ft} goods

$$C_t = \left[(1-\omega)^{\frac{1}{\eta}} (c_{Ht})^{1-\frac{1}{\eta}} + \omega^{\frac{1}{\eta}} (c_{Ft})^{1-\frac{1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{5}$$

where $\omega \in (0, 1)$ is openness, $\eta > 0$ is the elasticity of substitution between c_H and c_F. The home good c_{Ht} is a CES aggregate of varieties $i \in [0, 1]$ given by

$$c_{Ht} = \left(\int c_{Hit}^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{6}$$

with elasticity $\epsilon > 0$. The household budget constraint is

$$\int P_{Hit} c_{Hit} di + P_{Ft} c_{Ft} + \frac{B_t}{R_t} + \mathcal{E}_t \frac{B_t^*}{R_t^*} + T_t = W_t L_t + B_{t-1} + \mathcal{E}_t B_{t-1}^* + \Pi_t, \tag{7}$$

where P_{Hit} and P_{Ft} are the prices of home and foreign goods denominated in local currency; risk-free bonds B_t denominated in local currency earn gross return R_t, and B_t^* denominated in foreign currency earn return R_t^* in foreign currency; $\mathcal{E}_t$ is the nominal exchange rate (the price of foreign currency in terms of domestic currency, $\mathcal{E}_t \uparrow$ is a depreciation); T_t are lump-sum taxes; W_t is the nominal wage; and Π_t are home firm profits.

The household's problem is to choose allocations $\{c_{Hit}, c_{Ft}, L_t, B_t, B_t^*\}_{t=0}^{\infty}$ that maximize utility, subject to the aggregation technologies (5) and (6), the sequence of budget constraints (7), given a sequence of prices, profits, taxes, and an initial level of bonds B_{-1}, B_{-1}^*. The optimal consumption allocation across domestic varieties gives

$$c_{Hit} = \left(\frac{P_{Hit}}{P_{Ht}} \right)^{-\epsilon} c_{Ht}, \tag{8}$$

where $P_{Ht} \equiv \left(\int P_{Hit}^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}$ is the price index of domestically produced goods. The optimal allocation between home and foreign goods consumption is

$$c_{Ht} = (1-\omega) \left(\frac{P_{Ht}}{P_t} \right)^{-\eta} C_t, \qquad c_{Ft} = \omega \left(\frac{P_{Ft}}{P_t} \right)^{-\eta} C_t, \tag{9}$$

where $P_t \equiv [(1-\omega) P_{Ht}^{1-\eta} + \omega P_{Ft}^{1-\eta}]^{\frac{1}{1-\eta}}$ is the home consumer price index. The optimal labor supply and consumption-saving conditions in local and foreign currency bonds[43] are

$$\frac{\phi L_t^{\nu}}{C_t^{-\sigma}} = \frac{W_t}{P_t}, \tag{10}$$

$$C_t^{-\sigma} = \beta R_t \mathbb{E}_t\left[\frac{P_t}{P_{t+1}} C_{t+1}^{-\sigma}\right], \tag{11}$$

$$C_t^{-\sigma} = \beta R_t^* \mathbb{E}_t\left[\frac{P_t}{P_{t+1}} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} C_{t+1}^{-\sigma}\right]. \tag{12}$$

Firms technology. A continuum of firms i hire labor from the household n_{it} to produce variety i of the home good, with a production technology $y_{Hit} = n_{it}^{1-\alpha}$ with returns to scale α. Each firm i faces domestic demand (8) from the household problem, and similarly for foreign demand from the rest of the world

$$c_{Hit}^* = \left(\frac{P_{Hit}^*}{P_{Ht}^*}\right)^{-\epsilon} c_{Ht}^*, \tag{13}$$

where, similar to (9), foreign demand for home goods is given by

$$c_{Ht}^* = \omega \left(\frac{P_{Ht}^*}{P_t^*}\right)^{-\eta} C^*, \tag{14}$$

where $P_{Ht}^* \equiv \left(\int {P_{Hit}^*}^{1-\epsilon_t} di\right)^{\frac{1}{1-\epsilon_t}}$ is the foreign price index of home goods, $P_t^* \equiv [(1-\omega)(P_{Ft}^*)^{1-\eta} + \omega(P_{Ht}^*)^{1-\eta}]^{\frac{1}{1-\eta}}$ the foreign consumption price index expressed in foreign currency, and C^* is aggregate foreign consumption.

As in Galí and Monacelli (2005), I assume the law of one price holds for all goods, e.g. for each variety i of the home good $P_{Hit} = \mathcal{E}_t P_{Hit}^*$, where P_{Hit}^* is the foreign price of the home good variety i expressed in foreign currency, and similarly for the foreign good. The

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[43] Combining the local and foreign currency bond optimality conditions gives the uncovered interest parity condition $\mathbb{E}_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\frac{P_t}{P_{t+1}}\left(R_t - R_t^*\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}\right)\right] = 0$. Including forward contracts $F_{t,t+1}$ in the Galí and Monacelli (2005) model would give the covered interest parity condition $R_t = R_t^*\frac{F_{t,t+1}}{\mathcal{E}_t}$. This leads to an equivalent exchange rate response to an unanticipated monetary policy shock under perfect foresight.

firm labor demand problem given prices is to maximize their profits which are given by

$$\max_{n_{it}} \pi_{it} = P_{Hit} n_{it}^{1-\alpha} - W_t n_{it}. \tag{15}$$

This gives rise to the labor demand for firm i

$$(1-\alpha) n_{it}^{-\alpha} = \frac{W_t}{P_{Hit}}. \tag{16}$$

Nominal rigidities. Firms set prices with price stickiness à la Calvo (1983) and can adjust its price each period with an exogenous probability $(1-\theta)$. When setting prices, the firm maximizes its expected discounted profits, taking as given its optimal production decision (16), aggregate prices, domestic demand (8), and foreign demand (13) and (14). The firm price setting problem and solution is detailed in Appendix C.

Monetary policy. The monetary authority follows a Taylor rule targeting CPI inflation $\Pi_t \equiv P_t/P_{t-1}$ given by

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\Pi}\right)^{\phi_\pi} e^{m_t}, \tag{17}$$

where the policy parameter $\phi_\pi > 0$ determines the responsiveness of the monetary authority to deviations of inflation from the steady state level, and m_t is a monetary policy shock which follows an AR(1) process $m_t = \rho_m m_{t-1} + \sigma_m \varepsilon_{m,t}$, $\varepsilon_{m,t} \sim N(0,1)$.[44] For the baseline model I use CPI inflation as this is the inflation measure officially targeted by each of the emerging market central banks in my sample.

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[44] The quantitative model will allow for a more general Taylor rule with persistence in the interest rate rule and to respond to deviations of output from steady state.

Fiscal policy. The fiscal authority levies lump-sum taxes T_t on households and borrows B_t^G in local-currency bonds, with government budget constraint

$$\frac{B_t^G}{R_t} + T_t = B_{t-1}^G. \tag{18}$$

I restrict government debt to be denominated in local currency because during my sample period for the set of emerging markets the average share of local-currency denominated debt is more than 85 per cent. The government follows the fiscal rule from Leeper (1991) for taxes to output $\mathcal{T}_t \equiv \frac{T_t}{P_t Y_t}$, and government debt to output $D_t \equiv \frac{B_t^G/R_t}{P_t Y_t}$, given by

$$\frac{\mathcal{T}_t}{\mathcal{T}} = \left(\frac{D_{t-1}}{D}\right)^{\gamma_d} \left(\frac{Y_t}{Y}\right)^{\gamma_y}, \tag{19}$$

where the policy parameters $\gamma_d > -1$ and γ_y determine the responsiveness of the fiscal authority to deviations of the lagged level of government debt and current level of output, respectively, from their steady state level.

Rest of the world. The rest of the world comprises a continuum of symmetric small open economies.[45] The rest of the world exchanges home and foreign goods, local currency denominated bonds B_t^{ROW}, and provides a perfectly elastic supply of foreign currency denominated bonds at the interest rate R_t^* with the small open economy.

Equilibrium. I now define an equilibrium of the model.

***Definition* 1.** *Given initial asset positions $B_{-1}, B_{-1}^*, B_{-1}^G$, the monetary policy rule (17), the fiscal policy rule (19), and a sequence of foreign demand and interest rates $\{c_{Ht}^*, R_t^*\}_{t=0}^{\infty}$, a competitive equilibrium is a sequence of private allocations $\left\{C_t, c_{Ht}, c_{Ft}, L_t, B_t, B_t^*, n_{it}, B_t^{ROW}\right\}_{t=0}^{\infty}$, prices $\{P_{Ht}, P_{Ft}, W_t, \mathcal{E}_t, R_t\}_{t=0}^{\infty}$, and government policies $\left\{B_t^G, T_t\right\}_{t=0}^{\infty}$, such that:*

1. *Allocations solve the households' and firms' problem given prices;*

2. *Government policies satisfy the government budget constraint (18);*

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[45] Each small open economy is measure zero relative to the rest of the world.

3. Markets clear:

$$L_t = \int n_{it} di, \tag{20}$$

$$c_{Ht} + c^*_{Ht} = Y_t \equiv \int n_{it}^{1-\alpha} di, \tag{21}$$

$$B_t + B_t^{ROW} = B_t^G, \tag{22}$$

$$P_{Ht} c^*_{Ht} - P_{Ft} c_{Ft} = \Delta NFA_t, \tag{23}$$

where $\Delta NFA_t \equiv \mathcal{E}_t \left(\frac{B_t^*}{R_t^*} - B_{t-1}^* \right) - \left(\frac{B_t^{ROW}}{R_t} - B_{t-1}^{ROW} \right)$.

Equations (20), (21) and (22) are the market clearing conditions for labor, home goods and the local currency bond, and (23) is the balance of payments which requires that net exports must equal the change in net foreign assets in local currency.[46]

3.2. Monetary-led and fiscal-led policy regimes

I proceed by loglinearizing the model by a first-order approximation around a symmetric zero-inflation steady state (see Appendix C for details), and combining the optimality and market clearing conditions, the equilibrium is characterized by

$$y_t = \mathbb{E}_t y_{t+1} - 1/\sigma_\omega (r_t - \mathbb{E}_t \pi_{H,t+1}), \tag{24}$$

$$\pi_{H,t} = \kappa y_t + \beta \mathbb{E}_t \pi_{H,t+1}, \tag{25}$$

$$\pi_t = (1-\omega)\pi_{H,t} + \omega \Delta e_t, \tag{26}$$

$$\Delta e_t = \sigma_\omega (y_t - y_{t-1}) + \pi_{H,t}, \tag{27}$$

$$r_t = \phi_\pi \pi_t + m_t, \tag{28}$$

$$\tau_t = \gamma_d d_{t-1} + \gamma_y y_t, \tag{29}$$

$$d_t = \frac{1}{\beta}[y_{t-1} - y_t + d_{t-1} + r_{t-1} - \pi_t - (1-\beta)\tau_t], \tag{30}$$

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[46] Appendix C derives the balance of payments condition (23) for the small open economy.

where lower case letters denote the log difference of the upper case variable from steady state, e.g., $y_t \equiv \log Y_t - \log Y$, and $\pi_{H,t} = \log \Pi_{H,t}$, where $\Pi_{H,t} \equiv P_{Ht}/P_{Ht-1}$, is domestic price inflation.[47] The first two equations (24) and (25) are the small open economy IS curve and New Keynesian Phillips curve, respectively.[48] Equation (26) shows the components of CPI inflation from domestic price inflation and the change in the exchange rate, which is in turn determined by (27). The policy rule for monetary policy is (28) and fiscal policy is (29), and (30) gives the law of motion for government debt as a share of output. I next formally characterize the possible policy regimes, which depend on the policy parameters, in the following proposition.

***Proposition* 1.** *There exist the following equilibria depending on the policy parameters:*

(i) Monetary led: if $\phi_\pi > 1$, $\gamma_d > 1$, then there is a unique stationary equilibrium.

(ii) Fiscal led: if $\phi_\pi < 1$, $\gamma_d < 1$, then there is a unique stationary equilibrium.

(iii) if $\phi_\pi > 1$, $\gamma_d < 1$, then there is no stationary equilibrium.

(iv) if $\phi_\pi < 1$, $\gamma_d > 1$, then there are multiple equilibria (indeterminacy).

Proof: see Appendix C3.

Proposition 1 shows the policy mix which lead to a unique stationary equilibrium, extending to the small open New Keynesian economy the Leeper (1991) closed-economy results.[49] In the *monetary-led* policy regime, the monetary authority responds strongly to deviations of inflation and output from their steady state levels, and the fiscal authority responds strongly by adjusting taxes to deviations in government debt as a share of output. Whereas in the *fiscal-led* policy regime, the monetary authority responds relatively weakly to deviations of inflation and output, and the fiscal authority also responds weakly by changing taxes to deviations in government debt. I now illustrate the response to a monetary policy shock for each case to understand how the policy regime affects the macroeconomic dynamics.

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[47] $r_t \equiv \log R_t - \log R$, where the steady state nominal interest rate $R = 1/\beta$.

[48] Appendix C provides the derivation. κ and σ_ω depend on the model parameters.

[49] The *monetary-led* policy regime is the analogue of the Leeper (1991) "active" monetary and "passive" fiscal regime, and the *fiscal-led* policy regime the "active" fiscal and "passive" monetary.

3.3. Inflation response to monetary policy shock

In this Section I show that in the model the *fiscal-led* policy regime can explain the empirical results from Section 2, whereas the *monetary-led* regime cannot. For simplicity, I assume $\gamma_y = 0$ so both the monetary and fiscal authorities do not respond to fluctuations in output.

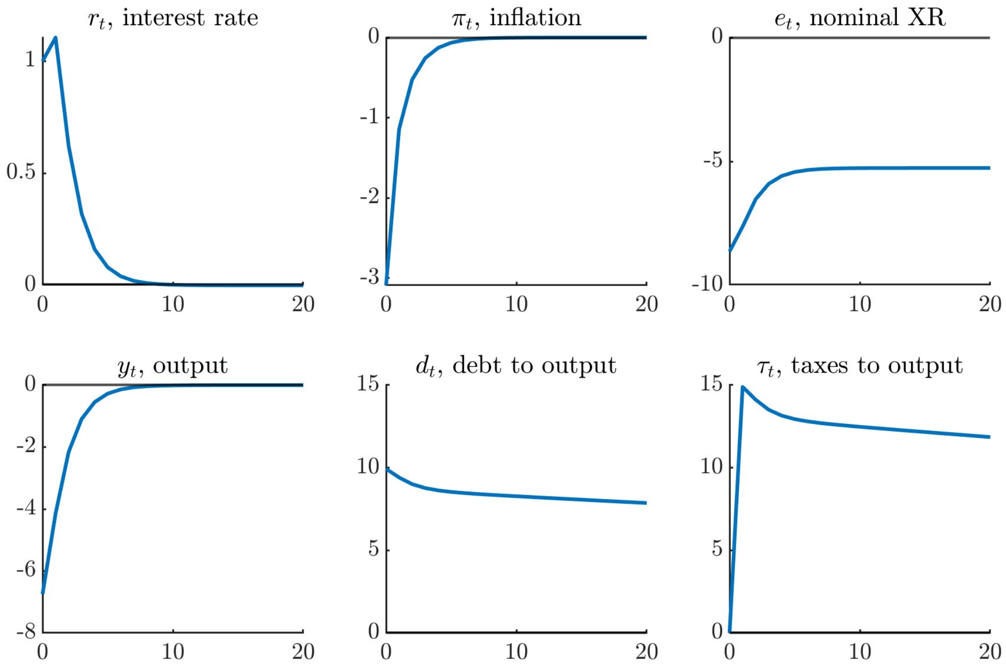
Monetary led. First, the *monetary-led* regime ($\phi_\pi > 1$ and $\gamma_d > 1$), for an unanticipated monetary policy tightening shock m_t is illustrated in Figure 5. The parameters are standard and given in Table C1. The increase in the domestic interest rate increases households' willingness to save and reduces domestic consumption demand, decreasing domestic output (shown in the bottom left panel). This increases government debt as a share of output. Taxes rise due to the strong response in the fiscal rule ($\gamma_d > 1$). Facing lower demand, domestic firms reduce prices so inflation falls (shown in the top center panel). The exchange rate appreciates (a decrease in e_t) because the real interest rate rises, reducing foreign demand for domestic output.

Fiscal led. In the *fiscal-led* regime ($\phi_\pi < 1$ and $\gamma_d < 1$) the response to a monatery policy tightening is very different, as shown in Figure 6. The increase in the interest rate similarly reduces households' domestic demand, leading to an initial fall in output. Government debt as a share of output increases but because of the weak response in the fiscal rule ($\gamma_d < 1$), taxes increase by less than government debt. In this case, the price level must rise to stabilize the level of government debt. Inflation increases to reduce the government debt burden and ensure it is sustainable so households are willing to save in it. This higher inflation is accommodated by monetary policy since $\phi_\pi < 1$. Finally, the exchange rate depreciates because the real interest rate falls, increasing foreign demand.

This simple model shows the *fiscal-led* policy regime can explain an increase in inflation in response to a monetary policy tightening. In the following section, I estimate the policy rule parameters in emerging markets in a quantitative version of the model.

Figure 5: Monetary led: Impulse Responses to Monetary Policy Shock

1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses to a monetary-policy shock that increases the interest rate by 1 percentage point on impact for the model in Section 3.1. $\phi_\pi = 1.6$, $\gamma_d = 1.5$, and the remaining parameters are given in Table C1. More detailed responses are depicted in Appendix Figure C1.

4. Quantitative Results

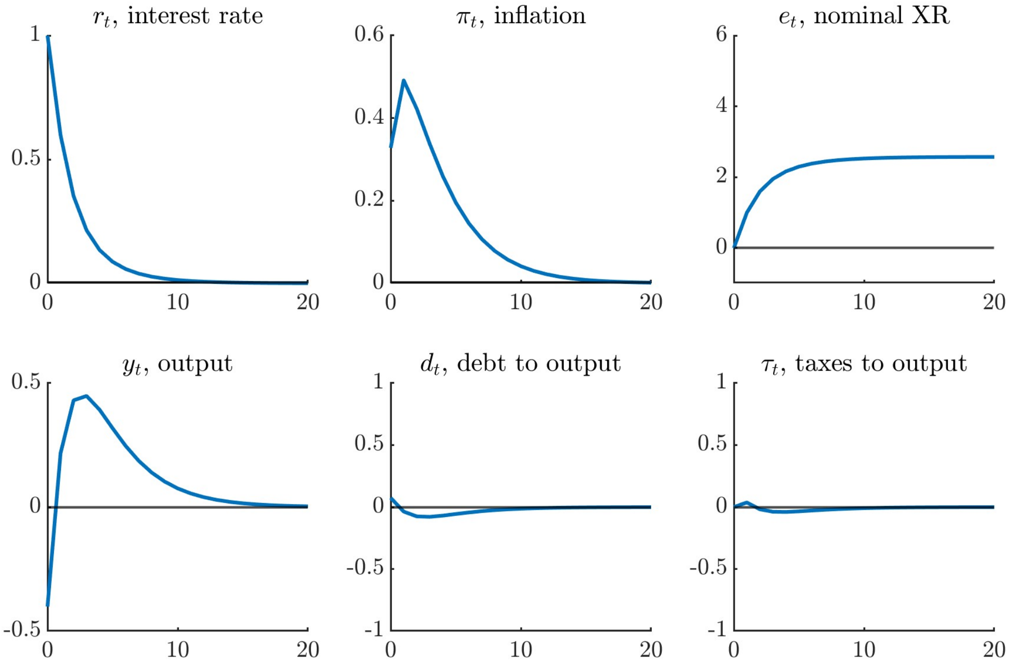
In this section I provide the quantitative results on the impact of monetary policy on inflation in emerging markets. In Section 4.1 I overview the quantitative model. Section 4.2 outlines the Bayesian estimation. Section 4.3 provides the main results for the emerging markets and compares with the estimation results for the U.S.

4.1. Quantitative model

For the quantitative analysis I extend the model from Section 3.1 by adding several key features of emerging markets (detailed in Appendix D1). Firms are subject to a working-capital constraint, i.e. firms must borrow a fraction of the wage bill in advance of production,

Figure 6: Fiscal led: Impulse Responses to Monetary Policy Shock

1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses to a monetary-policy shock that increases the interest rate by 1 percentage point on impact for the model in Section 3.1. $\phi_\pi = 0.3$, $\gamma_d = 0.5$, and the remaining parameters are given in Table C1. More detailed responses are depicted in Appendix Figure C2.

consistent with emerging market business cycles (Neumeyer and Perri, 2005). I allow for incomplete exchange rate pass-through to import prices, which is well-documented empirically (e.g., Campa and Goldberg, 2005; Gopinath, Itskhoki and Rigobon, 2010). I also assume habits in consumption for households, and for firm price setting, that firms which do not reset prices adjust their price with partial indexation to previous period inflation. These are common assumptions in quantitative models and generate inertia in output and inflation to match time series behavior in the data. I allow for a rich set of shocks for the small open economy to demand via household preferences, markups (cost-push shocks) which enter the Phillips curve, monetary policy, government spending, and import prices, which are all assumed to follow AR(1) processes.

The monetary and fiscal policy rules are also more general. Monetary policy follows a

Taylor rule given by

$$\frac{R_t}{R} = \left[\frac{R_{t-1}}{R}\right]^{\rho_r} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\phi_\pi} \left(\frac{Y_t}{Y}\right)^{\phi_y}\right]^{1-\rho_r} e^{m_t}, \tag{31}$$

where m_t is a monetary policy shock. This allows for persistence in the nominal interest rate and monetary policy to respond to inflation and domestic output. The fiscal policy rule is

$$\frac{\mathcal{T}_t}{\mathcal{T}} = \left[\frac{\mathcal{T}_{t-1}}{\mathcal{T}}\right]^{\rho_t} \left[\left(\frac{D_{t-1}}{D}\right)^{\gamma_d} \left(\frac{Y_t}{Y}\right)^{\gamma_y}\right]^{1-\rho_t} e^{g_t}, \tag{32}$$

where g_t is a government spending shock. The set of linearized equilibrium conditions for the quantitative model around the steady state are provided in Appendix D2.

4.2. Estimation

I estimate the model using Bayesian techniques. A period is one quarter. The posterior distribution for the model parameters is obtained from the likelihood function evaluated using the Kalman filter.

The data I use for the estimation is 7 variables for Brazil, Chile, Mexico and South Africa observed quarterly from 2010 to 2019.[50] These are real GDP growth, CPI inflation, the monetary policy rate, the monetary policy shock, government debt as a share of GDP, the government budget balance as a share of GDP, and the nominal exchange rate against the U.S. dollar.[51] Appendix D3 details the sources and construction of these variables.[52]

I incorporate the high-frequency monetary policy shocks in the estimation, similar to Bianchi *et al.* (2022).[53] I do so by assuming the monetary policy shock includes an observed component, for which I use the estimated monetary policy shocks from Section 2, and an unobserved component.

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[50] Colombia does not have detailed quarterly government budget data to be included in the estimation.

[51] Figure A3 shows government debt and budget balance in each of the countries during the sample.

[52] I also assume output, government debt to output, inflation, and taxes to output are potentially measured with error.

[53] Bianchi *et al.* (2022) use high-frequency data in a structural estimation in a richer way by using data on other assets and allowing for changes in investor beliefs around monetary policy announcements.

Table 1: Fixed Parameters

Parameter		Value
Risk-aversion coefficient	σ	2
Discount factor	β	0.98
Frisch labor supply elasticity	$1/\nu$	1
Returns to scale	α	0.25
Elasticity home-foreign	η	1.5
Elasticity between varieties	ϵ	2.9
Habits in consumption	h	0.9
Price inflation indexation	χ_p	0.25

Notes: This table shows the fixed parameters for the quantitative model. See text for further detail.

I fix a subset of 8 parameters and estimate the remaining 19 parameters. The fixed parameters are given in Table 1. I assume standard parameters in the open-economy literature that households have a coefficient of relative risk aversion of 2 and discount factor $\beta = 0.98$. The Frisch elasticity of labor supply is 1 and $\alpha = 0.25$ so production is decreasing returns to scale in labor. The elasticity between home and foreign goods is 1.5 from Feenstra, Luck, Obstfeld and Russ (2018)[54] and the elasticity of substitution between varieties to 2.9 following Broda and Weinstein (2006). The habits in consumption and price inflation indexation parameters are fixed similar to the estimates in Bianchi *et al.* (2023a).

The right panel of Table D3 reports the priors for the estimated structural and exogenous process parameters. I assume flat priors, so the posterior mode coincides with the maximum likelihood estimation. Appendix D4 provides more detail on the estimation.

4.3. Results

Table 2 Panel (a) provides the results for the emerging market policy parameter estimates. The monetary policy interest rate response to inflation, ϕ_π, is less than one and close to zero, and the response to output, ϕ_y, is also less than one. The fiscal policy rule response to government debt, γ_d, is also less than one and close to zero, which together finds the

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[54] This standard value is also used in Backus, Kehoe and Kydland (1994), Chari, Kehoe and McGrattan (2002), and Itskhoki and Mukhin (2021).

Table 2: Monetary and Fiscal Policy Rule Estimates

Posterior Distribution		Mode	5%	95%
a. Emerging Markets				
Mon. pol resp. to inflation	ϕ_π	0.01	0.00	0.02
Mon. pol resp. to output	ϕ_y	0.92	0.51	1.17
Fiscal resp. to govt debt	γ_d	-0.01	-0.12	0.11
Fiscal resp. to output	γ_y	0.43	0.27	0.65
b. U.S. 1979-2019				
Mon. pol resp. to inflation	ϕ_π	1.57	1.22	3.15
Mon. pol resp. to output	ϕ_y	0.46	0.24	0.86
Fiscal resp. to govt debt	γ_d	1.51	0.37	3.01
Fiscal resp. to output	γ_y	0.47	0.14	1.83

Notes: This table shows the posterior modes, medians, and 90% posterior credible sets for the policy parameters. See Tables D3 and D4 for further detail.

presence of a *fiscal-led* policy regime for the emerging markets.[55] In addition, there is a weak fiscal policy response to output, γ_y, in accordance with procyclical fiscal policy in emerging markets (Gavin and Perotti, 1997; Talvi and Végh, 2005). This is consistent with the estimated increase in inflation to a monetary policy tightening from Section 2.

Next, I estimate the model with the same fixed parameters and priors for the U.S. from 1979-2019. The results are shown in Table 2 Panel (b). For the U.S., I find the monetary policy response to inflation, ϕ_π, is greater than one, and the fiscal policy response to government debt, γ_d, is greater than one, implying a *monetary-led* policy regime for the U.S. during this period.[56] These findings rationalize the decrease in inflation for a monetary policy tightening in the U.S., and opposite response to the emerging markets results.

Figure 7 plots the impulse responses for the estimated quantitative model for the emerging markets against the empirical results from Figure 3. In particular, this shows the consistent increase in inflation response to a monetary policy shock in the quantitative model as

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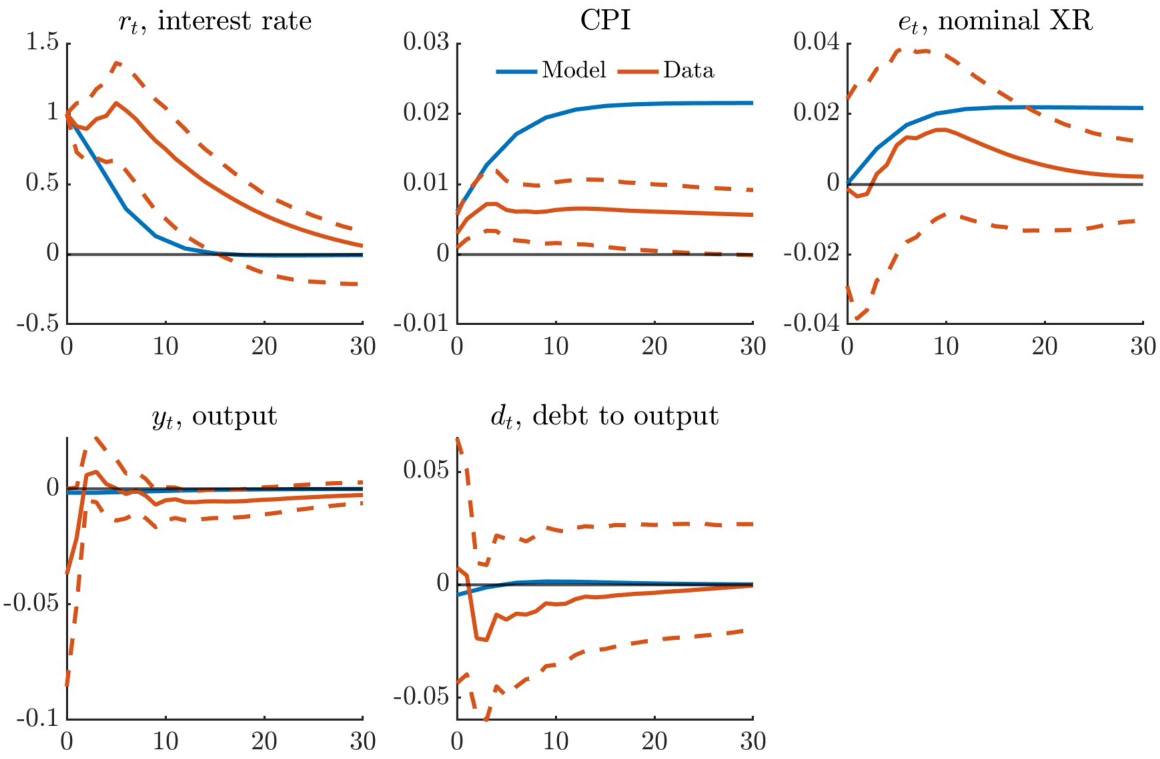
[55] I verify quantitatively that the combination of ϕ_π and ϕ_y indeed lead to a *fiscal-led* policy regime.

[56] This is consistent with estimates for the Taylor rule for the U.S. during this period, e.g., Clarida *et al.* (2000), Fernández-Villaverde and Rubio-Ramírez (2007), and Carvalho *et al.* (2021).

Figure 7: Emerging Markets: Quantitative Model and Empirics

1 percentage point interest rate shock, percent



Notes: This figure shows in red the impulse responses to a 1 percentage point monetary policy shock from Figure 3 with 90 per cent confidence bands. In blue are the results for the quantitative model estimates in Table 2.

in the data. There is also a similar small response in the level of government debt to output, and an exchange rate depreciation.

5. Effect of U.S. monetary policy on emerging markets

In this Section I extend the analysis to the impact of U.S. monetary policy shocks on emerging markets in a *fiscal-led* and *monetary-led* regime. De Leo *et al.* (2023) estimate the impact of a U.S. monetary tightening for a large set of emerging markets using panel local projections with the Gertler and Karadi (2015) monetary policy shocks as an instrumental variable. De Leo *et al.* (2023) find that a U.S. monetary tightening leads to a decrease in the monetary policy interest rate, output growth and inflation in emerging markets.[57] Table 3 Panel (a) summarizes the results for the minimum of each variable over the four quarters following a U.S. monetary policy shock.

I return to the simple model in Section 3 and study the effect of a shock to the world interest rate depending on the monetary and fiscal policy mix. The world interest rate affects the households' local and foreign currency bonds portfolio decision, which gives the loglinearized uncovered interest rate parity condition

$$r_t = r_t^* + \mathbb{E}_t e_{t+1} - e_t, \tag{33}$$

where r_t^* is the log deviation of the world nominal interest rate from the steady state level, which is exogenous and assumed to follow an AR(1) process. In the model I study the impact of a 1 percentage point shock to the world interest rate, similar to the De Leo *et al.* (2023) estimates for a U.S. interest rate shock.

Table 3 Panel (b) shows the response in the model in the *fiscal-led* policy mix, which matches the decline in each variable, whereas in the *monetary-led* policy mix the monetary policy interest rate and inflation increase. This response occurs in the *fiscal-led* regime because the world interest rate tightening reduces the level of government debt to output. Due to the weak response of taxes in this case, this leads to a decrease in inflation in equilibrium to stabilize the level of government debt, which reduces the monetary policy rate and output. These results provide further support for the *fiscal-led* policy mix in emerging markets.[58]

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[57] De Leo *et al.* (2023) study the effect on a number of other variables, see Section 3 of their paper.

[58] Figure E1 plots the dynamics for the *fiscal-led* model against the De Leo *et al.* (2023) estimates. One area where the *fiscal-led* model falls short is the magnitude of the decline in the policy rate. This can be explained by the absence of risk premia in the model, which De Leo *et al.* (2023) emphasize in response to a U.S. monetary policy shock and is a key channel in their model.

Table 3: Impact of U.S. monetary policy tightening on emerging markets

Minimum in year following 1 pp r_t^* shock	r_t	Δy_t	π_t
a. Estimates			
EMs (De Leo *et al.*, 2023)	-0.4	-1.0	-0.3
b. Model			
Fiscal led	-0.1	-1.1	-0.2
Monetary led	$+0.4$	-0.2	$+0.2$

Notes: This table shows the estimated response to a 1 percentage point U.S. monetary policy shock from De Leo *et al.* (2023) and the model response to a 1 percentage point world interest rate shock. Panel (a) provides the minimum in the four quarters following the U.S. monetary policy shock for emerging markets from the estimates of De Leo *et al.* (2023) Figure 3 for the monetary policy interest rate, real GDP growth and CPI inflation. Panel (b) shows the estimates for a 1 percentage point shock to the world interest rate r_t^* in the *fiscal-led* policy regime with $\phi_\pi = 0.3$, $\gamma_d = 0.5$, and in the *monetary-led* policy regime with $\phi_\pi = 1.5$, $\gamma_d = 1.5$. See Appendix E for further detail.

6. Welfare and optimal monetary policy in fiscal-led regime

In this section I study quantitatively the welfare effects of monetary policy in a *fiscal-led* regime. I use the simple model of Section 3, and examine the effects of domestic productivity and markup shocks. Galí and Monacelli (2005) study this for monetary policy only, under alternative monetary policy rules. For the Cole and Obstfeld (1991) preference parameterization ($\sigma = \eta = 1$), welfare for households depends on domestic price inflation and deviations of output from the natural rate, with the latter denoted by $\widetilde{y}_t$.[59] Welfare relative to the first-best allocation is

$$W = -\frac{(1-\omega)}{2}\sum_{t=0}^{\infty}\beta^t\left[\pi_{H,t}^2 + v\widetilde{y}_t^2\right], \tag{34}$$

---

[59] These preference assumptions are log utility and a unit elasticity of substitution between home and foreign goods. The natural rate is the equilibrium level of output under flexible prices, i.e. in the absence of nominal rigidities. Galí and Monacelli (2005) also assume the employment subsidy which offsets firms' market power and terms of trade distortions, so the flexible price equilibrium is optimal, as is standard in the closed-economy New Keynesian literature.

where $v \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}\left(\frac{1+\nu}{1-\alpha+\alpha\epsilon}\right)\frac{1}{\epsilon}$.[60] The IS and Phillips curve in terms of the output gap are

$$\widetilde{y}_t = \mathbb{E}_t\widetilde{y}_{t+1} - 1/\sigma_\omega(r_t - \mathbb{E}_t\pi_{H,t+1} - \psi_a a_t), \tag{35}$$

$$\pi_{H,t} = \kappa\widetilde{y}_t + \beta\mathbb{E}_t\pi_{H,t+1} + u_t, \tag{36}$$

where aggregate productivity of domestic firms follows an AR(1) process in logs[61] and u_t is a markup shock as in Section 4.1. Appendix F provides further detail.

The first-best allocation stabilizes domestic prices and closes the output gap $\pi_{H,t} = \widetilde{y}_t = 0$. In response to a productivity shock, this can be implemented in the *monetary-led* regime as a unique equilibrium by the monetary rule $r_t = \psi_a a_t + \phi_\pi\pi_t + \phi_y\widetilde{y}_t$ (where $\kappa(\phi_\pi - 1) + (1-\beta)\phi_y > 0$, and fiscal rule with $\gamma_d > 1$).[62] Here the monetary authority sets the interest rate equal to the natural interest rate by committing to strongly varying the interest rate to any deviations of domestic inflation and the output gap, thereby achieving the open economy "divine coincidence" (Blanchard and Galí, 2007).[63]

Motivated by the evidence in Section 4 for emerging markets, I analyze for a given *fiscal-led* policy, the welfare consequences of alternative monetary policy rules.[64] As a baseline, I set $\gamma_d = 0.5$ and calculate welfare using (34) when varying $\phi_\pi \in [0, 1)$.[65] Figure 8 provides an example of the impulse responses to a markup shock for different values of ϕ_π.[66] In response to the markup shock, inflation increases and for a stronger monetary policy response to inflation (higher value of ϕ_π) there is a larger change in the interest rate. This leads to a larger initial fall in output and, therefore, a larger increase in inflation to stabilize the level of government debt to output in equilibrium.

Evaluating welfare for the alternative monetary policy rules more generally, Figure 9

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[60] For a second-order approximation around the zero-inflation steady state, see Galí (2015) Chapter 8.

[61] $a_t = \rho_a a_{t-1} + \sigma_a\varepsilon_{a,t}$, $\varepsilon_{a,t} \sim N(0,1)$, and $\psi_a \equiv -\sigma_w\left(\frac{1+\nu}{\sigma_w(1-\alpha)+\nu+\alpha}\right)(1-\rho_a)$.

[62] Observe this is not a simple Taylor rule as in Section 3, here the interest rate also responds to the productivity shock a_t.

[63] For a markup shock the first best cannot be achieved through such a policy rule, as in Blanchard and Galí (2007).

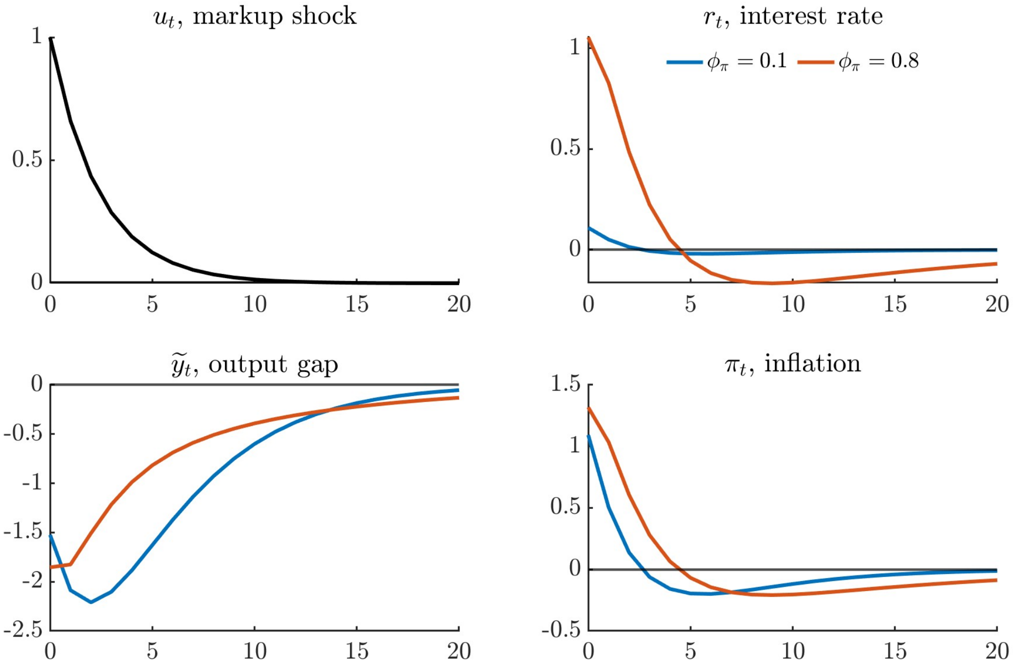
[64] As in Section 3, I assume monetary and fiscal policy do not respond to fluctuations in output $\phi_y = \gamma_y = 0$.

[65] I assume ϕ_π must be non-negative and give rise to a unique stationary equilibrium (see Proposition 1).

[66] Figures F1 and F2 provide more detailed impulse responses for a productivity shock and a markup shock, respectively, for different values of ϕ_π.

Figure 8: Fiscal led: Impulse Responses to Markup Shock

1 percentage point markup shock, percent



Notes: This figure shows the impulse responses to a 1 percent markup shock for the model in Section 6 with $\gamma_d = 0.5$ when varying $\phi_\pi < 1$, and the remaining parameters given in Table F1. More detailed responses are depicted in Appendix Figure F2.

Panel (a) shows that in the *fiscal-led* regime, for both productivity and markup shocks, welfare is increased by reducing the monetary policy responsiveness to inflation, ϕ_π. This suggests the empirical estimates for the emerging markets monetary policy in Section 4 of little response to inflation are close to optimal given the *fiscal-led* regime.

In the *monetary-led* regime with fixed $\gamma_d > 1$ shown in Figure 9 Panel (b), by contrast, welfare is increased for greater monetary policy responsiveness to inflation, ϕ_π. In this case the strong fiscal policy reaction aids monetary policy in dampening the inflation response to both shocks. Comparing welfare across the two regimes, the *monetary led* achieves higher welfare than the *fiscal-led* regime.[67] Therefore, a shift in the overall policy mix to *monetary led* for the emerging markets would be welfare improving.

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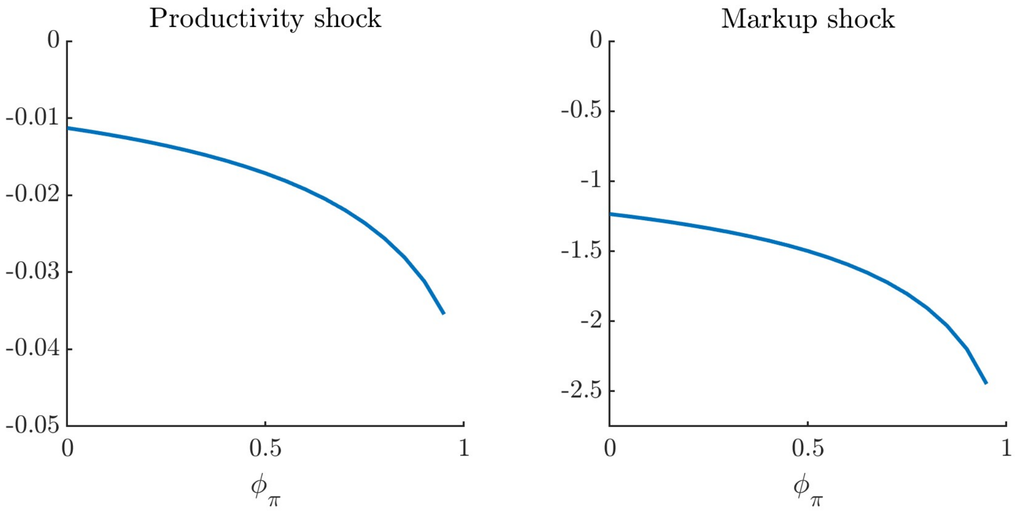
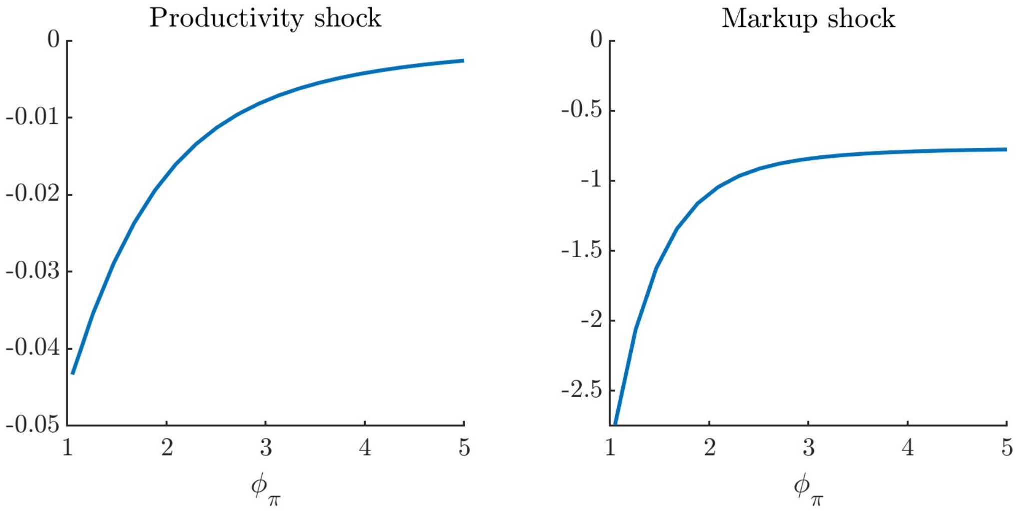
[67] If $\phi_\pi < 0$, then $\phi_\pi \in (-1, 0)$ is also *fiscal led* and leads to a unique stationary equilibrium, with welfare continuing to increase as ϕ_π decreases. However, welfare in the *monetary-led* policy regime remains higher.

Figure 9: Welfare: Results

(a) Fiscal-led regime



(b) Monetary-led regime



Notes: This figure shows welfare in response to 1 percent shocks to productivity and markups for the model in Section 6. In the *fiscal-led* regime $\gamma_d = 0.5$ when varying $\phi_\pi \in [0, 1)$, and in the *monetary-led* regime $\gamma_d = 1.5$ when varying $\phi_\pi > 1$. The remaining parameters are given in Table F1. See text and Appendix F for further detail.

7. Conclusion

In this paper I study the effect of monetary policy in emerging markets. I measure high-frequency monetary policy shocks using changes in exchange rates around monetary policy announcements. I find that in response to a monetary policy tightening, inflation increases in emerging markets, the opposite response to advanced economies. This is also consistent with high-frequency changes in inflation expectations. I study inflation outcomes in a small open economy model with monetary and fiscal policy. I show that a *fiscal-led* policy mix, with accommodative monetary policy, can explain the increase in inflation to a monetary policy tightening. The estimated quantitative model finds a *fiscal-led* policy mix in the emerging markets. This is further supported by evidence on the effect of U.S. monetary policy shocks in emerging markets. I examine welfare in a *fiscal-led* policy regime for alternative monetary policy and find welfare is increased by reducing the monetary policy responsiveness to inflation, but higher welfare overall can be achieved in a *monetary-led* regime.

There are a number of areas for further work. First, this paper has considered a fixed policy regime in place. It would be interesting to identify and examine episodes of policy regime changes and estimate the impact of monetary policy shocks in different policy regimes. Similarly, the model could be extended to include regime switching between *fiscal led* and *monetary led*, for example, as in Sims and Zha (2006) and Bianchi and Melosi (2017) for the U.S. Also, in the model fiscal policy excludes government default risk and risk-premia considerations (Arellano *et al.*, 2020; De Leo *et al.*, 2023). In addition, I have only considered lump-sum taxes and could enrich the model with proportional consumption, labor-income, and payroll taxes. These fiscal policy features are potentially quantitatively relevant for emerging markets and would be worth incorporating in future work.

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Appendices

A. Data

A1. Data Description

Daily data on forward and spot exchange rates used to measure monetary policy shocks are from Refinitiv Thomson ONE. For emerging markets I use the exchange rate in domestic currency per U.S. dollar (where an increase in an exchange rate depreciation for the emerging market. For the U.S., when computing the change in the forward premium I use the average of the change in the U.S. dollar against the euro, Japanese yen, British pound and Swiss franc. I use a 2-day window for the emerging markets to measure the change in the forward premium as several countries (e.g., Brazil and Colombia) announce monetary policy decisions close to or after market closing time during the sample period.

Monetary policy meeting dates are collected from national central bank websites and Central Bank News[68].

Monthly macroeconomic variables for the VAR are from the IMF International Financial Statistics unless otherwise noted. The variables are given by:

The interest rate is the 1-year government bond (Treasury) rate. For Chile and Colombia, this is not available so I use the money market rate.

CPI is the log overall consumer price index.

Industrial production is log real industrial production index. For Colombia, the industrial production data are from the OECD. For South Africa, the overall index is not available so I use the manufacturing industrial production index.

Government debt is the log gross government debt to output. Given data on gross central government debt B_t^G from the IMF IFS, and national statistics offices, Treasuries and central banks, the interest rate $R_{n,t}^B$, the CPI P_t, and industrial production Y_t, the share of government debt to

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[68] See http://www.centralbanknews.info.

output is given by

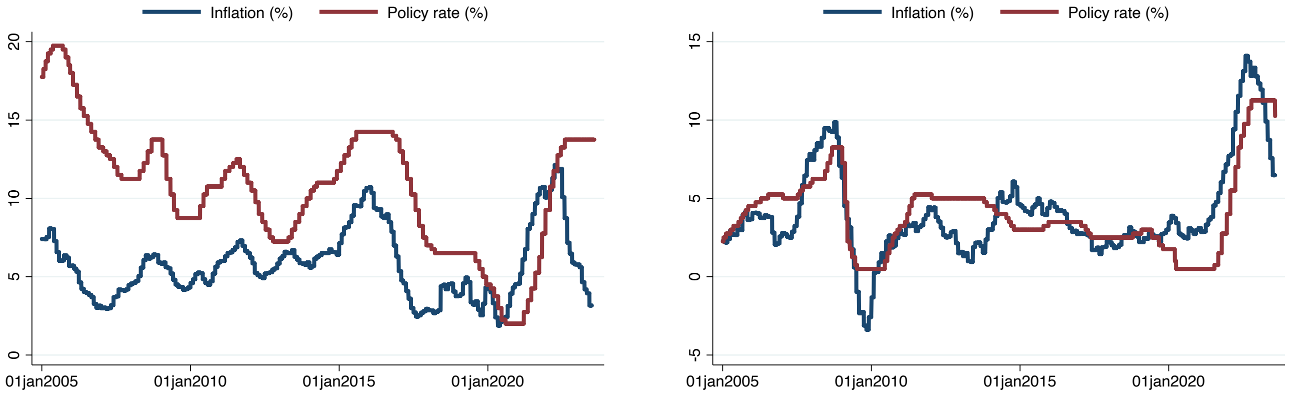
$$d_t \equiv \frac{B_t^G / R_{n,t}^B}{P_t Y_t}. \tag{37}$$

This is not available for Colombia, so it is not included the panel regressions with government debt.

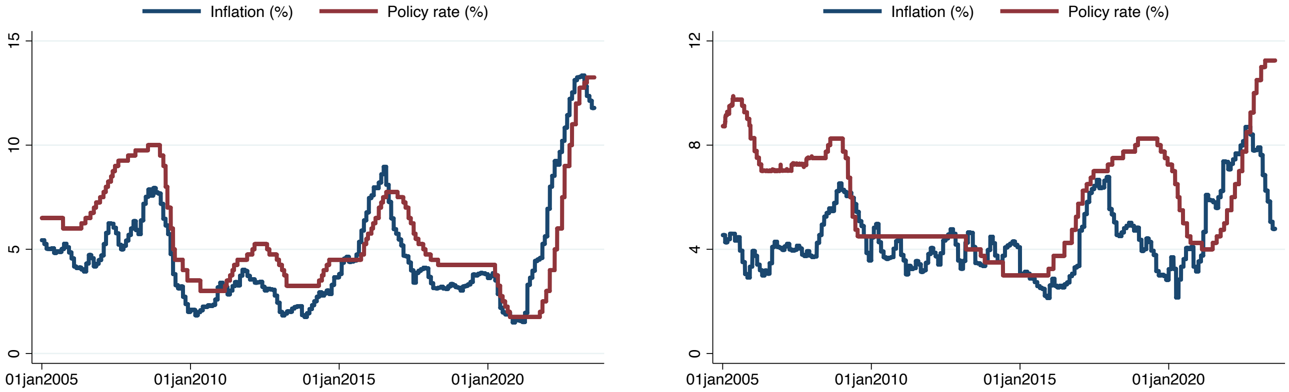
The exchange rate is the log nominal exchange rate against the U.S. dollar.

A2. Additional Figures

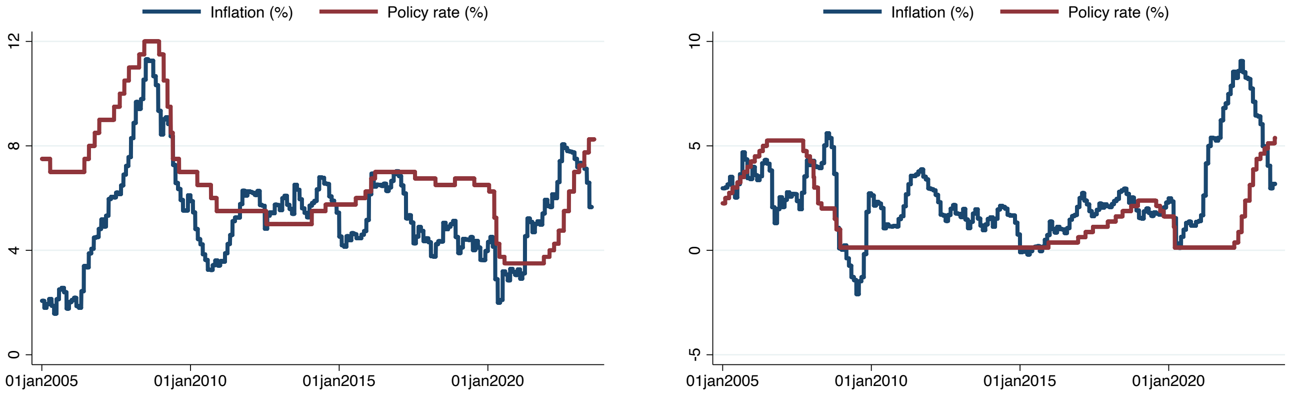
Figure A1: Inflation and Monetary Policy Rate


(a) Brazil

(b) Chile


(c) Colombia

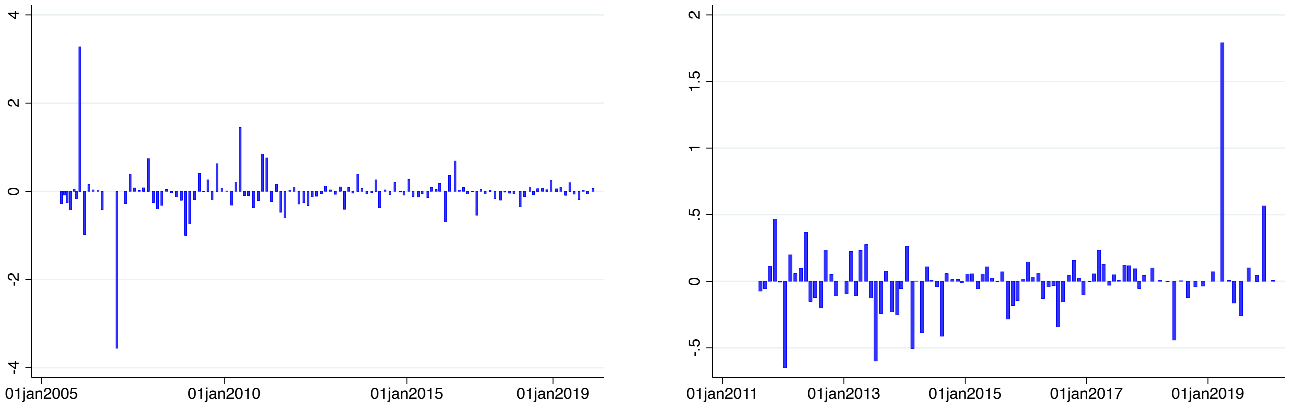
(d) Mexico


(e) South Africa

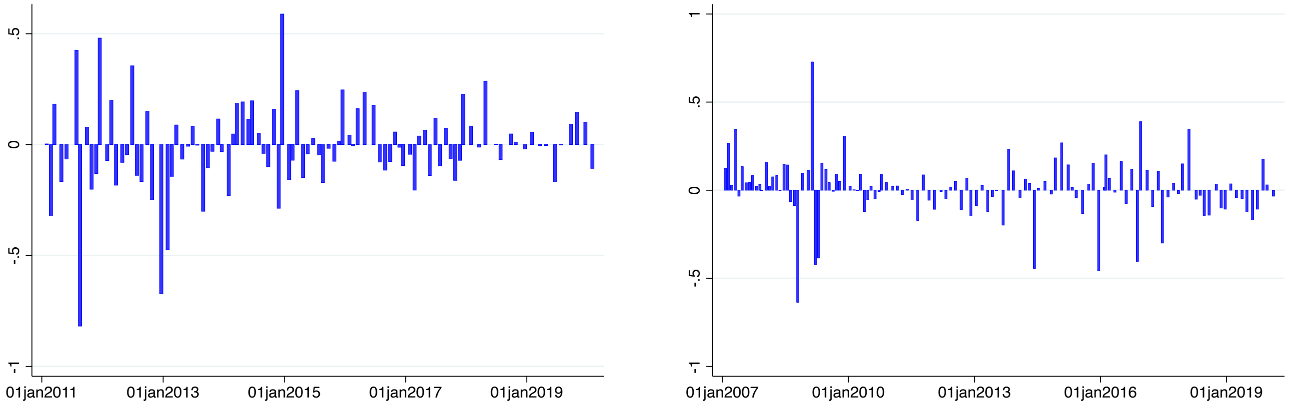
(f) U.S.

Notes: This figure shows inflation and the monetary policy rate for each country in the sample. Inflation is the monthly consumer price index percentage change on the previous year. Data sources: BIS, IMF.

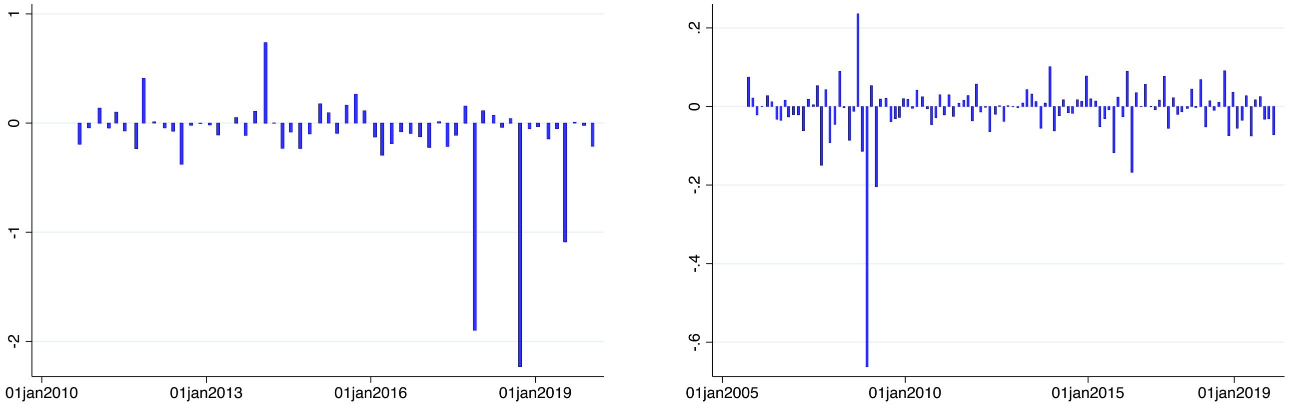
Figure A2: Monetary Policy Shocks from Forward Premium



(a) Brazil (b) Chile



(c) Colombia (d) Mexico



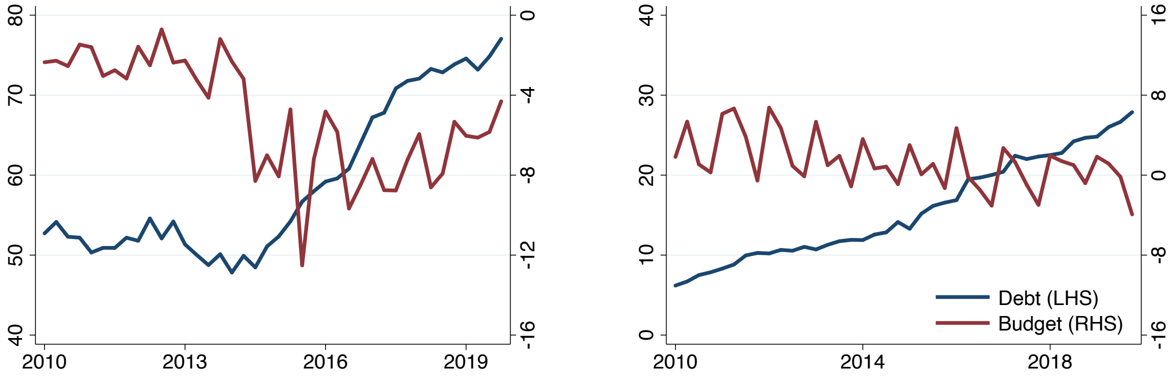
(e) South Africa (f) U.S.

Notes: This figure shows the 2-day change in the 1-year forward premium for each country on monetary policy decision dates. The U.S. is the 1-day change. Data sources: Refinitiv Datastream, national central banks.

Figure A3: Government Debt and Budget Balance

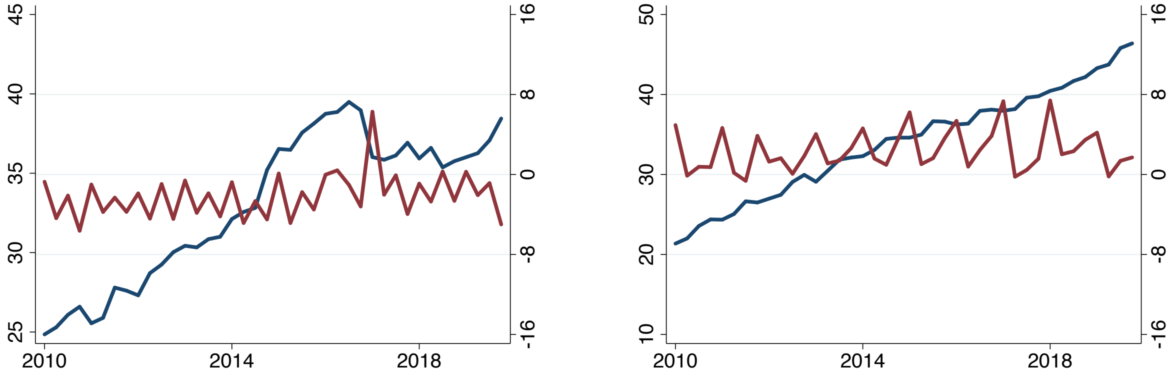
(a) Brazil

(b) Chile



(c) Mexico

(d) South Africa



Notes: This figure shows quarterly central government debt as a share of annualized nominal GDP, and the central government net operating balance as a share of nominal GDP. Chile is the primary operating balance. South Africa is the net cash flow from operating activities. Data for Colombia are not available. Data sources: IMF, national Tresuries and central banks.

B. Additional Empirical Results

B1. Test of Assumption 1

I use daily data on covered interest parity deviations λ_t from Du and Schreger (2016) and Du, Im and Schreger (2018a) which are computed using government bond yields, and U.S. Treasury 1-year government bond yields $\Delta i_t^{\$}$ from FRED.

The results below regress the change around emerging market monetary policy meeting dates for the post-Great Recession period 2009m7-2020m2.

Table B1: CIP and U.S. Interest Rates – Emerging Market Monetary Policy Meetings

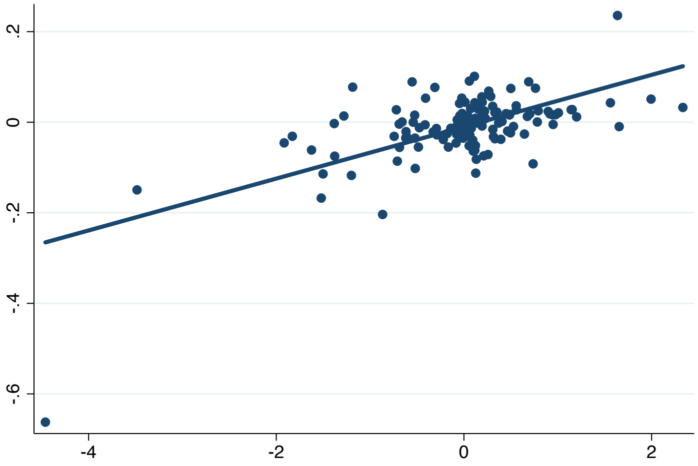
MP dates	$\Delta\lambda_t$	$\Delta i_t^{\$}$	N Obs
Brazil	-0.021	-0.012	74
	(0.021)	(0.008)	
Chile	-0.001	0.031	96
	(0.011)	(0.028)	
Colombia	-0.006	0.021	91
	(0.023)	(0.018)	
Mexico	-0.011	-0.004	70
	(0.008)	(0.007)	
South Africa	0.017	-0.004	61
	(0.011)	(0.003)	

Notes: This table shows the results of a regression of the 2-day change in the covered interest parity deviation and U.S. interest rate on emerging market monetary policy meeting dates. Robust standard errors in parentheses.

B2. Validation – High-Frequency – Monetary Policy Shocks

Figure B1: U.S.: Forward Premium and Monetary Policy Shocks

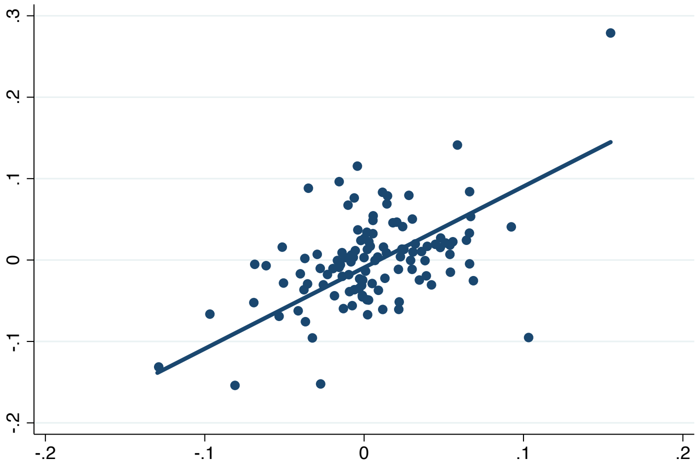
Δfp (% pts, y-axis), Nakamura Steinsson MP shocks (x-axis)
2005m9−2022m9



Notes: $R^2 = 0.39$. This figure plots the 1-day change in the 1-year forward premium and Nakamura and Steinsson (2018) monetary policy shocks, updated by Acosta (2022), on U.S. FOMC meeting dates.

Figure B2: U.S.: Forward Premium and Monetary Policy Shocks

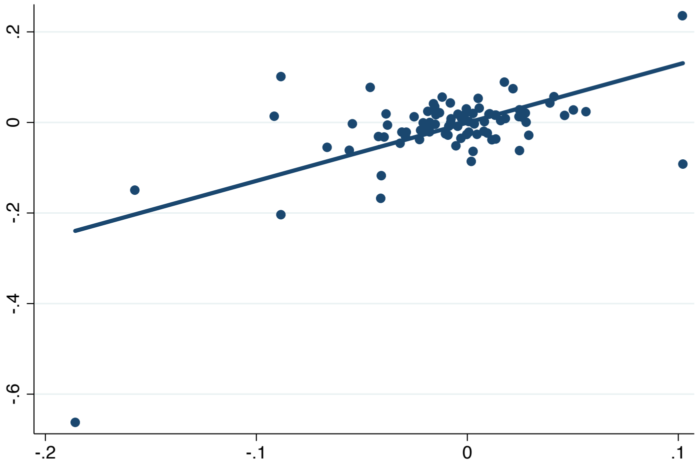
Δfp (% pts, y-axis), Bauer Swanson MP shocks (x-axis)
2005m9−2019



Notes: $R^2 = 0.31$. This figure plots the 1-day change in the residualized 1-year forward premium and Bauer and Swanson (2023b) monetary policy shocks on U.S. FOMC meeting dates. The change in the forward premium is orthogonalized following Bauer and Swanson (2023b).

Figure B3: U.S.: Forward Premium and Monetary Policy Shocks

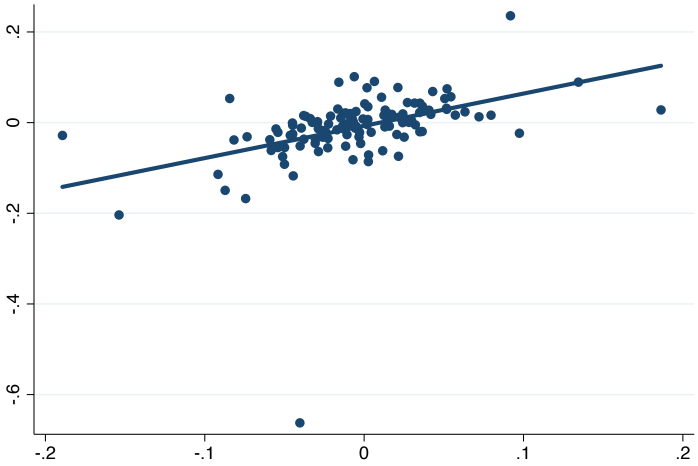
Δfp (% pts, y-axis), Jarociński Karadi MP shocks (x-axis)
2005m9−2016



Notes: $R^2 = 0.35$. This figure plots the 1-day change in the 1-year forward premium and Jarociński and Karadi (2020) monetary policy shocks on U.S. FOMC meeting dates.

Figure B4: U.S.: Forward Premium and Monetary Policy Shocks

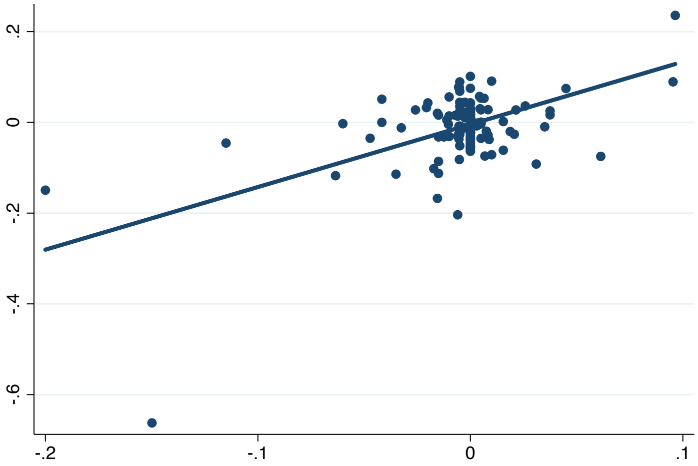
Δfp (% pts, y-axis), Bu Rogers Wu MP shocks (x-axis)
2005m9−2020



Notes: $R^2 = 0.18$. This figure plots the 1-day change in the 1-year forward premium and Bu *et al.* (2021) monetary policy shocks on U.S. FOMC meeting dates.

Figure B5: U.S.: Forward Premium and Monetary Policy Shocks

Δfp (y-axis), Gürkaynak Sack Swanson MP shocks (x-axis), % pts
2005m9−2022m9



Notes: $R^2 = 0.29$. This figure plots the 1-day change in the 1-year forward premium and Gürkaynak *et al.* (2005) monetary policy shocks, updated by Acosta (2022), on U.S. FOMC meeting dates.

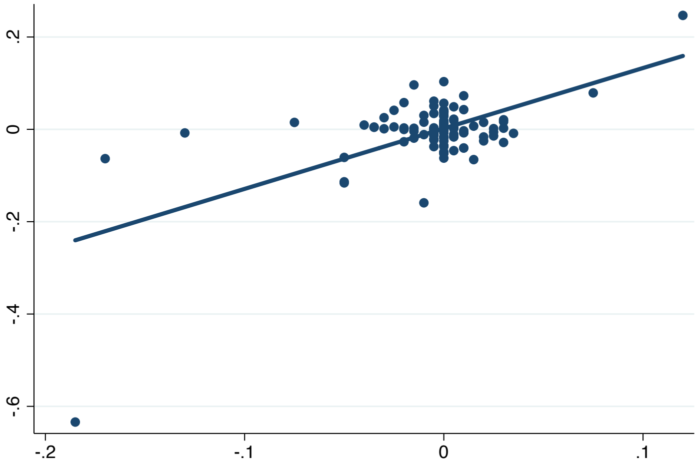
Table B2: U.S.: Forward Premium and Monetary Policy Shocks Regression Results

MP shocks	Gertler Karadi	Nakamura Steinsson	Bauer Swanson	Jarociński Karadi	Bu Rogers Wu	Gürkaynak Sack Swanson
$\widehat{\beta}_{fp}$	1.64*** (0.56)	0.58*** (0.019)	0.996*** (0.32)	1.29** (0.57)	0.71*** (0.16)	1.38** (0.59)
R-squared	0.45	0.39	0.31	0.35	0.18	0.29
Time period	2005m9 -2016	2005m9 -2022m9	2005m9 -2019	2005m9 -2016	2005m9 -2020	2005m9 -2022m9
N Observations	87	136	115	87	122	136

Notes: This table shows the coefficient estimate of a regression of the 1-day change in the forward premium on different monetary policy shocks indicated by the column title on U.S. FOMC meeting dates. Robust standard errors in parentheses. See Figure 1, Figures B1-B5, and text for further detail.

Figure B6: U.S.: Forward Premium and Monetary Policy Shocks

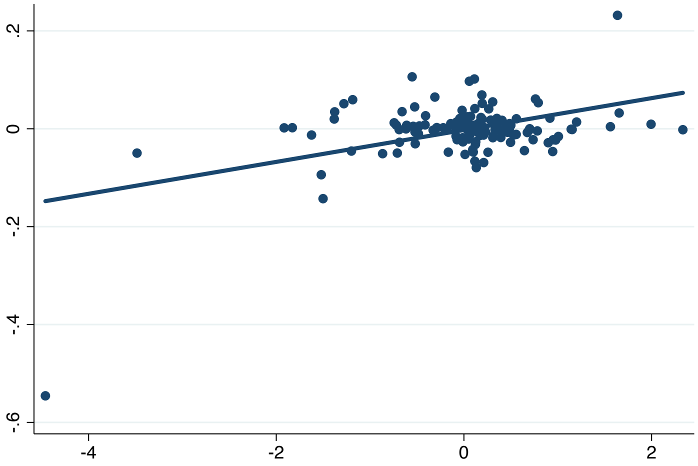
Δ 6-month fp (y-axis), Gertler Karadi MP shocks (x-axis)
% pts, 2005m9−2019m6



Notes: $R^2 = 0.36$. This figure plots the 1-day change in the 6-month forward premium and Gertler and Karadi (2015) monetary policy shocks, updated by Gürkaynak, Karasoy-Can and Lee (2022), on U.S. FOMC meeting dates.

Figure B7: U.S.: Forward Premium and Monetary Policy Shocks

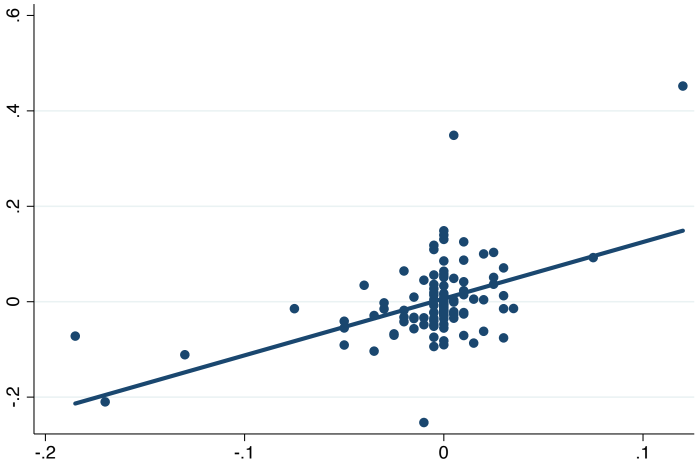
Δ 3-month fp (y-axis), Gertler Karadi MP shocks (x-axis)
% pts, 2005m9−2019m6



Notes: $R^2 = 0.31$. This figure plots the 1-day change in the 3-month forward premium and Gertler and Karadi (2015) monetary policy shocks, updated by Gürkaynak *et al.* (2022), on U.S. FOMC meeting dates.

Figure B8: U.S.: Forward Premium and Monetary Policy Shocks

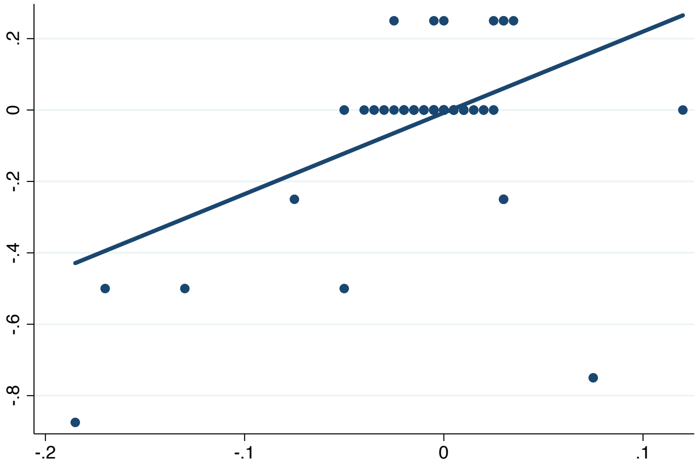
2-day window, Δfp (y-axis), Gertler Karadi MP shocks (x-axis)
% pts, 2005m9−2019m6



Notes: $R^2 = 0.24$. This figure plots the 2-day change in the 1-year forward premium and Gertler and Karadi (2015) monetary policy shocks, updated by Gürkaynak *et al.* (2022), on U.S. FOMC meeting dates.

Figure B9: U.S.: Federal Funds rate and Monetary Policy Shocks

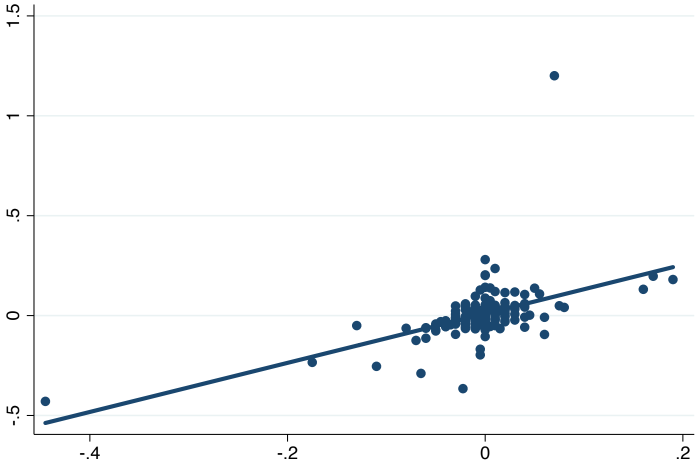
Δ Federal funds rate (y-axis), Gertler Karadi MP shocks (x-axis)
% pts, 2005m9−2019m6



Notes: $R^2 = 0.25$. This figure plots the change in the Federal funds rate and Gertler and Karadi (2015) monetary policy shocks, updated by Gürkaynak *et al.* (2022), on U.S. FOMC meeting dates.

Figure B10: U.K.: Forward Premium and Monetary Policy Shocks

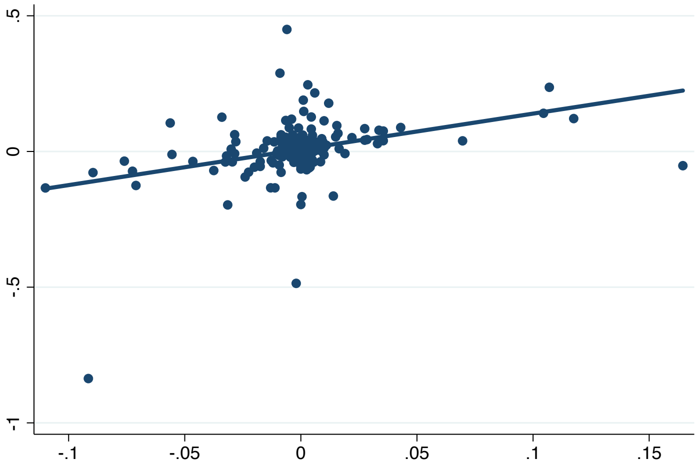
Δfp (% pts, y-axis), Cesa-Bianchi Thwaites Vicondoa MP shocks (x-axis)
2005m9−2021m3



Notes: $R^2 = 0.28$. This figure plots the 1-day change in the 1-year forward premium and updated Cesa-Bianchi *et al.* (2020) monetary policy shocks on U.K. Bank of England monetary policy dates.

Figure B11: ECB: Forward Premium and Monetary Policy Shocks

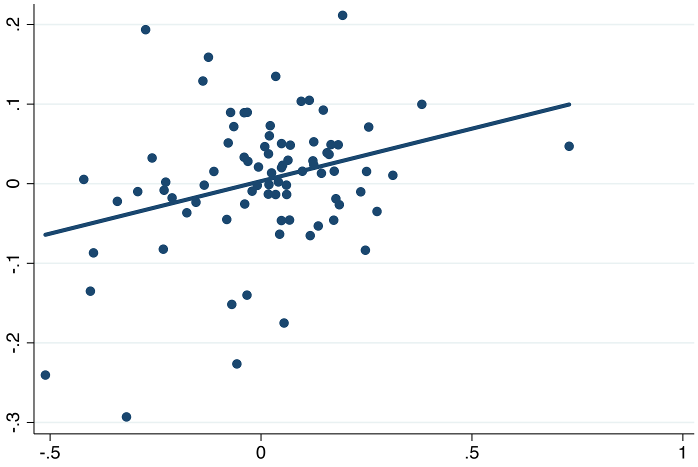
Δfp (% pts, y-axis), Jarociński Karadi MP shocks (x-axis)
2005m9−2016m12



Notes: $R^2 = 0.13$. This figure plots the 1-day change in the 1-year forward premium and Jarociński and Karadi (2020) monetary policy shocks on European Central Bank meeting dates.

Figure B12: Canada: Forward Premium and Monetary Policy Shocks

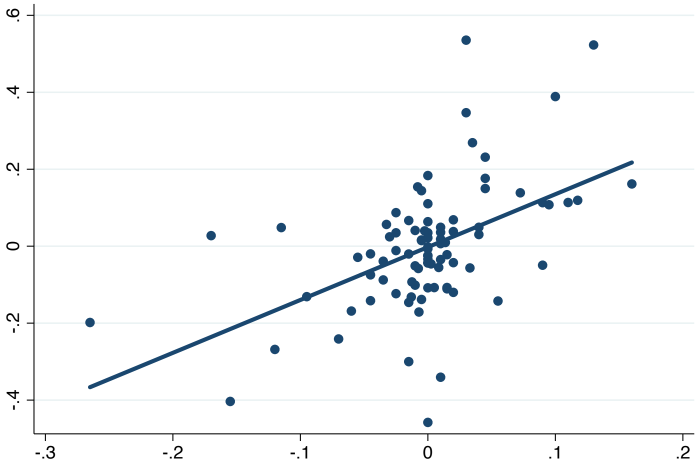
Δfp (% pts, y-axis), Champagne Sekkel MP shocks (x-axis)
2005m9−2015m10



Notes: $R^2 = 0.09$. This figure plots the 1-day change in the 1-year forward premium on Bank of Canada meeting dates and Champagne and Sekkel (2018) monthly monetary policy shocks.

Figure B13: Mexico: Forward Premium and Monetary Policy Shocks

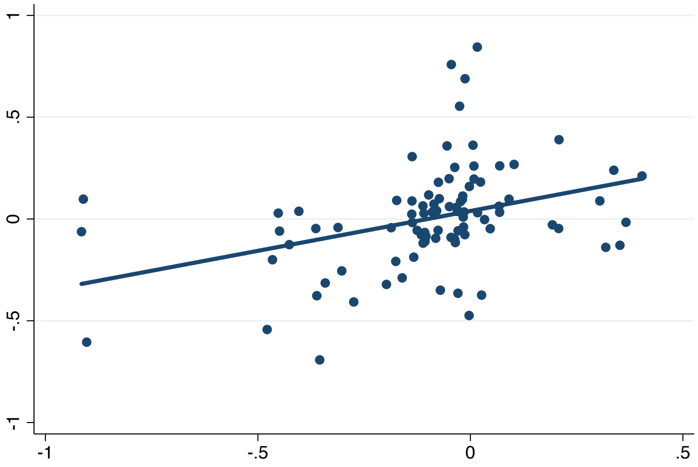
Δfp (y-axis), Solís MP shocks (x-axis)
% pts, 2011−2021m11



Notes: $R^2 = 0.31$. This figure plots the 2-day change in the 1-year forward premium and Solis (2023) monetary policy shocks on Bank of Mexico meeting dates.

Figure B14: Brazil: Forward Premium and Monetary Policy Shocks

Δfp (% pts, y-axis), Gomes Iachan Santos Ruhe MP shocks (x-axis)
2010−2021m8

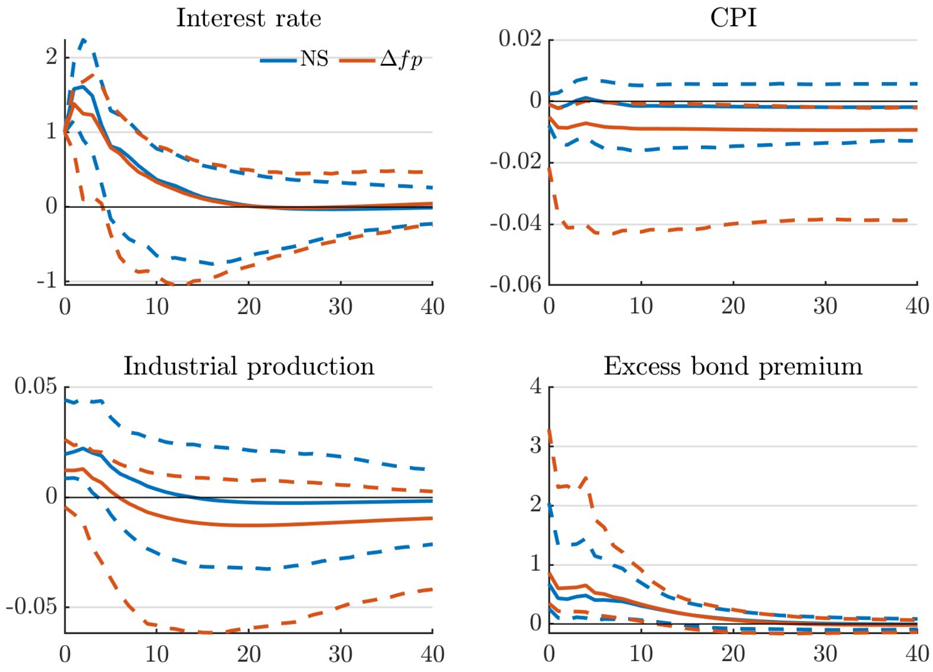


Notes: $R^2 = 0.13$. This figure plots the 2-day change in the 1-year forward premium and Gomes *et al.* (2023) monetary policy shocks on Central Bank of Brazil meeting dates.

B3. Validation – Macroeconomic impact – Monetary Policy Shocks

Figure B15: U.S. SVAR-IV: Forward Premium and Nakamura Steinsson MP Shocks

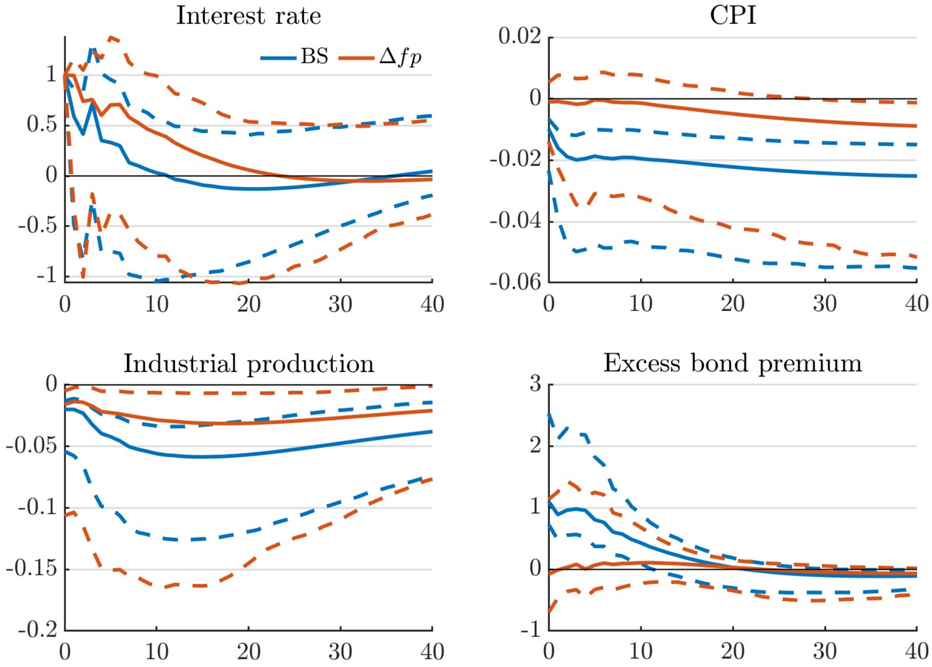
1 percentage point interest rate shock



Notes: This figure shows the impulse responses in the monthly VAR using the 1-day change in the 1-year forward premium and Nakamura and Steinsson (2018) monetary policy shocks, updated by Acosta (2022), as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B16: U.S. SVAR-IV: Forward Premium and Bauer Swanson MP Shocks

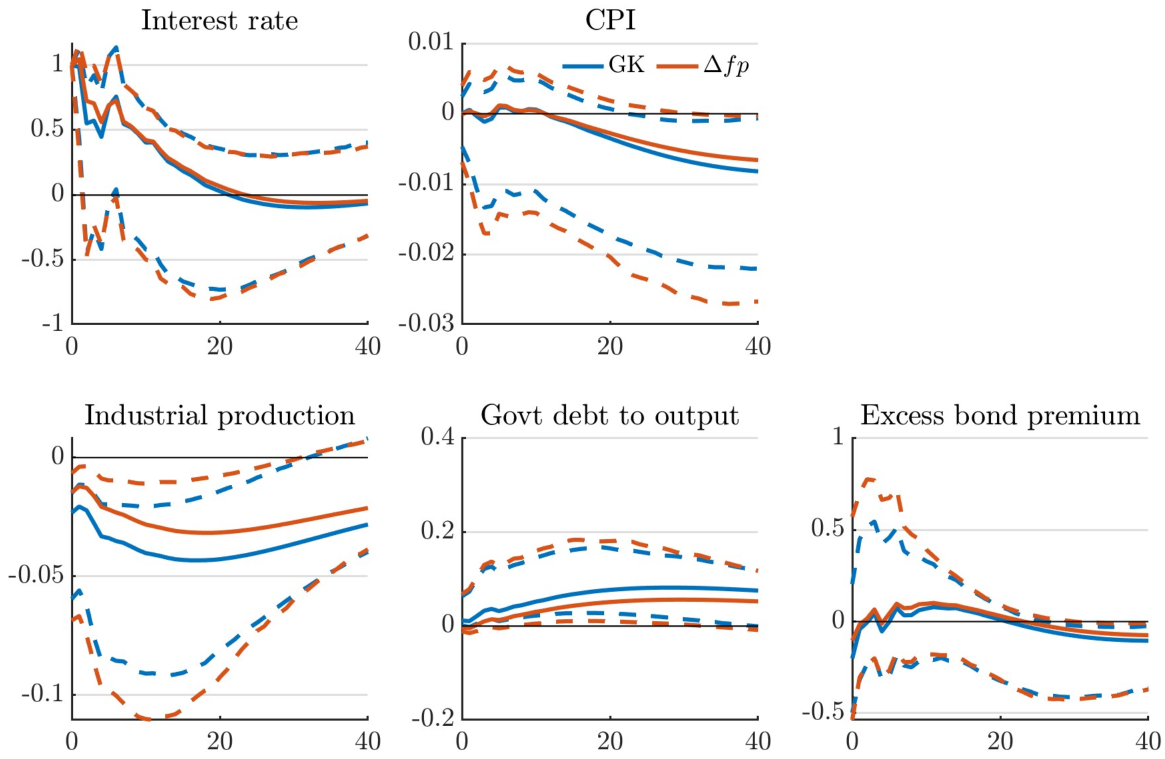
1 percentage point interest rate shock



Notes: This figure shows the impulse responses in the monthly VAR using the 1-day change in the 1-year forward premium and Bauer and Swanson (2023b) monetary policy shocks as an external instrument. The change in the forward premium is orthogonalized following Bauer and Swanson (2023b). 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B17: U.S. SVAR-IV: Forward Premium and Gertler Karadi MP Shocks

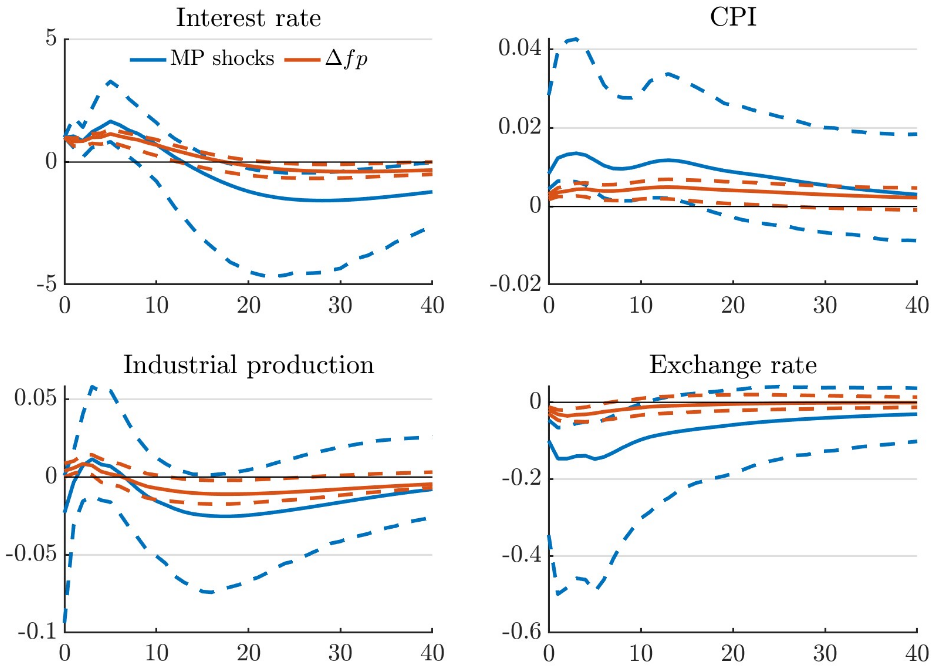
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR using the 1-day change in the 1-year forward premium and Gertler and Karadi (2015) monetary policy shocks, updated by Gürkaynak *et al.* (2022), as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B18: Mexico and Brazil SVAR-IV: Forward Premium and MP Shocks

1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR using the 2-day change in the 1-year forward premium and Solis (2023) and Gomes *et al.* (2023) monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Table B3: First stage – SVAR-IV

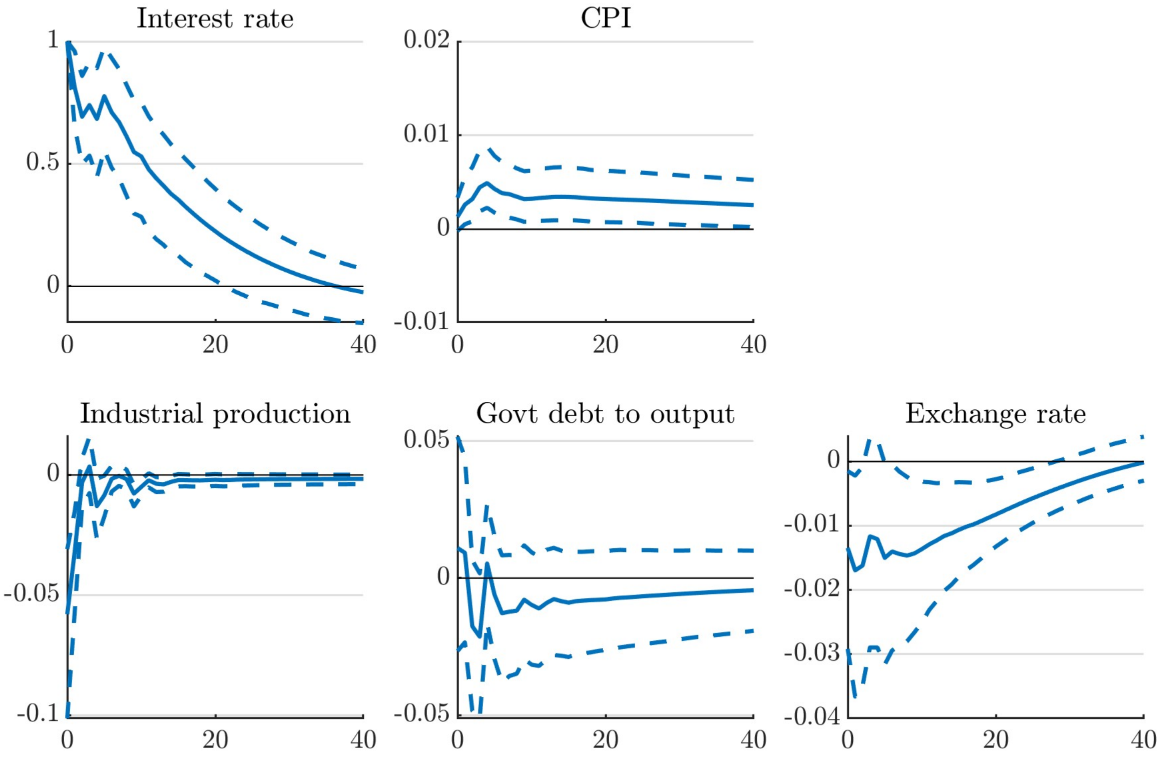
	β_{IV}	N Obs	F-stat
U.S. GK	2.09*** (0.60)	135	12.03
U.S. Δfp	0.85*** (0.27)	135	9.53
EMs Δfp	0.14** (0.07)	566	15.74

Notes: This table shows the first stage results of a regression of the interest rate residual on the monetary policy shock for the baseline U.S. monetary policy shocks validation exercise in Figure 2 using the Gertler and Karadi (2015) monetary policy shocks and the change in the forward premium, and for the emerging markets using the change in the forward premium in Figure 3. Robust standard errors in parentheses.

B4. Robustness – Emerging Market Results

Figure B19: EMs SVAR-IV: Add Time Fixed Effects

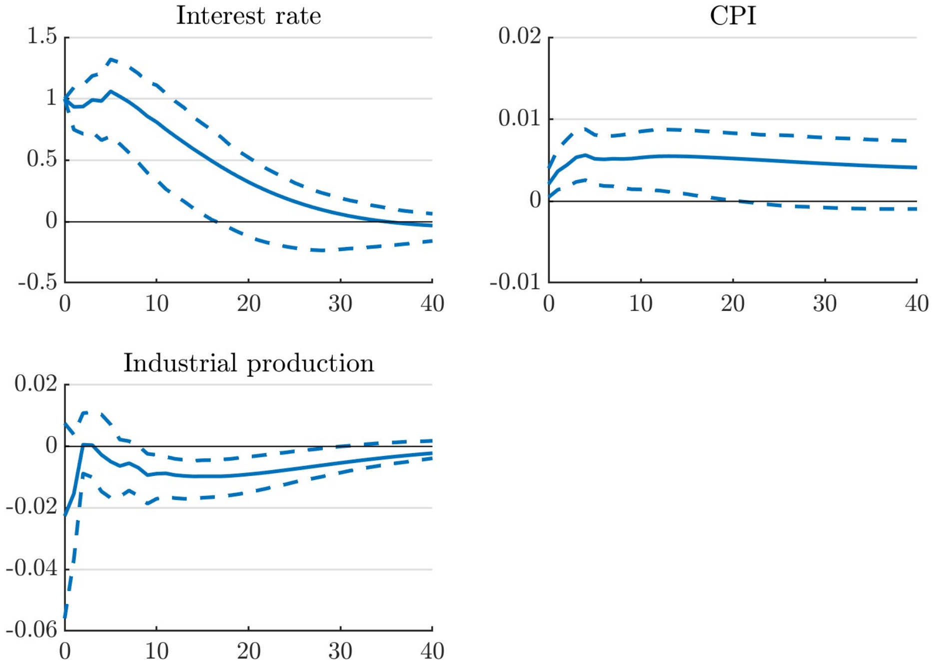
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B20: EMs SVAR-IV: Small-Scale VAR

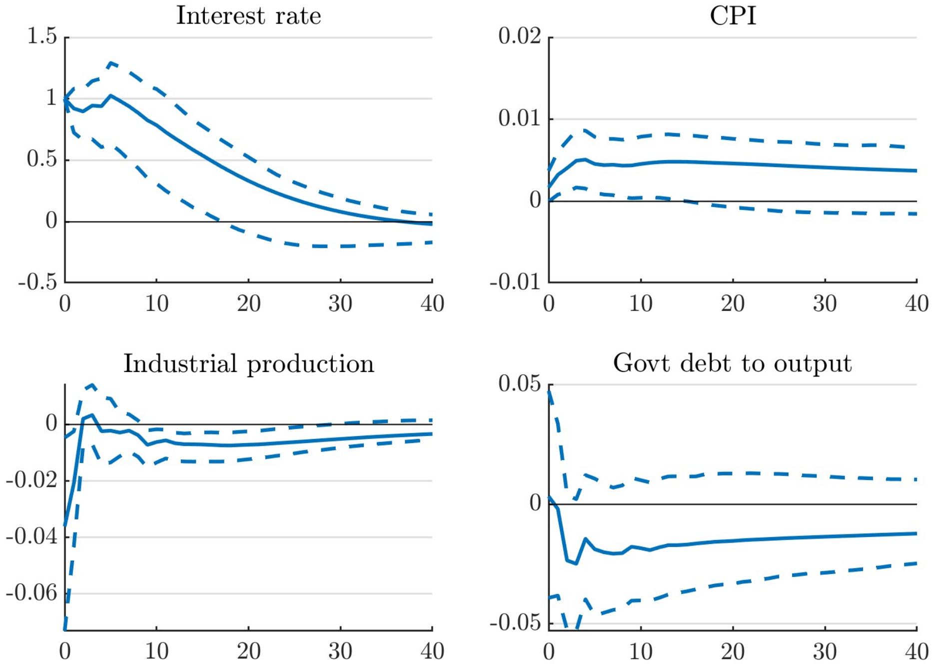
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B21: EMs SVAR-IV: No Exchange Rate

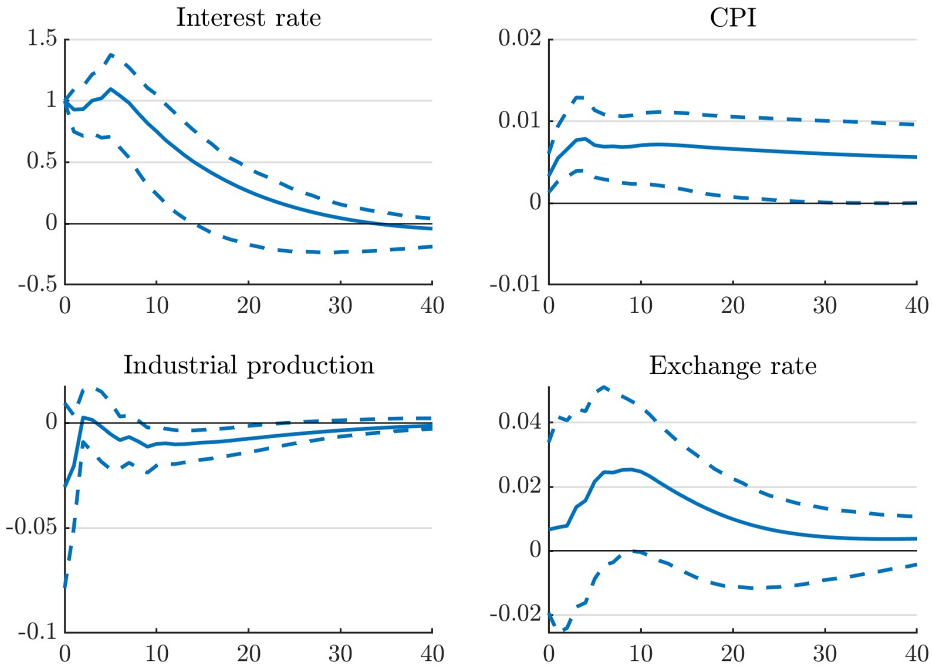
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B22: EMs SVAR-IV: No Government Debt

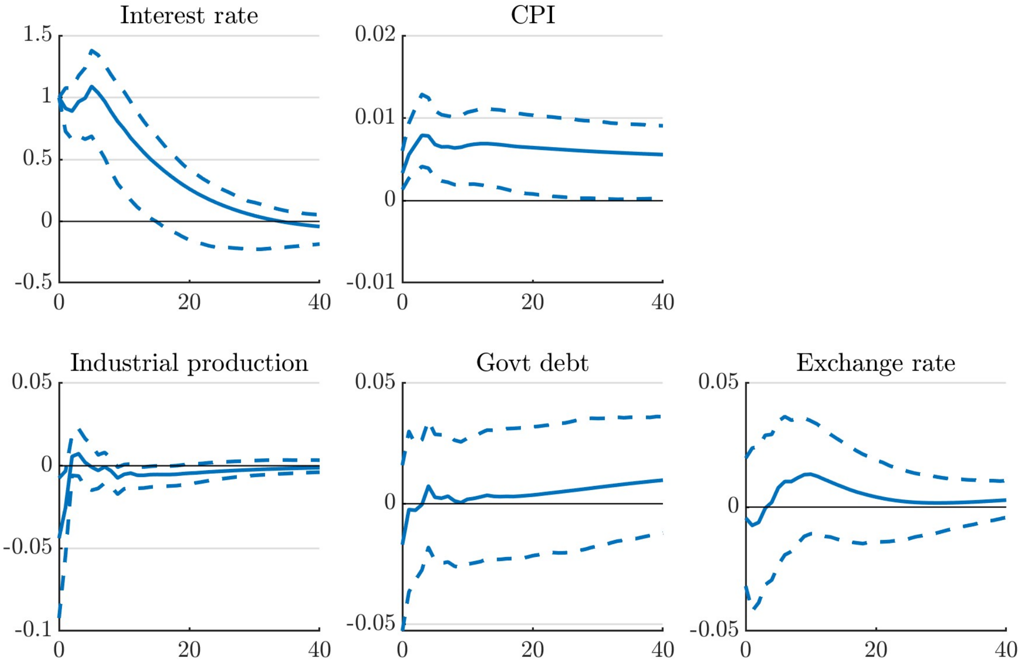
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B23: EMs SVAR-IV: Government Debt in Levels

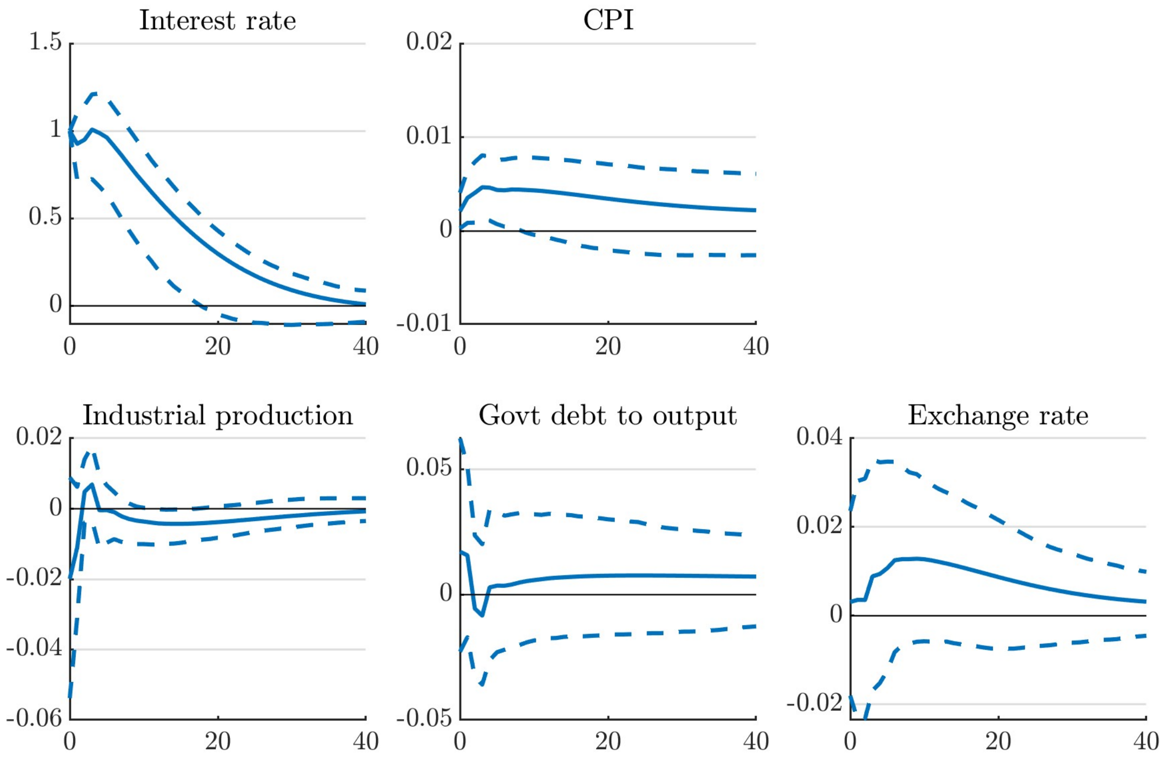
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B24: EMs SVAR-IV: Forward Premium MP Shock: 4 lags

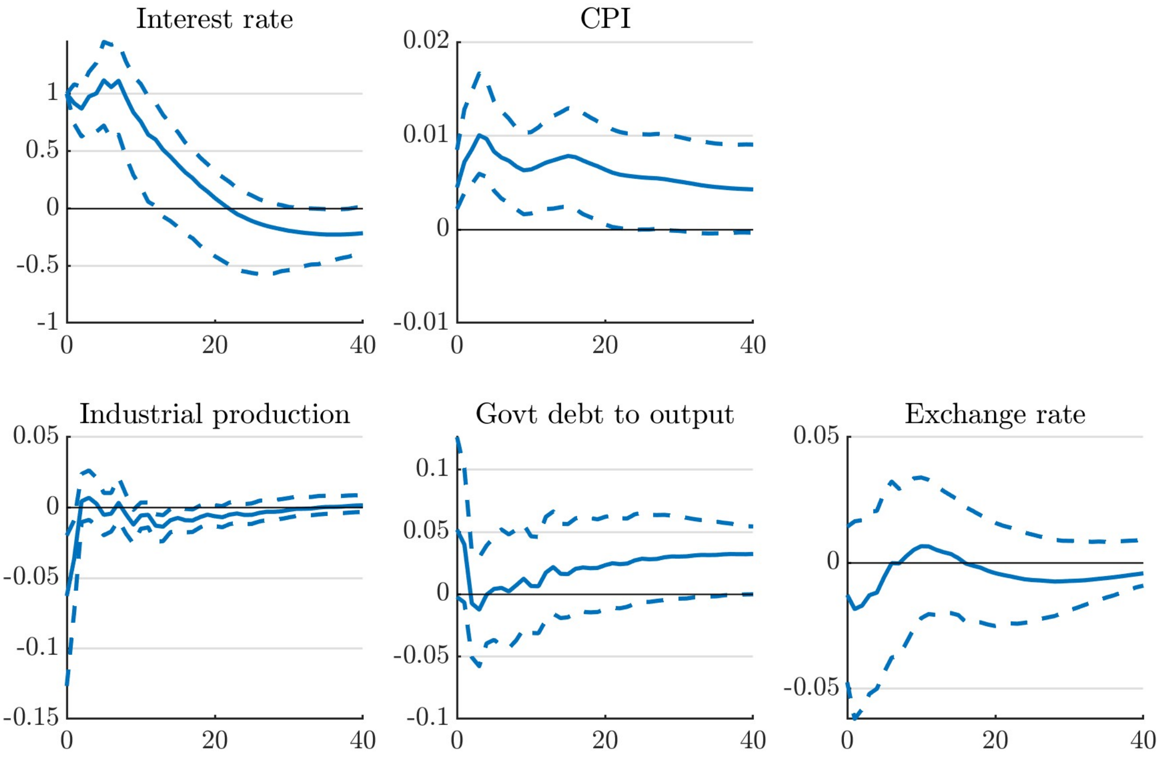
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR using 4 lags and the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B25: EMs SVAR-IV: Forward Premium MP Shock: 8 lags

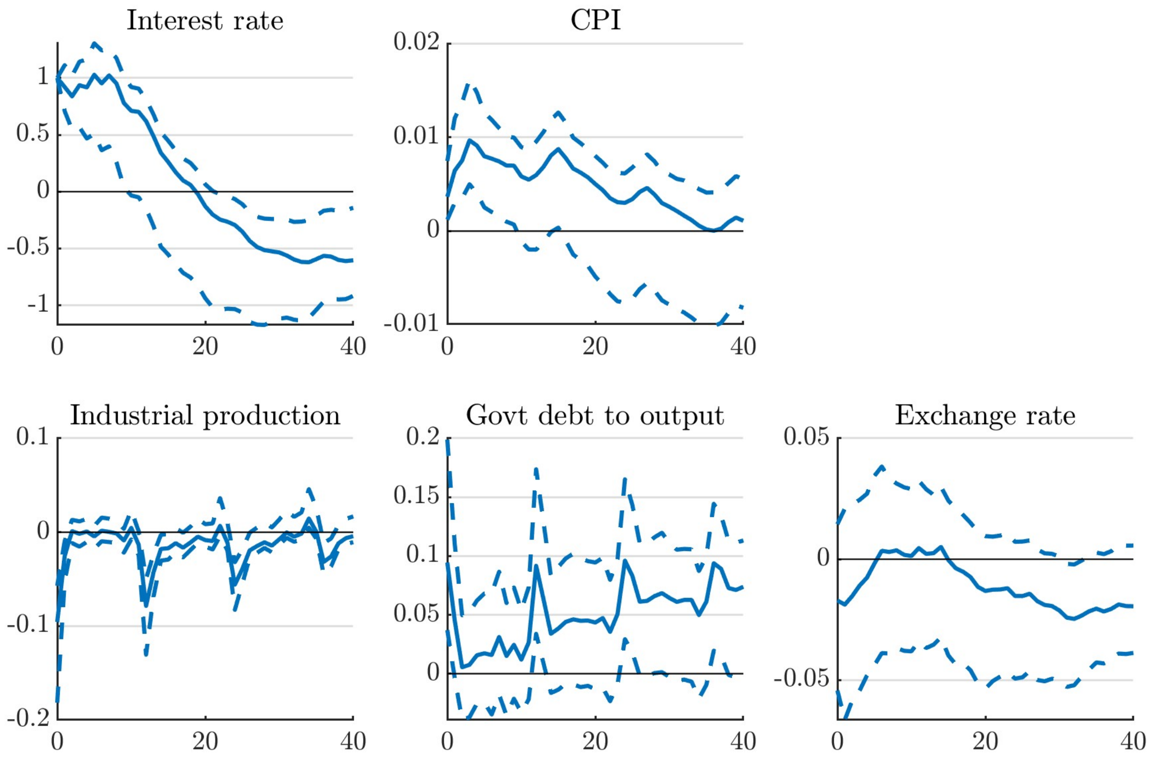
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR using 8 lags and the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B26: EMs SVAR-IV: Forward Premium MP Shock: 12 lags

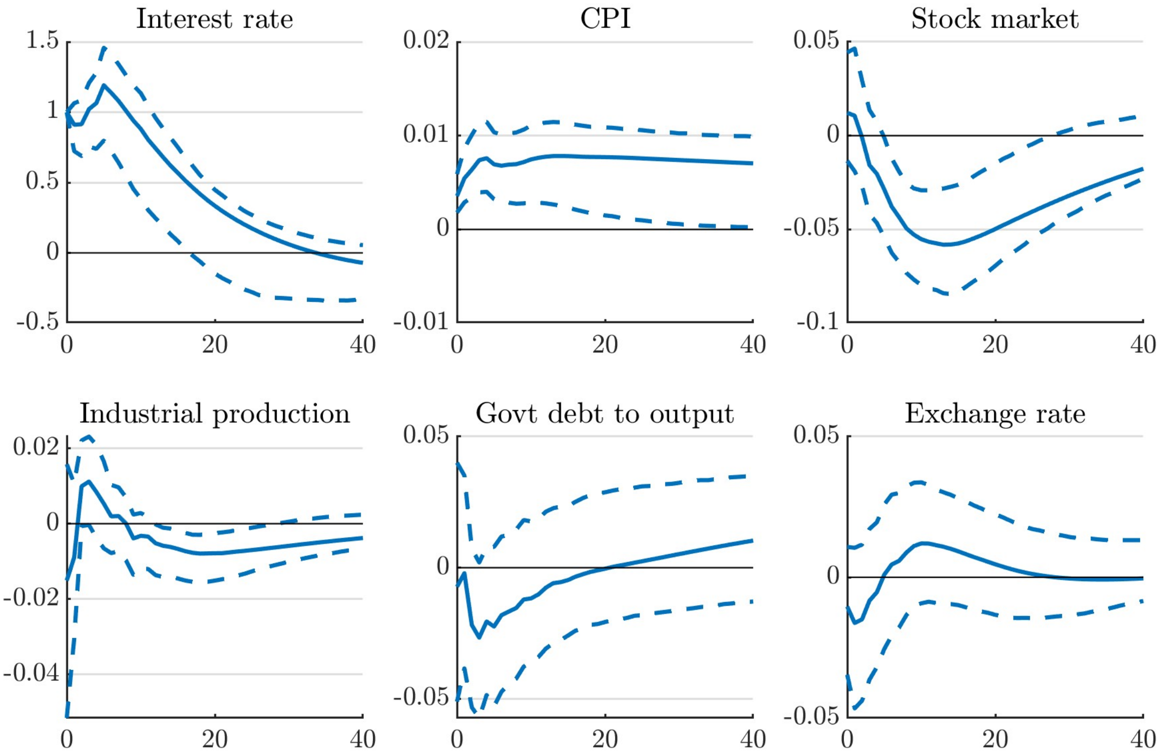
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR using 12 lags and the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B27: EMs SVAR-IV: Add Stock Market

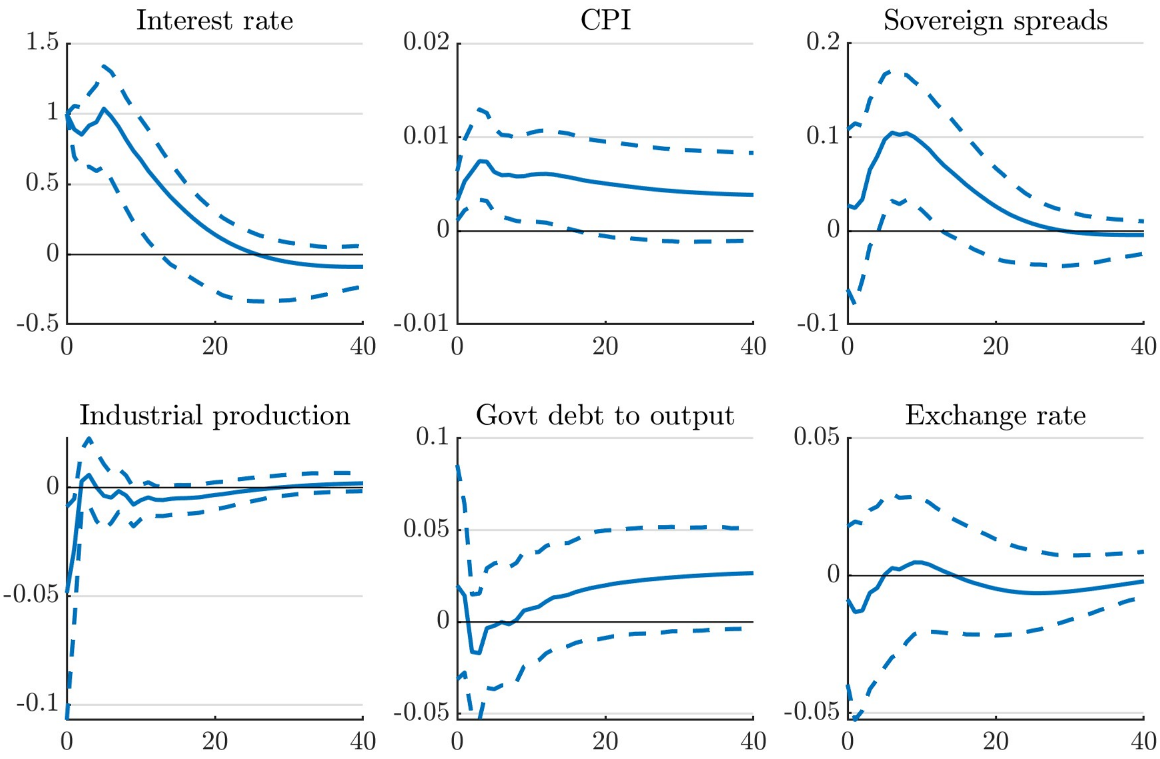
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B28: EMs SVAR-IV: Add Sovereign Spreads

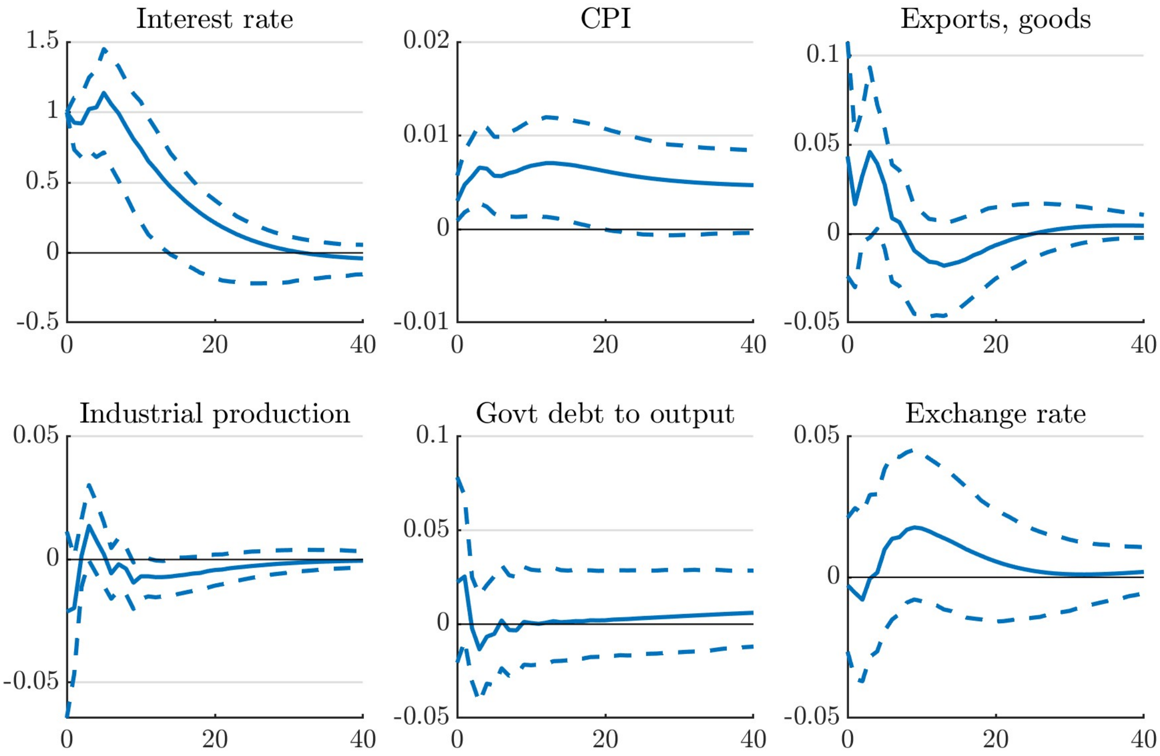
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B29: EMs SVAR-IV: Add Exports

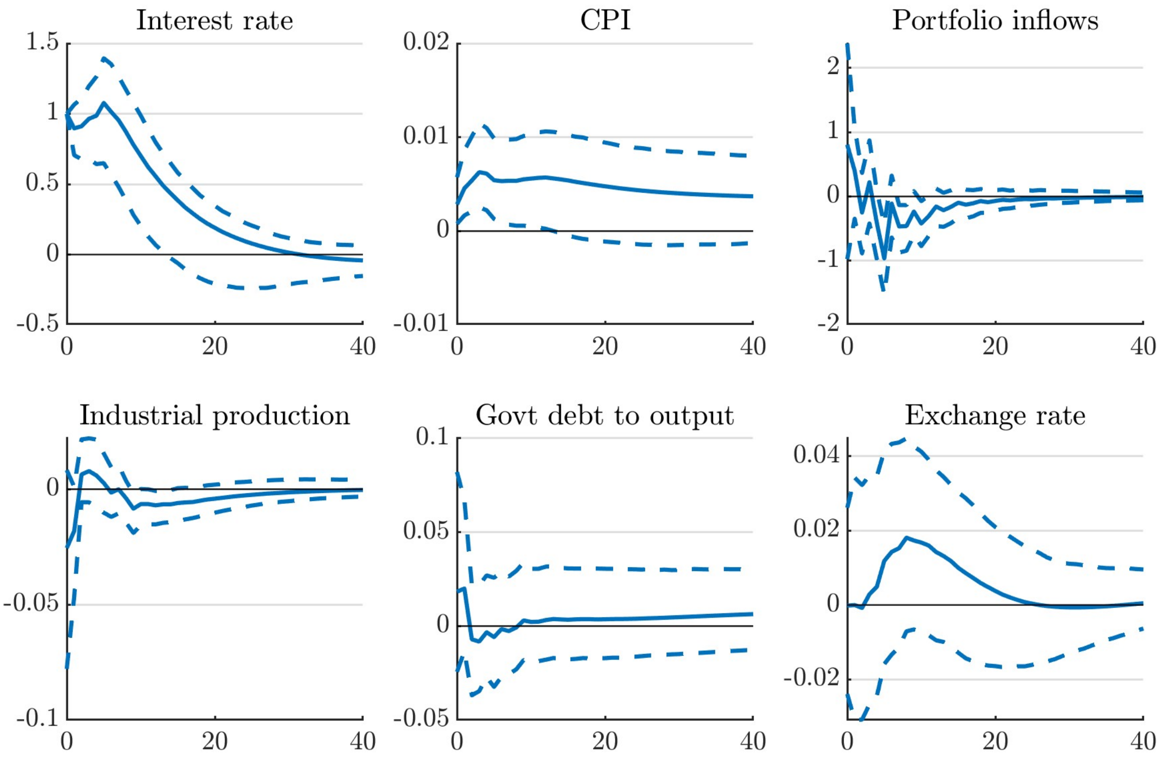
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. Brazil, Chile, and South Africa. Exports of goods in current USD. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B30: EMs SVAR-IV: Add Capital Flows

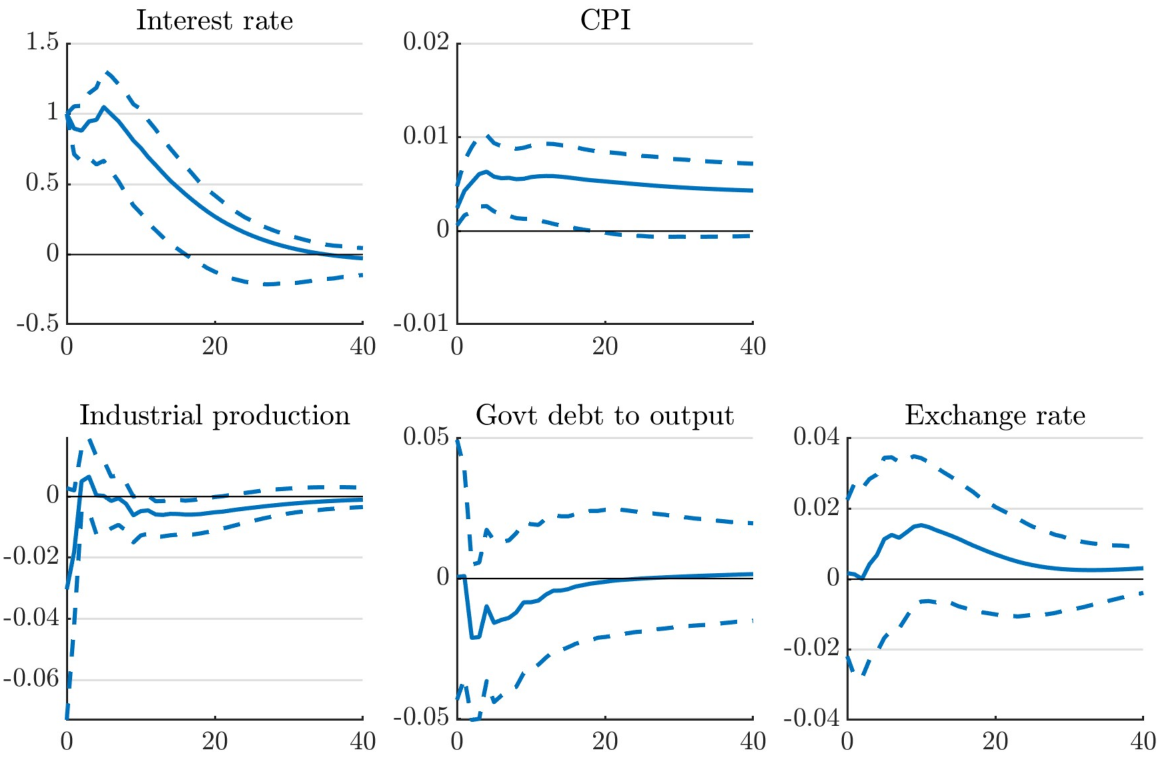
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument. Brazil, Chile, and South Africa. Portfolio inflows in current USD. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B31: EMs SVAR-IV: Control U.S. Interest Rates

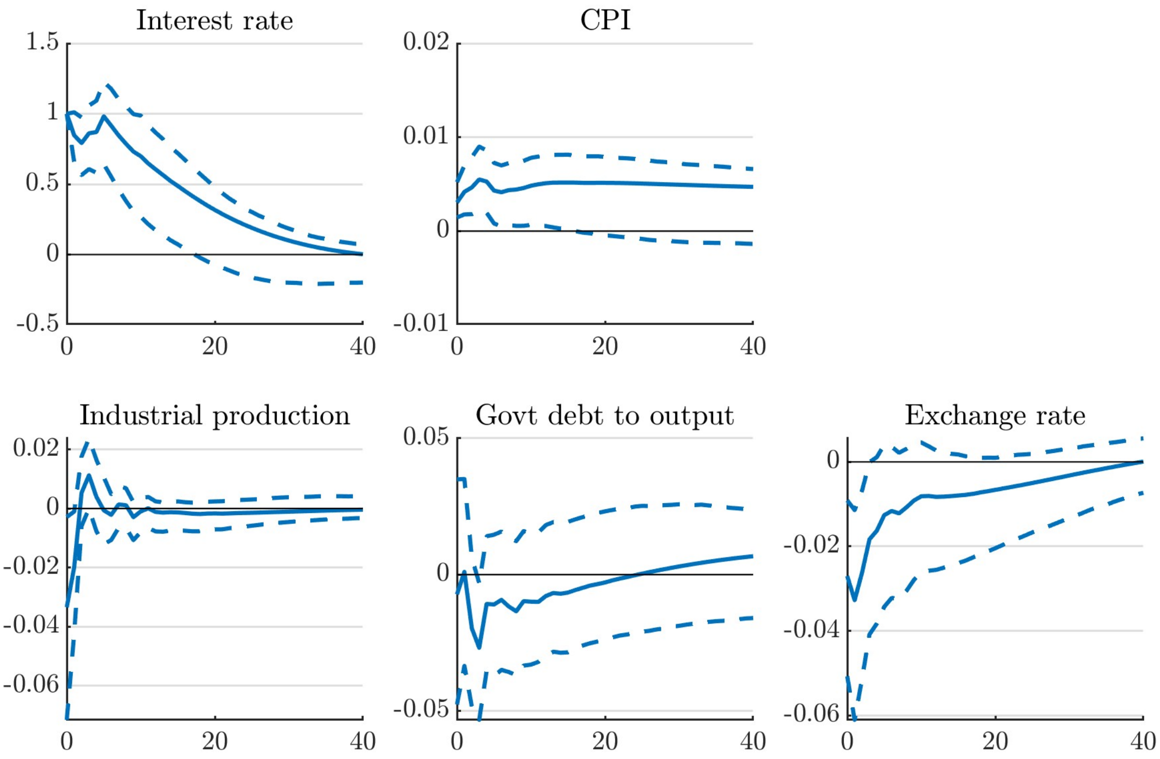
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument, including the 1-year U.S. government bond rate as control variable. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B32: EMs SVAR-IV: Control Commodity Prices

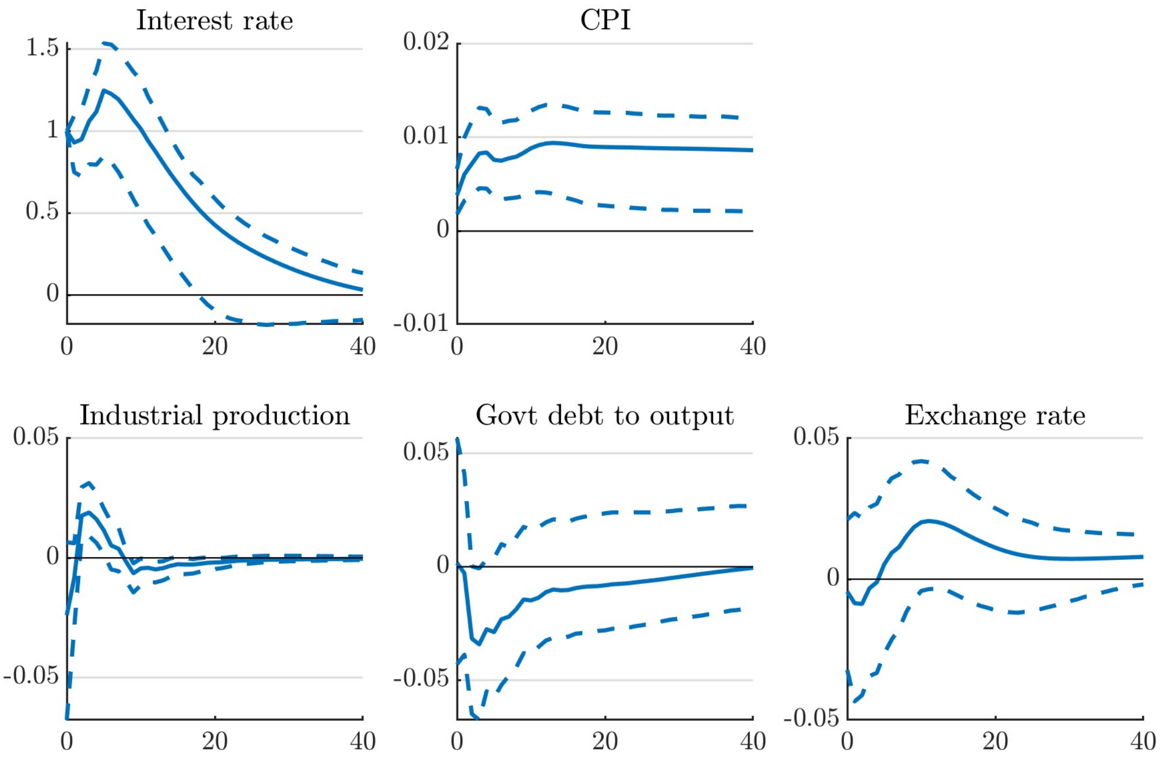
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument, including country-specific commodity price indices from the IMF as control variable. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B33: EMs SVAR-IV: Using Output Gap

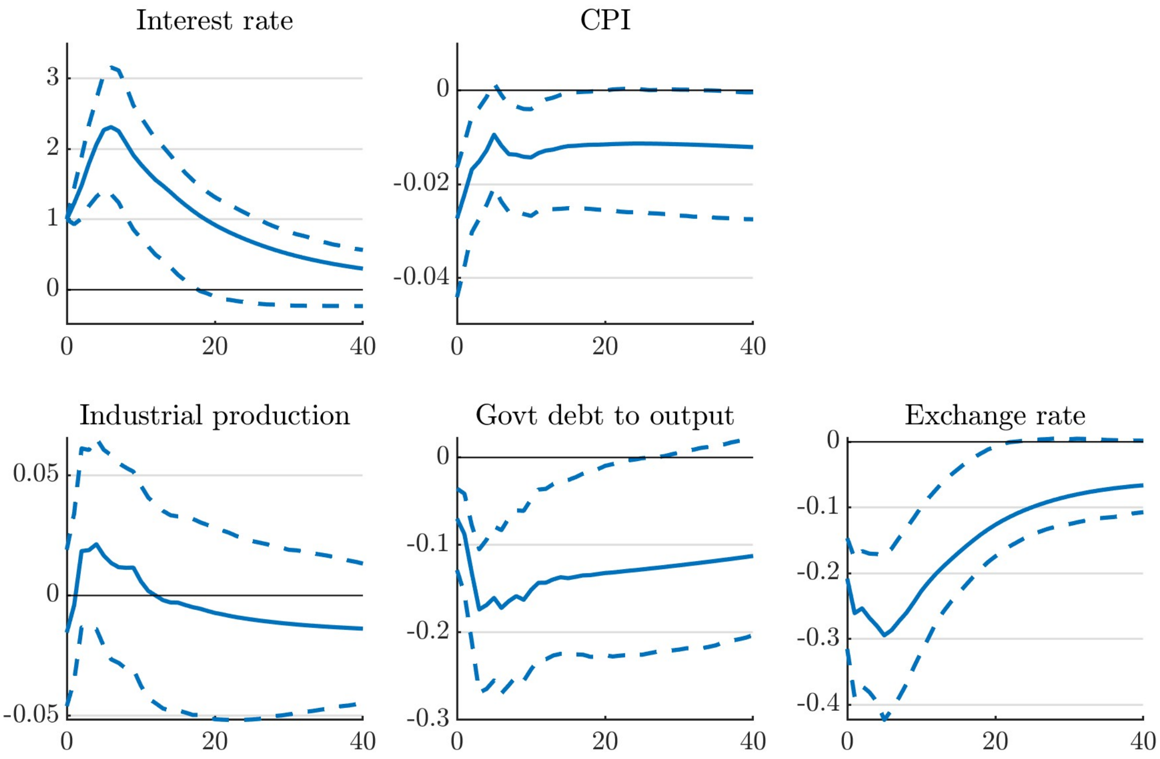
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR with 6 lags using the 2-day change in the 1-year forward premium monetary policy shocks as an external instrument, where industrial production is detrended using a Hodrick-Prescott filter. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

Figure B34: Canada and U.K. SVAR-IV: Forward Premium MP Shock

1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses in the monthly VAR using 6 lags and the 1-day change in the 1-year forward premium monetary policy shocks as an external instrument. 90 per cent confidence bands computed using wild bootstrap following Mertens and Ravn (2013).

B5. Monetary Policy and Inflation Expectations

Table B4: Monetary Policy Shocks and Inflation Expectations

β_{mps}	MP dates	N Obs
a. Panel		
EMs	0.21** (0.10)	372
b. Individual		
Brazil	-0.06 (0.05)	81
Chile	0.06* (0.03)	91
Colombia	0.10* (0.06)	88
Mexico	0.15* (0.09)	66
South Africa	0.43*** (0.10)	46
c. United States		
U.S.	-0.26*** (0.12)	119

Notes: This table shows the results of a regression of the monetary policy shock on the change in inflation expectations around monetary policy meeting dates shown in Figure 4. Panel (a) is for a panel regression of the emerging markets with country fixed effects. Panel (b) is for a regression the each of the emerging markets individually. Panel (c) is for the U.S. Robust standard errors in parentheses.

C. Theoretical Framework

C1. Model – Additional Detail

Firm price setting. The cost function for firm i, after substituting the optimal labor demand condition (16) is

$$\mathcal{C}(y_{Hit}) = P_{Hit}(1-\alpha)y_{Hit}. \tag{C1}$$

Therefore, nominal marginal cost is

$$MC^n_{i,t} \equiv \mathcal{C}'(y_{Hit}) = P_{Hit}(1-\alpha). \tag{C2}$$

Firm i profits, given the law of one price $P_{Hit} = \mathcal{E}_t P^*_{Hit}$ and dividing by the domestic price level P_{Ht}, are

$$\begin{aligned} \Pi_{it}/P_{Ht} &= 1/P_{Ht}(P_{Hit}y_{Hit} - \mathcal{C}(y_{Hit})) && \text{(C3)} \\ &= y_{Hit}/P_{Ht}(P_{Hit} - MC^n_{i,t}). && \text{(C4)} \end{aligned}$$

The optimal price-setting problem for a firm i which can adjust its price in period t is to set P^o_{Hit} that maximizes the expected discounted profits for that price, subject to $y_{Hit} \geq c_{Hit} + c^*_{Hit}$ and the demand functions (8) and (13)

$$\max_{P^o_{Hit}} \quad \mathbb{E}_t \left[\sum_{s=0}^{\infty} \theta^s \Lambda_{t,s} \frac{y_{Hit+s|t}}{P_{Ht+s}} \left(P^o_{Hit} - MC^n_{it+s|t} \right) \right], \tag{C5}$$

where $\Lambda_{t,s} \equiv \beta^s \left(\frac{C_{t+s}}{C_t}\right)^{-\sigma}$ is the stochastic discount factor, and $y_{Hit+s|t}$ and $MC^n_{it+s|t}$ denote output and nominal marginal cost, respectively, for a firm which last reset its price in period t. Substituting in the constraints gives

$$\max_{P^o_{Hit}} \quad \mathbb{E}_t \left[\sum_{s=0}^{\infty} \theta^s \Lambda_{t,s} \frac{1}{P_{Ht+s}} \left(P^o_{Hit} - MC^n_{it+s|t} \right) \left(\left[\frac{P^o_{Hit}}{P_{Ht+s}} \right]^{-\epsilon} c_{Ht+s} + \left[\frac{P^o_{Hit}}{P_{Ht+s}} \right]^{-\epsilon} c^*_{Ht+s} \right) \right], \tag{C6}$$

where from the law of one price $P_{Ht} = \mathcal{E}_t P^*_{Ht}$.

The FOC for this maximization problem gives

$$\mathbb{E}_t\left[\sum_{s=0}^{\infty}\theta^s\Lambda_{t,s}\frac{y_{Hit+s|t}}{P_{Ht+s}}\left(P^o_{Hit}-(1+\mu)MC^n_{it+s|t}\right)\right]=0, \tag{C7}$$

where $1+\mu\equiv\frac{\varepsilon}{\varepsilon-1}$ is the steady-state gross markup. Note that all the adjusting firms face the same decision problem, thus, $P^o_{Hit}=P^o_{Ht}$ $\forall i$ that adjust prices.

Following Galí (2015), taking a loglinear approximation around the perfect foresight zero inflation steady state gives

$$p^o_{Ht}=\mu+(1-\beta\theta)\sum_{s=0}^{\infty}(\beta\theta)^s\mathbb{E}_t mc^n_{t+s|t}, \tag{C8}$$

where $mc^n_{t+s|t}\equiv\log MC^n_{t+s|t}$ is the log nominal marginal cost and μ is the steady state net markup.

Given that the optimal reset price does not depend on firms' existing price, all adjusting firms set prices equal to P^o_{Ht}, and the average price of firms that do not adjust is equal to last period price index P_{Ht-1} (as the probability of adjustment is random), then we can rewrite each period t domestic price index as

$$\begin{aligned}P_{Ht}&=\left(\int_0^1 P^{1-\varepsilon}_{Hit}di\right)^{\frac{1}{1-\varepsilon}}\\&=\left[\theta P^{1-\varepsilon}_{Ht-1}+(1-\theta){P^o_{Ht}}^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}, \qquad\text{(C9)}\\ \Pi^{1-\epsilon}_{H,t}&=\theta+(1-\theta)\left(\frac{P^o_{Ht}}{P_{Ht-1}}\right)^{1-\varepsilon}. \qquad\text{(C10)}\end{aligned}$$

Taking a loglinear approximation around the zero inflation steady state where $\Pi=1$, $P^o_{Ht}=P_{Ht-1}=P_{Ht}$ gives

$$\pi_{H,t}=(1-\theta)\left(p^o_{Ht}-p_{Ht-1}\right). \tag{C11}$$

Combining with the evolution of domestic prices

$$\begin{aligned}p_{Ht}&=\theta p_{Ht-1}+(1-\theta)p^o_{Ht}, \qquad\text{(C12)}\\ \pi_{H,t}=p_{Ht}-p_{Ht-1}&=\frac{1-\theta}{\theta}(p^o_{Ht}-p_{Ht}). \qquad\text{(C13)}\end{aligned}$$

C2. Equilibrium.

Define the terms of trade $\mathcal{S}_t \equiv \frac{P_{Ft}}{P_{Ht}}$ and loglinearize around a symmetric steady state satisfying purchasing power parity: $P_H = P_F$, i.e., $\mathcal{S} = 1$, $s = 0$, then

$$s_t = p_{Ft} - p_{Ht}. \tag{C14}$$

Loglinearizing the consumer price index gives the relationship between CPI and domestic inflation

$$p_t = (1-\omega)p_{Ht} + \omega p_{Ft} \tag{C15}$$

$$= p_{Ht} + \omega s_t, \tag{C16}$$

$$\pi_t = \pi_{H,t} + \omega \Delta s_t, \tag{C17}$$

where ω is the openness parameter.

Now deriving each of the equilibrium conditions.

Dynamic IS curve. From goods market clearing condition for each firm i, $y_{it} = c_{Hit} + c^*_{Hit}$

$$y_{it} = \left(\frac{P_{Hit}}{P_{Ht}}\right)^{-\epsilon} \left[(1-\omega)\left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C_t + \omega \mathcal{S}_t^{\eta} Y_t^*\right], \tag{C18}$$

where by global goods market clearing $C_t^* = Y_t^*$. Substituting the definition of aggregate domestic output $Y_t \equiv \left(\int y_{Hit}^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}}$ gives

$$Y_t = (1-\omega)\left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C_t + \omega \mathcal{S}_t^{\eta} Y_t^*. \tag{C19}$$

Following Galí (2015), loglinearizing around the symmetric steady state gives

$$y_t = (1-\omega)c_t + \omega(2-\omega)\eta s_t + \omega y_t^*. \tag{C20}$$

Assuming a complete set of state-contingent securities are traded internationally (Galí and Monacelli, 2005), the world analogue of the household Euler equation for the continuum of symmetric small open economies gives

$$C_t = C_t^* \left(\mathcal{Q}_t\right)^{\frac{1}{\sigma}}, \tag{C21}$$

where $\mathcal{Q}_t \equiv \frac{P_{Ft}}{P_t}$ is the real exchange rate for the small open economy and

$$\begin{aligned} q_t &= p_{Ft} - p_t && \text{(C22)} \\ &= s_t + p_{Ht} - p_t && \text{(C23)} \\ &= (1-\omega)s_t. && \text{(C24)} \end{aligned}$$

Loglinearizing (C21) and using world market clearing $c_t^* = y_t^*$

$$c_t = y_t^* + \left(\frac{1-\omega}{\sigma}\right) s_t. \tag{C25}$$

Substituting this expression into (C20) gives

$$\begin{aligned} y_t &= y_t^* + \frac{(1-\omega)^2}{\sigma} s_t + \omega(2-\omega)\eta s_t && \text{(C26)} \\ \sigma(y_t - y_t^*) &= \left[(1-\omega)^2 + \sigma\omega(2-\omega)\eta\right] s_t && \text{(C27)} \\ s_t &= \frac{\sigma}{1-\omega+\omega(\sigma\eta+(1-\omega)(\sigma\eta-1))}(y_t - y_t^*). && \text{(C28)} \end{aligned}$$

Assume world output is equal to the steady state level $y_t^* = 0$.

Loglinearizing the household Euler equation for domestic currency bonds and then substituting for c_t from (C25) and π_t from (C17)

$$\begin{aligned} c_t &= \mathbb{E}_t c_{t+1} - \frac{1}{\sigma}(r_t - \mathbb{E}_t \pi_{t+1}) && \text{(C29)} \\ \left(\frac{1-\omega}{\sigma}\right) s_t &= \left(\frac{1-\omega}{\sigma}\right) \mathbb{E}_t s_{t+1} - \frac{1}{\sigma}(r_t - \mathbb{E}_t \pi_{H,t+1}) + \frac{\omega}{\sigma}\mathbb{E}_t \Delta s_{t+1} && \text{(C30)} \\ s_t &= \mathbb{E}_t s_{t+1} - (r_t - \mathbb{E}_t \pi_{H,t+1}) && \text{(C31)} \\ y_t &= \mathbb{E}_t y_{t+1} - \frac{1}{\sigma_\omega}(r_t - \mathbb{E}_t \pi_{H,t+1}), && \text{(C32)} \end{aligned}$$

where the last line substitutes y_t from (C28) and $\sigma_\omega \equiv \frac{\sigma}{1-\omega+\omega(\sigma\eta+(1-\omega)(\sigma\eta-1))}$.

Small open economy New Keynesian Phillips curve. Loglinearizing the household labor supply condition (10) around the steady state

$$\frac{W_t}{P_t} = \phi \frac{L_t^{\nu}}{C_t^{-\sigma}} \tag{C33}$$

$$w_t - p_t = \sigma c_t + \nu l_t. \tag{C34}$$

From labor market clearing

$$y_{Hit} = n_{it}^{1-\alpha}, \tag{C35}$$

$$N_t \equiv \int n_{it} di = Y_t^{\frac{1}{1-\alpha}} D_t, \tag{C36}$$

where $Y_t \equiv \left(\int y_{Hit}^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}$, $D_t \equiv \log \int \left(\frac{P_{Hit}}{P_{Ht}} \right)^{-\epsilon} di$ and variations in D_t around the zero inflation steady state are of second order. Therefore, taking a first-order approximation gives:

$$y_t = (1-\alpha) n_t. \tag{C37}$$

From the firm the optimal labor demand condition (16) for a firm i that last set its price in period t

$$MC_{it+s|t}^{n} = \frac{W_{t+s}}{MPN_{it+s|t}} \tag{C38}$$

$$mc_{it+s|t}^{n} = w_{t+s} - mpn_{it+s|t}, \tag{C39}$$

where $MPN_{it+s|t}$ is the marginal product of labor in period $t+s$ for a firm i that last set its price in period t, $MPN_{it+s|t} = (1-\alpha) n_{it+s|t}^{-\alpha}$, and $mpn_{it+s|t} \equiv \log MPN_{it+s|t}$. Therefore,

$$mc_{it+s|t}^{n} = w_{t+s} - (-\alpha n_{it+s|t} + \log(1-\alpha)) \tag{C40}$$

$$mc_{t+s|t}^{n} = w_{t+s} - (-\alpha n_{t+s|t} + \log(1-\alpha)), \tag{C41}$$

since $n_t = \int n_{it} di$. The log average marginal cost across all firms at t, $mc^n_t \equiv \int mc^n_{it}$

$$mc^n_t = (1-\theta)\sum_{s=0}^{\infty}\theta^s mc^n_{t|t-s} \tag{C42}$$

$$= w_t - (-\alpha n_t + \log(1-\alpha)). \tag{C43}$$

Combining these expressions gives

$$mc^n_{t+s|t} = mc^n_{t+s} + \alpha(n_{t+s|t} - n_{t+s}) \tag{C44}$$

$$= mc^n_{t+s} + \frac{\alpha}{1-\alpha}(y_{t+s|t} - y_{t+s}) \tag{C45}$$

$$= mc^n_{t+s} - \frac{\alpha\varepsilon}{1-\alpha}(p^o_{Ht} - p_{Ht+s}), \tag{C46}$$

where the last line follows from $y_t = c_{Ht} + c^*_{Ht}$ and loglinearizing the demand functions (8) and (13) used above. Substituting this into the optimal price setting condition (C8)

$$p^o_{Ht} = (1-\beta\theta)\sum_{s=0}^{\infty}(\beta\theta)^s \mathbb{E}_t\left[p_{Ht+s} - \Phi(p_{Ht+s} - mc^n_{t+s} - \mu)\right], \tag{C47}$$

where $\Phi \equiv \frac{1-\alpha}{1-\alpha+\alpha\epsilon}$. Expressing this recursively

$$p^o_{Ht} = \beta\theta\mathbb{E}_t p^o_{Ht+1} + (1-\beta\theta)(p_{Ht} - \Phi(p_{Ht} - mc^n_t - \mu) \tag{C48}$$

$$= \beta\theta\mathbb{E}_t p^o_{Ht+1} + (1-\beta\theta)(p_{Ht} + \Phi mc_t), \tag{C49}$$

where $mc_t \equiv mc^n_t - p_{Ht} + \mu$ is the log deviation of real marginal cost from steady state. Rearranging and using (C13) gives

$$p^o_{Ht} - p_{Ht} = (1-\beta\theta)\Phi mc_t + \beta\theta\mathbb{E}_t[p^o_{Ht+1} - p_{Ht+1} + p_{Ht+1} - p_{Ht}] \tag{C50}$$

$$\frac{\theta}{1-\theta}\pi_{H,t} = (1-\beta\theta)\Phi mc_t + \beta\theta\mathbb{E}_t\left[\frac{\theta}{1-\theta}\pi_{H,t+1} + \pi_{H,t+1}\right] \tag{C51}$$

$$\pi_{H,t} = \frac{(1-\beta\theta)(1-\theta)}{\theta}\Phi mc_t + \beta\mathbb{E}_t\pi_{H,t+1}. \tag{C52}$$

Solving for mc_t by substituting and using that $n_t = l_t$ in equilibrium and substituting (C16) and (C34) gives

$$
\begin{aligned}
mc_t &\equiv mc_t^n - p_{Ht} + \mu && \text{(C53)}\\
&= w_t - (-\alpha n_t + \log(1-\alpha)) - p_{Ht} + \log(1-\alpha) && \text{(C54)}\\
&= w_t - p_t + p_t - p_{Ht} + \alpha n_t && \text{(C55)}\\
&= \sigma c_t + \nu n_t + p_t - p_{Ht} + \alpha n_t && \text{(C56)}\\
&= \sigma c_t + \left(\frac{\nu+\alpha}{1-\alpha}\right) y_t + \omega s_t && \text{(C57)}\\
&= s_t + \left(\frac{\nu+\alpha}{1-\alpha}\right) y_t && \text{(C58)}\\
&= \left(\sigma_\omega + \frac{\nu+\alpha}{1-\alpha}\right) y_t, && \text{(C59)}
\end{aligned}
$$

where the second last line substitutes c_t from (C25) and the last line substitutes y_t from (C28).

Substituting for mc_t into (C52) gives the small open economy New Keynesian Phillips curve

$$\pi_{H,t} = \kappa y_t + \beta \mathbb{E}_t \pi_{H,t+1}, \tag{C60}$$

where $\kappa \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta}\left(\frac{1-\alpha}{1-\alpha+\alpha\epsilon}\right)\left(\sigma_\omega + \frac{\nu+\alpha}{1-\alpha}\right)$.

Consumer price inflation. From the law of one price, where $e_t \equiv \log \mathcal{E}_t$, and the definition of the terms of trade

$$s_t = e_t + p_t^* - p_{Ht}. \tag{C61}$$

Therefore, from (C17)

$$
\begin{aligned}
\pi_t &= \pi_{H,t} + \omega(\Delta e_t + \pi_t^* - \pi_{H,t}) && \text{(C62)}\\
&= (1-\omega)\pi_{H,t} + \omega \Delta e_t, && \text{(C63)}
\end{aligned}
$$

assuming the world price level is equal to the steady state.

Nominal exchange rate. From (C61) and substituting y_t from (C28)

$$\Delta s_t = \Delta e_t - \pi_{H,t} \tag{C64}$$

$$\Delta e_t = \sigma_\omega (y_t - y_{t-1}) + \pi_{H,t}. \tag{C65}$$

Government debt. Law of motion for debt to GDP

From government budget constraint

$$\frac{B_t^G}{R_t} + T_t = B_{t-1}^G \tag{C66}$$

$$\frac{B_t^G/R_t}{P_t Y_t} + \frac{T_t}{P_t Y_t} = \frac{B_{t-1}^G/R_{t-1}}{P_{t-1}Y_{t-1}} \frac{P_{t-1}}{P_t} \frac{Y_{t-1}}{Y_t} R_{t-1} \tag{C67}$$

$$D_t + \mathcal{T}_t = D_{t-1} \frac{1}{\Pi_t} \frac{Y_{t-1}}{Y_t} R_{t-1}. \tag{C68}$$

In the zero-inflation steady state $\Pi = 1$ and $R = 1/\beta$ so this expression is given by

$$D + \mathcal{T} = D \frac{1}{\beta} \tag{C69}$$

$$e^{\log D} + e^{\log \mathcal{T}} = e^{\log D + \log R} \tag{C70}$$

$$1 + e^{\log \mathcal{T} - \log D} = e^{\log R} \tag{C71}$$

$$e^{\log \mathcal{T} - \log D} = \frac{1-\beta}{\beta}. \tag{C72}$$

Loglinearizing (C68) by taking a first-order Taylor expansion around the steady state

$$e^{\log D_t} + e^{\log \mathcal{T}_t} = e^{\log D_{t-1} - \pi_t + \log Y_{t-1} - \log Y_t + \log R_{t-1}} \tag{C73}$$

$$e^{\log D} + e^{\log \mathcal{T}} + e^{\log D} d_t + e^{\log \mathcal{T}} \tau_t = e^{\log D + \log R} (1 + d_{t-1} - \pi_t + y_{t-1} - y_t + r_{t-1}) \tag{C74}$$

$$e^{\log D} d_t + e^{\log \mathcal{T}} \tau_t = e^{\log D + \log R} (d_{t-1} - \pi_t + y_{t-1} - y_t + r_{t-1}) \tag{C75}$$

$$d_t + e^{\log \mathcal{T} - \log D} \tau_t = \frac{1}{\beta} (d_{t-1} - \pi_t + y_{t-1} - y_t + r_{t-1}) \tag{C76}$$

$$d_t = \frac{1}{\beta} \left[d_{t-1} - \pi_t + y_{t-1} - y_t + r_{t-1} - (1-\beta)\tau_t \right]. \tag{C77}$$

By definition, log deviations of taxes and government debt from steady state are $t_t = \tau_t + p_t + y_t$ and $b_t^g = d_t + r_t + p_t + y_t$.

Balance of payments. From household budget constraint, substituting for firms profits

$$P_t C_t + \frac{B_t}{R_t} + \mathcal{E}_t \frac{B_t^*}{R_t^*} + T_t = W_t L_t + B_{t-1} + \mathcal{E}_t B_{t-1}^* + \Pi_t \tag{C78}$$

$$P_{Ht} c_{Ht} + P_{Ft} c_{Ft} + \frac{B_t}{R_t} + \mathcal{E}_t \frac{B_t^*}{R_t^*} + T_t = P_{Ht} Y_t + B_{t-1} + \mathcal{E}_t B_{t-1}^*. \tag{C79}$$

Using home good market clearing $c_{Ht} + c_{Ht}^* = Y_t$, and the law of one price gives

$$P_{Ft} c_{Ft} + \frac{B_t}{R_t} + \mathcal{E}_t \frac{B_t^*}{R_t^*} + T_t = \mathcal{E}_t P_{Ht}^* c_{Ht}^* + B_{t-1} + \mathcal{E}_t B_{t-1}^*. \tag{C80}$$

Next substitute the government budget constraint $\frac{B_t^G}{R_t} + T_t = B_{t-1}^G$ and local currency bond market clearing $B_t + B_t^{ROW} = B_t^G$

$$\mathcal{E}_t P_{Ht}^* c_{Ht}^* - P_{Ft} c_{Ft} = \frac{B_t}{R_t} - \frac{B_t^G}{R_t} + \mathcal{E}_t \frac{B_t^*}{R_t^*} - \mathcal{E}_t B_{t-1}^* + B_{t-1}^G - B_{t-1} \tag{C81}$$

$$\mathcal{E}_t P_{Ht}^* c_{Ht}^* - P_{Ft} c_{Ft} = \mathcal{E}_t \frac{B_t^*}{R_t^*} - \mathcal{E}_t B_{t-1}^* - \left(\frac{B_t^{ROW}}{R_t} - B_{t-1}^{ROW} \right), \tag{C82}$$

which states that net exports equals the change in the net foreign asset position, which comprises sum of the change in the rest of the world local currency bond holdings and the change in domestic households' foreign currency bond holdings, in domestic currency terms.

Net exports. A first order approximation around the symmetric steady state with balanced trade gives

$$nx_t \equiv \frac{1}{Y} \left(Y_t - \frac{P_t}{P_{Ht}} C_t \right) \tag{C83}$$

$$= \left(\frac{\sigma\eta + (1-\omega)(\sigma\eta - 1)}{\sigma} - 1 \right) (p_t - p_{Ht}) \tag{C84}$$

$$= \omega \left(\frac{\sigma\eta + (1-\omega)(\sigma\eta - 1)}{\sigma} - 1 \right) s_t. \tag{C85}$$

C3. Proof of Proposition 1

The equilibrium system equations (24)–(30) are

$$y_t = \mathbb{E}_t y_{t+1} - 1/\sigma_\omega (r_t - \mathbb{E}_t \pi_{H,t+1}), \tag{C86}$$

$$\pi_{H,t} = \kappa y_t + \beta \mathbb{E}_t \pi_{H,t+1}, \tag{C87}$$

$$\pi_t = (1-\omega)\pi_{H,t} + \omega \Delta e_t, \tag{C88}$$

$$\Delta e_t = \sigma_\omega (y_t - y_{t-1}) + \pi_{H,t}, \tag{C89}$$

$$r_t = \phi_\pi \pi_t, \tag{C90}$$

$$\tau_t = \gamma_d d_{t-1} + \gamma_y y_t, \tag{C91}$$

$$d_t = \frac{1}{\beta}[y_{t-1} - y_t + d_{t-1} + r_{t-1} - \pi_t - (1-\beta)\tau_t], \tag{C92}$$

where without loss of generality I omit the exogenous AR(1) monetary policy shock m_t.

Substitute for Δe_t from (C89) into (C88)

$$\pi_t = (1-\omega)\pi_{H,t} + \omega\sigma_\omega (y_t - y_{t-1}) + \omega \pi_{H,t} \tag{C93}$$

$$= \pi_{H,t} + \omega\sigma_\omega (y_t - y_{t-1}). \tag{C94}$$

Therefore, (C90) becomes

$$r_t = \phi_\pi \pi_{H,t} + \phi_\pi \omega \sigma_\omega y_t - \phi_\pi \omega \sigma_\omega y_{t-1}. \tag{C95}$$

Iterating the IS curve (C86) forward gives

$$y_t = \mathbb{E}_t y_{t+1} - 1/\sigma_\omega r_t + 1/\sigma_\omega \mathbb{E}_t \pi_{H,t+1} \tag{C96}$$

$$= -1/\sigma_\omega \sum_{s=0}^{\infty} r_{t+s} + 1/\sigma_\omega \sum_{s=0}^{\infty} \mathbb{E}_t \pi_{H,t+1+s}, \tag{C97}$$

where $\lim_{s\to\infty} \mathbb{E}_t y_{t+s} = 0$ in a stable equilibrium. Substituting for r_t from (C95)

$$y_t = -1/\sigma_\omega \sum_{s=0}^{\infty} \phi_\pi \pi_{H,t+s} + 1/\sigma_\omega \sum_{s=0}^{\infty} \mathbb{E}_t \pi_{H,t+1+s}, \tag{C98}$$

where the y_{t+s} terms cancel and the initial steady state at t condition is $y_{t-1} = 0$. Expressing (C98) recursively

$$y_t = -\phi_\pi/\sigma_\omega \pi_{H,t} + 1/\sigma_\omega \mathbb{E}_t \pi_{H,t+1} + \mathbb{E}_t y_{t+1}. \tag{C99}$$

Substituting for π_t and the fiscal policy rule (C91) into the law of motion for government debt gives

$$\begin{aligned}
d_t &= \frac{1}{\beta}[y_{t-1} - y_t + d_{t-1} + r_{t-1} - \pi_t - (1-\beta)\tau_t] && \text{(C100)}\\
&= \frac{1}{\beta}[y_{t-1} - y_t + d_{t-1} + r_{t-1} - \pi_{H,t} - \omega\sigma_\omega(y_t - y_{t-1}) - (1-\beta)\gamma_d d_{t-1} - (1-\beta)\gamma_y y_t] && \text{(C101)}\\
&= \frac{1}{\beta}[(1+\omega\sigma_\omega)y_{t-1} - (1+\omega\sigma_\omega + (1-\beta)\gamma_y)y_t - \pi_{H,t} + (1-(1-\beta)\gamma_d)d_{t-1} + r_{t-1}]. && \text{(C102)}
\end{aligned}$$

Substituting the monetary policy rule (C90) gives the fiscal block:

$$\begin{aligned}
d_t = \frac{1}{\beta}[&(1+\omega\sigma_\omega)y_{t-1} - (1+\omega\sigma_\omega + (1-\beta)\gamma_y)y_t - \pi_{H,t} + (1-(1-\beta)\gamma_d)d_{t-1} && \text{(C103)}\\
&+ \phi_\pi \pi_{H,t-1} + \phi_\pi\omega\sigma_\omega y_{t-1} - \phi_\pi\omega\sigma_\omega y_{t-2}]. && \text{(C104)}
\end{aligned}$$

Therefore, the equilibrium system condenses to three equations

$$\begin{aligned}
y_t &= -\phi_\pi/\sigma_\omega \pi_{H,t} + 1/\sigma_\omega \mathbb{E}_t \pi_{H,t+1} + \mathbb{E}_t y_{t+1}, && \text{(C105)}\\
\pi_{H,t} &= \kappa y_t + \beta \mathbb{E}_t \pi_{H,t+1}, && \text{(C106)}\\
d_t &= \frac{1}{\beta}[(1+\omega\sigma_\omega)y_{t-1} - (1+\omega\sigma_\omega + (1-\beta)\gamma_y)y_t - \pi_{H,t} + (1-(1-\beta)\gamma_d)d_{t-1}\\
&\quad + \phi_\pi \pi_{H,t-1} + \phi_\pi\omega\sigma_\omega y_{t-1} - \phi_\pi\omega\sigma_\omega y_{t-2}]. && \text{(C107)}
\end{aligned}$$

There are two non-predetermined variables y_t and $\pi_{H,t}$, and one predetermined variable d_t. In order to express the system recursively, add two auxiliary pre-determined variables $z_{t+1} = y_t$, $x_{t+1} = z_t$, such that the law of motion for government debt becomes

$$\begin{aligned}
d_t = \frac{1}{\beta}[&(1+\omega\sigma_\omega)z_t - (1+\omega\sigma_\omega + (1-\beta)\gamma_y)y_t - \pi_{H,t} + (1-(1-\beta)\gamma_d)d_{t-1}\\
&+ \phi_\pi \pi_{H,t-1} + \phi_\pi\omega\sigma_\omega z_t - \phi_\pi\omega\sigma_\omega x_t]. && \text{(C108)}
\end{aligned}$$

Substituting for $\pi_{H,t-1} = \kappa y_{t-1} + \beta \pi_{H,t} = \kappa z_t + \beta \pi_{H,t}$ gives

$$\begin{aligned} d_t = & \frac{1}{\beta}[(1+\omega\sigma_\omega)z_t - (1+\omega\sigma_\omega + (1-\beta)\gamma_y)y_t - \pi_{H,t} + (1-(1-\beta)\gamma_d)d_{t-1} \\ & + \phi_\pi \kappa z_t + \phi_\pi \beta \pi_{H,t} + \phi_\pi \omega\sigma_\omega z_t - \phi_\pi \omega\sigma_\omega x_t] \qquad \text{(C109)} \\ = & \frac{1}{\beta}[(1+\omega\sigma_\omega + \phi_\pi\kappa + \phi_\pi\omega\sigma_\omega)z_t - (1+\omega\sigma_\omega + (1-\beta)\gamma_y)y_t - (1-\phi_\pi\beta)\pi_{H,t} \\ & + (1-(1-\beta)\gamma_d)d_{t-1} - \phi_\pi\omega\sigma_\omega x_t]. \qquad \text{(C110)} \end{aligned}$$

Substituting for $\mathbb{E}_t \pi_{H,t+1} = \frac{1}{\beta}\pi_{H,t} - \frac{1}{\beta}\kappa y_t$ into (C105) gives

$$[1+\kappa/(\beta\sigma_\omega)]\, y_t = \, -[\phi_\pi/\sigma_\omega - 1/(\beta\sigma_\omega)]\, \pi_{H,t} + \mathbb{E}_t y_{t+1}. \qquad \text{(C111)}$$

Rearrange the system of equations

$$\begin{aligned} \mathbb{E}_t \pi_{H,t+1} &= \frac{1}{\beta}\pi_{H,t} - \frac{\kappa}{\beta} y_t, \qquad \text{(C112)} \\ \mathbb{E}_t y_{t+1} &= [1+\kappa/(\beta\sigma_\omega)]\, y_t + [\phi_\pi/\sigma_\omega - 1/(\beta\sigma_\omega)]\, \pi_{H,t}, \qquad \text{(C113)} \\ z_{t+1} &= y_t, \qquad \text{(C114)} \\ x_{t+1} &= z_t, \qquad \text{(C115)} \\ d_t &= \frac{1}{\beta}[(1+\omega\sigma_\omega + \phi_\pi\kappa + \phi_\pi\omega\sigma_\omega)z_t - (1+\omega\sigma_\omega + (1-\beta)\gamma_y)y_t - (1-\phi_\pi\beta)\pi_{H,t} \\ & \quad + (1-(1-\beta)\gamma_d)d_{t-1} - \phi_\pi\omega\sigma_\omega x_t]. \qquad \text{(C116)} \end{aligned}$$

Express this system in vector form where $w_t \equiv [\pi_t \quad y_t \quad z_t \quad x_t \quad d_{t-1}]'$

$$\mathbb{E}_t w_{t+1} = M w_t, \qquad \text{(C117)}$$

where

$$M = \begin{pmatrix} 1/\beta & -\kappa/\beta & 0 & 0 & 0 \\ \phi_\pi/\sigma_\omega - 1/(\beta\sigma_\omega) & 1+\kappa/(\beta\sigma_\omega) & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ \zeta_1 & \zeta_2 & \zeta_3 & \zeta_4 & 1/\beta(1-(1-\beta)\gamma_d) \end{pmatrix},$$

with $\zeta_1 = -1/\beta(1 - \phi_\pi\beta)$, $\zeta_2 = -1/\beta(1 + \omega\sigma_\omega + (1 - \beta)\gamma_y)$, $\zeta_3 = 1/\beta(1 + \omega\sigma_\omega + \phi_\pi\kappa + \phi_\pi\omega\sigma_\omega)$, $\zeta_4 = -1/\beta\phi_\pi\omega\sigma_\omega$.

Note that M may be written in block form

$$M = \begin{pmatrix} A & 0 \\ C & D \end{pmatrix},$$

where

$$A = \begin{pmatrix} 1/\beta & -\kappa/\beta \\ \phi_\pi/\sigma_\omega - 1/(\beta\sigma_\omega) & 1 + \kappa/(\beta\sigma_\omega) \end{pmatrix},$$

and

$$D = \begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ \lambda_3 & \lambda_4 & 1/\beta(1 - (1 - \beta)\gamma_d) \end{pmatrix}.$$

Therefore, the eigenvalues of M are the two eigenvalues of A and the three eigenvalues of D. Since D is a triangular matrix, the three eigenvalues of D are $0, 0$, and $1/\beta(1 - (1 - \beta)\gamma_d)$. The last of these eigenvalues

$$1/\beta(1 - (1 - \beta)\gamma_d) > 1 \Leftrightarrow \gamma_d < 1, \tag{C118}$$

$$1/\beta(1 - (1 - \beta)\gamma_d) < 1 \Leftrightarrow \gamma_d > 1. \tag{C119}$$

The eigenvalues of A are given by the solution to

$$\left(\frac{1}{\beta} - \lambda\right)(\chi + 1 - \lambda) + \frac{\kappa}{\beta}\left(\frac{\phi_\pi}{\sigma_\omega} - \frac{1}{\beta\sigma_\omega}\right) = 0 \tag{C120}$$

$$\left(\frac{1}{\beta} - \lambda\right)(\chi + 1 - \lambda) + \chi\left(\phi_\pi - \frac{1}{\beta}\right) = 0, \tag{C121}$$

where $\chi = \frac{\kappa}{\beta\sigma_\omega} > 0$. Further manipulating this expression gives

$$\frac{1}{\beta}(1 - \lambda) - \lambda(\chi + 1 - \lambda) + \chi\phi_\pi = 0 \tag{C122}$$

$$\lambda^2 - \left(1 + \frac{1}{\beta} + \chi\right)\lambda + \frac{1}{\beta} + \chi\phi_\pi = 0. \tag{C123}$$

The eigenvalues of A then are

$$\lambda_1 = \frac{1+\frac{1}{\beta}+\chi+\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2-4\left(\frac{1}{\beta}+\chi\phi_\pi\right)}}{2} > 1, \tag{C124}$$

$$\lambda_2 = \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2-4\left(\frac{1}{\beta}+\chi\phi_\pi\right)}}{2}. \tag{C125}$$

Since $\lambda_1 > 1$ for all ϕ_π, A has at least one eigenvalue outside the unit circle.

For the system (C112)–(C116) there are two non-predetermined variables y_t and $\pi_{H,t}$, and three predetermined variables z_{t+1}, x_{t+1} and d_t. From Blanchard and Kahn (1980) the necessary and sufficient condition for an equilibrium with a unique and stable path around the zero-inflation steady state, in this case is that matrix M has three eigenvalues of absolute values smaller than 1, and two eigenvalues of absolute values larger than 1.

Part (i) of Proposition 1 with $\phi_\pi > 1$, $\gamma_d > 1$.

$$\lambda_2 = \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2-4\left(\frac{1}{\beta}+\chi\phi_\pi\right)}}{2} \tag{C126}$$

$$= \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2-4\left(\frac{1}{\beta}+\chi\right)-4\chi(\phi_\pi-1)}}{2} \tag{C127}$$

$$> \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2-4\left(\frac{1}{\beta}+\chi\right)}}{2} \tag{C128}$$

$$= \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(\frac{1}{\beta}-1+\chi\right)^2}}{2} = 1. \tag{C129}$$

Therefore, block matrix A has two eigenvalues that lie outside the unit circle. Given $\gamma_d > 1$, matrix M has two eigenvalues that lie outside the unit circle so there is a unique stationary equilibrium in this case.

Part (ii) of Proposition 1 with $\phi_\pi < 1$, $\gamma_d < 1$.

$$\lambda_2 = \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2-4\left(\frac{1}{\beta}+\chi\phi_\pi\right)}}{2} \tag{C130}$$

$$= \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2-4\left(\frac{1}{\beta}+\chi\right)-4\chi(\phi_\pi-1)}}{2} \tag{C131}$$

$$< \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2-4\left(\frac{1}{\beta}+\chi\right)}}{2} = 1, \tag{C132}$$

and

$$\lambda_2 = \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2-4\left(\frac{1}{\beta}+\chi\phi_\pi\right)}}{2} \tag{C133}$$

$$> \frac{1+\frac{1}{\beta}+\chi-\sqrt{\left(1+\frac{1}{\beta}+\chi\right)^2}}{2} = 0. \tag{C134}$$

Therefore, block matrix A has one eigenvalue λ_1 that lies outside the unit circle. Given $\gamma_d < 1$, matrix M has two eigenvalues that lie outside the unit circle so there is a unique stationary equilibrium in this case.

Part (iii) of Proposition 1 with $\phi_\pi > 1$, $\gamma_d < 1$.

In this case matrix M has three eigenvalues that lie outside the unit circle, greater than the two non-predetermined variables, so from Blanchard and Kahn (1980) there is no stationary equilibrium.

Part (iv) of Proposition 1 with $\phi_\pi < 1$, $\gamma_d > 1$.

In this case matrix M has one eigenvalue that lies outside the unit circle, less than the two non-predetermined variables, so from Blanchard and Kahn (1980) there are multiple equilibria (indeterminacy).

C4. Inflation response to monetary policy shock – Additional Detail

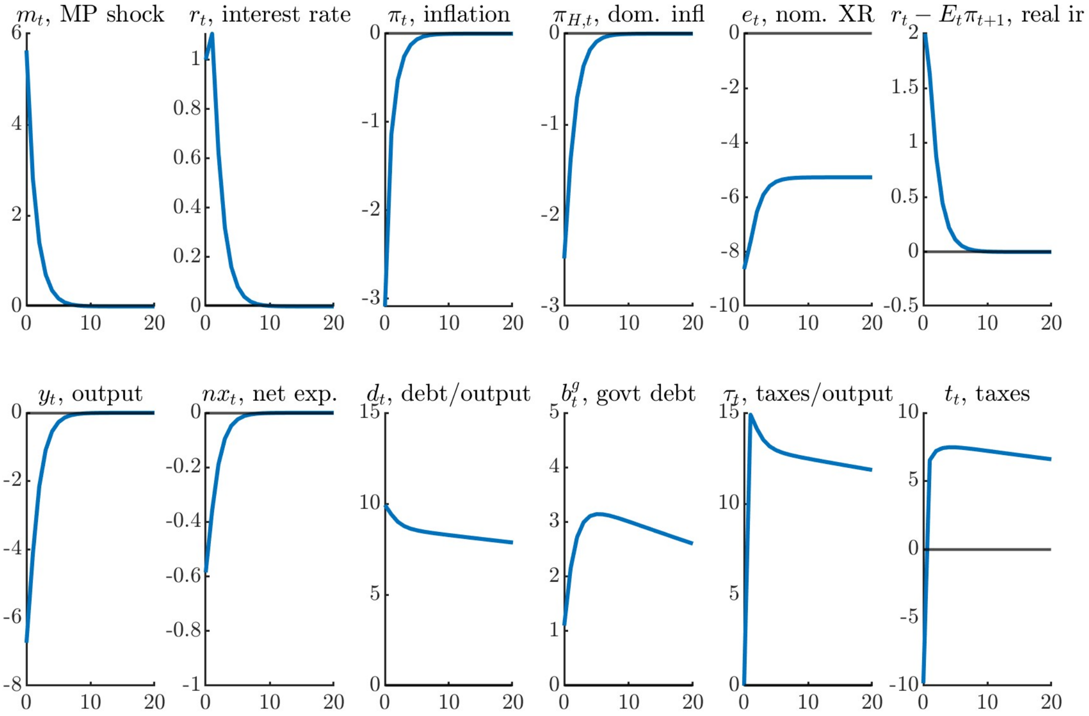
Table C1: Parameters – Model

Parameter		Value
Risk-aversion coefficient	σ	1
Discount factor	β	0.99
Frisch labor supply elasticity	$1/\nu$	1
Returns to scale	α	0.75
Openness	ω	0.3
Elasticity over imports	ϵ	1
Elasticity btwn varieties	η	1
Price Calvo prob fix.	θ	0.75
AR coeff mon. pol shock	ρ_ε	0.5
Slope NK Phillips curve	κ	0.23

Notes: This table shows the parameters for the baseline model results shown in Figures 5 and 6. See text for further detail.

Figure C1: Monetary led: Impulse Responses to Monetary Policy Shock

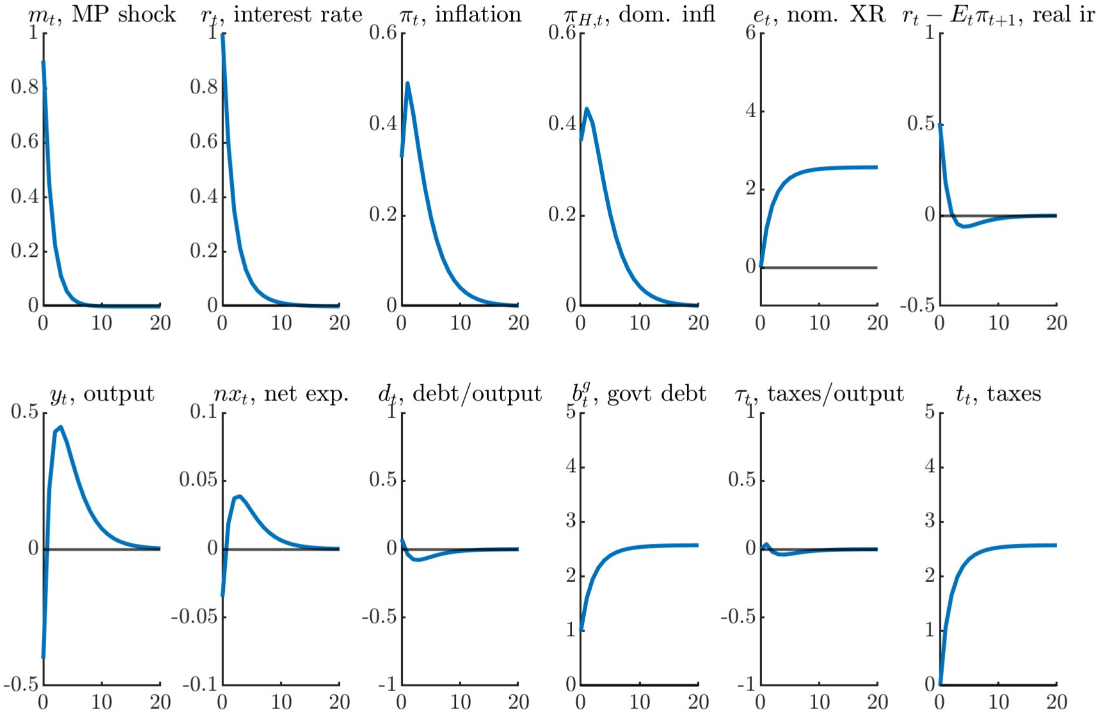
1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses to a monetary-policy shock that increases the interest rate by 1 percentage point on impact for the model in Section 3.1. $\phi_\pi = 1.5$, $\gamma_d = 1.5$, and the remaining parameters are given in Table C1.

Figure C2: Fiscal led: Impulse Responses to Monetary Policy Shock

1 percentage point interest rate shock, percent



Notes: This figure shows the impulse responses to a monetary-policy shock that increases the interest rate by 1 percentage point on impact for the model in Section 3.1. $\phi_\pi = 0.3$, $\gamma_d = 0.5$, and the remaining parameters are given in Table C1.

D. Quantitative Analysis

D1. Quantitative Model – Detail

Households The representative household has preferences given by

$$\sum_{t=0}^{\infty} \beta^t e^{z_t} \left[\frac{(C_t - hC_{t-1})^{1-\sigma}}{1-\sigma} - \phi \frac{L_t^{1+\nu}}{1+\nu} \right], \tag{D1}$$

where C_t is consumption and L_t is labor supply in period t. $\beta \in (0,1)$ is the discount factor and z_t is a preference shock which follows an AR(1) process $z_t = \rho_z z_{t-1} + \sigma_z \varepsilon_{z,t}$. Consumption C_t is a CES aggregate of home c_{Ht} and foreign c_{Ft} as in the baseline model (5). c_{Ht} is a CES aggregate of varieties $i \in [0,1]$ given by $c_{Ht} = \left(\int c_{Hit}^{\frac{\epsilon_t - 1}{\epsilon_t}} \, di \right)^{\frac{\epsilon_t}{\epsilon_t - 1}}$ with time-varying elasticity $\epsilon_t > 0$, which includes an exogenous markup shock component.

The household optimal labor supply and consumption-saving conditions give:

$$\frac{\phi L_t^{\nu}}{(C_t - hC_{t-1})^{-\sigma}} = \frac{W_t}{P_t} \tag{D2}$$

$$e^{z_t}(C_t - hC_{t-1})^{-\sigma} = \beta R_t \mathbb{E}_t \left[\frac{P_t}{P_{t+1}} e^{z_{t+1}} (C_{t+1} - hC_t)^{-\sigma} \right]. \tag{D3}$$

Firms. The firms technology is as in Section 3.1, but firm i faces a working-capital constraint (e.g., Christiano, Eichenbaum and Evans (2005), and Neumeyer and Perri (2005) for emerging markets). The firm problem is

$$\max_{n_{it}} \pi_{it} = P_{Hit} n_{it}^{1-\alpha} - W_t n_{it} - (R_t - 1)\Upsilon W_t n_{it}, \tag{D4}$$

where $\Upsilon \in [0,1]$ is the fraction of the total wage bill $W_t n_{it}$ that firms have to borrow from households in advance of production in period t at nominal interest rate R_t. $\Upsilon = 0$ is the standard model without the working-capital constraint.

The FOC for labor demand for the firm i gives

$$P_{Hit}(1-\alpha)n_{it}^{-\alpha} = W_t(1+(R_t-1)\Upsilon) \tag{D5}$$

$$\frac{(1-\alpha)n_{it}^{-\alpha}}{(1+(R_t-1)\Upsilon)} = \frac{W_t}{P_{Hit}}. \tag{D6}$$

Nominal rigidities. When setting prices, firms face frictions à la Calvo, i.e. at time t a firm i can optimally reset its price with probability θ. Otherwise it adjusts the price with partial indexation to the previous period domestic price inflation rate, according to the rule $P_{Hit} = \Pi_{H,t-1}^{\chi_p}\Pi_H^{1-\chi_p}P_{Hit-1}$, where $\chi_p \in [0,1]$ is the price-indexation parameter, $\Pi_{H,t-1} = \frac{P_{Ht-1}}{P_{Ht-2}}$, and Π_H denotes the aggregate rate of domestic price inflation at steady state.

Firms that are allowed to reset their price maximize the expected discounted stream of nominal profits. The problem for a firm f is

$$\max_{\{P_{Ht}^o(f)\}} \quad \mathbb{E}_t\left[\sum_{i=0}^{\infty}\theta^i\Lambda_{t,i}\left(\left[\prod_{k=1}^{s}\Pi_{H,t+k-1}^{\chi_p}\Pi_H^{1-\chi_p}\right]\frac{P_{Ht}^o(f)}{P_{Ht+i}} - MC_{t+i}^n\right)y_{Ht+i}(f)\right], \tag{D7}$$

where $\Lambda_{t,i}$ is the household stochastic discount factor.

Incomplete pass-through. Under incomplete exchange rate pass-through in import prices the law of one price does not hold. Following Monacelli (2005), define the deviation of the world price from the domestic currency price of imports $\Psi_t \equiv \frac{\mathcal{E}_t P_t^*}{P_{Ft}}$, where $\Psi_t = 1$ under complete pass-through. The real exchange rate is

$$\mathcal{Q}_t = \frac{\mathcal{E}_t P_t^*}{P_t} = \frac{\Psi_t P_{Ft}}{P_t}, \tag{D8}$$

which loglinearizing gives

$$q_t = \psi_t + (1-\omega)s_t, \tag{D9}$$

where $\psi_t \equiv \log\Psi_t$ and the terms of trade $s_t = p_{F,t} - p_{H,t}$.

Retailers import differentiated varieties of the foreign good and set the domestic currency price of these goods. The law of one price holds "at the dock" so the cost of good j to the retailer is $\mathcal{E}_t P_{Ftj}^*$. Retailers set an optimal markup on imports facing the downward sloping demand from the households using Calvo price setting similar to domestic producers, with a different reset probability θ_F. This leads to a similar Phillips for price inflation for the foreign good given below, where I allow for a import price (cost-push) shock x_t.

D2. Linearized model

Loglinearizing the household Euler equation for domestic currency bonds (D3)

$$\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1} = \mathbb{E}_t\left[\frac{1}{1-h}c_{t+1} - \frac{h}{1-h}c_t\right] - \frac{1}{\sigma}(r_t - \mathbb{E}_t\pi_{t+1}) + \frac{1}{\sigma}(1-\rho_z)z_t \tag{D10}$$

Given a complete set of state-contingent securities are traded internationally, the world analogue of the household Euler equation for the continuum of symmetric small open economies gives

$$C_t - hC_{t-1} = (C_t^* - hC_{t-1}^*)(Q_t)^{\frac{1}{\sigma}}, \tag{D11}$$

which loglinearizing and using world market clearing and the real exchange rate gives

$$\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1} = \frac{1}{1-h}y_t^* - \frac{h}{1-h}y_{t-1}^* + \frac{1}{\sigma}\psi_t + \left(\frac{1-\omega}{\sigma}\right)s_t. \tag{D12}$$

Substitute the definition of the terms of trade $s_t = p_{Ft} - p_{Ht}$ gives

$$\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1} = \frac{1}{1-h}y_t^* - \frac{h}{1-h}y_{t-1}^* + \frac{1}{\sigma}\psi_t + \left(\frac{1-\omega}{\sigma}\right)(p_{Ft} - p_{Ht}) \tag{D13}$$

$$\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1} = \frac{1}{\sigma}\psi_t + \left(\frac{1-\omega}{\sigma}\right)(p_{Ft} - p_{Ht}), \tag{D14}$$

assuming world output is equal to the steady state level.

Following Monacelli (2005), the goods market clearing condition gives

$$y_t = (1-\omega)c_t + \omega(2-\omega)\eta s_t + \omega\eta\psi_t + \omega y_t^* \tag{D15}$$

$$y_t = (1-\omega)c_t + \omega(2-\omega)\eta(p_{Ft} - p_{Ht}) + \omega\eta\psi_t. \tag{D16}$$

Similar to Appendix C, the solution to the firms' price-setting problem (D7) gives rise to the

Phillips curve

$$\pi_{H,t} = \kappa_{mc} mc_t + \frac{\beta}{1+\chi_p\beta}\mathbb{E}_t\pi_{H,t+1} + \frac{\chi_p}{1+\chi_p\beta}\pi_{H,t-1} + u_t, \tag{D17}$$

where $\kappa_{mc} = \frac{(1-\beta\theta)(1-\theta)}{\theta(1+\chi_p\beta)}\left(\frac{1-\alpha}{1-\alpha-\alpha\epsilon}\right)$ and u_t is a markup (cost-push) shock which follows an AR(1) process $u_t = \rho_u u_{t-1} + \sigma_u \varepsilon_{u,t}$.

Loglinearizing the household labor supply condition (D2) around the steady state

$$w_t - p_t = \sigma\left[\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1}\right] + \nu l_t \tag{D18}$$

Nominal marginal cost from the firm is

$$MC^n_{i,t} = P_{Hit}(1-\alpha) = W_t n^{\alpha}_{it}(1+(R_t-1)\Upsilon). \tag{D19}$$

Loglinearizing and solving for mc_t, similar to Appendix C, gives

$$\begin{aligned}
mc_t &\equiv mc^n_t - p_{Ht} + \mu && \text{(D20)}\\
&= w_t - p_t + p_t - p_{Ht} + \alpha n_t + r_t && \text{(D21)}\\
&= \sigma\left[\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1}\right] + \nu n_t + p_t - p_{Ht} + \alpha n_t + r_t && \text{(D22)}\\
&= \sigma\left[\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1}\right] + \left(\frac{\nu+\alpha}{1-\alpha}\right) y_t + \omega s_t + r_t && \text{(D23)}\\
&= \frac{\sigma}{1-\omega}\left[\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1}\right] + \left(\frac{\nu+\alpha}{1-\alpha}\right) y_t + r_t && \text{(D24)}
\end{aligned}$$

From the definition of the consumer price index

$$p_t = (1-\omega)p_{Ht} + \omega p_{Ft}, \tag{D25}$$

$$\pi_t = (1-\omega)\pi_{H,t} + \omega\pi_{F,t}. \tag{D26}$$

From D9 with the world price level at steady state

$$e_t = \psi_t + p_{Ft} \tag{D27}$$

$$\Delta e_t = \psi_t - \psi_{t-1} + \pi_{F,t}. \tag{D28}$$

The linearized equilibrium system for the quantitative model in Section 4.1 is

$$\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1} = \mathbb{E}_t\left[\frac{1}{1-h}c_{t+1} - \frac{h}{1-h}c_t\right] - \frac{1}{\sigma}(r_t - \mathbb{E}_t\pi_{t+1}) + \frac{1}{\sigma}(1-\rho_z)z_t, \tag{D29}$$

$$\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1} = \frac{1}{\sigma}\psi_t + \left(\frac{1-\omega}{\sigma}\right)(p_{Ft} - p_{Ht}), \tag{D30}$$

$$y_t = (1-\omega)c_t + \omega(2-\omega)\eta(p_{F,t} - p_{H,t}) + \omega\eta\psi_t, \tag{D31}$$

$$\pi_{Ht} = \kappa_{mc}mc_t + \frac{\beta}{1+\chi_p\beta}\mathbb{E}_t\pi_{Ht+1} + \frac{\chi_p}{1+\chi_p\beta}\pi_{Ht-1} + u_t, \tag{D32}$$

$$mc_t = \frac{\sigma}{1-\omega}\left[\frac{1}{1-h}c_t - \frac{h}{1-h}c_{t-1}\right] + \left(\frac{\nu+\alpha}{1-\alpha}\right)y_t + r_t, \tag{D33}$$

$$\pi_{Ft} = \kappa_F\psi_t + \frac{\beta}{1+\chi_p\beta}\mathbb{E}_t\pi_{Ft+1} + \frac{\chi_p}{1+\chi_p\beta}\pi_{Ft-1} + x_t, \tag{D34}$$

$$\Delta e_t = \psi_t - \psi_{t-1} + \pi_{F,t}, \tag{D35}$$

$$\pi_t = (1-\omega)\pi_{H,t} + \omega\pi_{F,t}, \tag{D36}$$

$$r_t = \rho_r r_{t-1} + (1-\rho_r)[\phi_\pi\pi_t + \phi_y y_t] + m_t, \tag{D37}$$

$$\tau_t = \rho_t\tau_{t-1} + (1-\rho_t)[\gamma_d d_{t-1} + \gamma_y y_t] + g_t, \tag{D38}$$

$$d_t = \frac{1}{\beta}[y_{t-1} - y_t + d_{t-1} + r_{t-1} - \pi_t - (1-\beta)\tau_t], \tag{D39}$$

$$p_{Ht} = \pi_{H,t} + p_{Ht-1}, \tag{D40}$$

$$p_{Ft} = \pi_{F,t} + p_{Ft-1}, \tag{D41}$$

which gives 13 equations for the 13 variables $\{c_t, y_t, r_t, \pi_t, \pi_{H,t}, \pi_{F,t}, mc_t, \psi_t, \Delta e_t, \tau_t, d_t, p_{Ht}, p_{Ft}\}$, and $\kappa_F = \frac{(1-\beta\theta_F)(1-\theta_F)}{\theta_F(1+\chi_p\beta)}$.

The exogenous processes are z_t is a demand shock, u_t is a markup shock, m_t is a monetary-policy shock, g_t is a government spending shock, and x_t is an import price shock which all follow

AR(1) processes

$$z_t = \rho_z z_{t-1} + \sigma_z \varepsilon_{z,t}, \tag{D42}$$

$$u_t = \rho_u u_{t-1} + \sigma_u \varepsilon_{u,t}, \tag{D43}$$

$$m_t = \rho_m m_{t-1} + \sigma_m \varepsilon_{m,t}, \tag{D44}$$

$$\varepsilon_{m,t}^{obs} = \sigma_m \varepsilon_{m,t} - \sigma_{m,u} \varepsilon_{m,t}^{u}, \tag{D45}$$

$$g_t = \rho_g g_{t-1} + \sigma_g \varepsilon_{g,t}, \tag{D46}$$

$$x_t = \rho_x x_{t-1} + \sigma_x \varepsilon_{x,t}, \tag{D47}$$

where $\varepsilon_{z,t}$, $\varepsilon_{u,t}$, $\varepsilon_{m,t}$, $\varepsilon_{m,t}^{u}$, $\varepsilon_{g,t}$, $\varepsilon_{x,t}$ each follow a standard normal and are distributed independently. I assume the monetary policy shock includes an observed component ε_{mt}^{obs}, for which I will use the estimated monetary policy shocks, and an unobserved component $\varepsilon_{m,t}^{u}$.

The seven observable variables in the estimation are $\{y_t, r_t, d_t, \Delta e_t, \pi_t, \tau_t, \varepsilon_{m,t}^{obs}\}$, and I assume output y_t, debt d_t, inflation π_t, and taxes τ_t are potentially measured with error.

For the estimation I assume the parameters $\theta = \theta_F$, $\sigma_m = \sigma_{m,u}$.

D3. Data

The data are quarterly and all series are demeaned by the sample average by country and are from the IMF International Financial Statistics unless otherwise noted. The variables are given by:

y_t is the year-on-year change in log real GDP.

π_t is the year-on-year change in log consumer price index.

r_t is the main monetary policy rate from the BIS.

$\varepsilon_{m,t}^{obs}$ is the observed component of the monetary policy shock, calculated as the quarterly aggregate (sum) of the high-frequency monetary policy shocks measured using the change in the forward premium.

Given data on gross central government debt B_t^G from the IMF IFS, national Treasuries and central banks and FRED, and the government bond rate $R_{n,t}^B$ (or money market rate where unavailable) and nominal GDP P_tY_t, the share of government debt to output is given by

$$d_t \equiv \frac{B_t^G / R_{n,t}^B}{P_t Y_t}. \tag{D48}$$

Δe_t is the change in the log nominal exchange rate against the U.S. dollar.

τ_t is government net taxes to output, calculated as the central government net operating balance (revenue less expenditure) from the IMF IFS, national Treasuries and FRED, relative to nominal GDP

$$\tau_t \equiv \frac{T_t}{P_t Y_t}. \tag{D49}$$

D4. Estimation – Detail

I find the posterior mode by using a minimization algorithm on the negative of the posterior. Given that I have flat priors, the point estimates coincide with the maximum likelihood estimates.

To determine the posterior distribution I use a MCMC algorithm.

Draws from the posterior are obtained using a standard Metropolis-Hastings algorithm initialized at the posterior mode, which follows the following steps:

- Step 1: Draw a new set of parameters θ_n from the proposal distribution: $\theta^* \sim N(\theta_{n-1}, c\overline{\Sigma})$.
- Step 2: Compute $\alpha_n = \min\{p(\widetilde{\theta^*})/p(\theta_{n-1}), 1\}$, where $p(\theta)$ which is the posterior evaluated at θ.
- Step 3: Accept the new parameter and set $\theta_n = \widetilde{\theta^*}$ if $u < \alpha_n$ where $u \sim U[0,1]$. Otherwise set $\theta_n = \theta_{n-1}$.
- Step 4: Stop if $m = n_{sim}$. Otherwise, go back to Step 1.

The matrix $\overline{\Sigma}$ corresponds to the inverse of the Hessian computed at the posterior mode. The parameter c is set to obtain an acceptance rate α of between $20-50$ percent. Tables D1 and D2 reports results based on the Brooks-Gelman-Rubin Potential Scale Reduction Factor using within and between variances based on the 2 chains used. I take 200,000 draws from using the Metropolis-Hastings algorithm using 2 parallel chains. I discard the first 10,000 draws and keep one out of 5 draws to remove correlation among draws to obtain a sample from the posterior of 36,000 observations. The numbers are well below the 1.2 benchmark value used as an upper bound for convergence.

For the emerging markets the acceptance rate by chain is $\widehat{\alpha}_1 = 0.27$ and $\widehat{\alpha}_1 = 0.28$. For the U.S. the acceptance rate by chain is $\widehat{\alpha}_1 = 0.26$ and $\widehat{\alpha}_1 = 0.37$.

Table D1: Convergence – Emerging Markets

Param	PSRF	Param	PSRF	Param	PSRF
ϕ_π	1.00	ω	1.02	σ_z	1.00
ϕ_y	1.01	ρ_z	1.00	σ_u	1.01
γ	1.00	ρ_u	1.03	σ_m	1.03
γ_y	1.02	ρ_m	1.00	σ_g	1.00
ρ_r	1.01	ρ_g	1.01	σ_x	1.01
ρ_t	1.00	ρ_x	1.02	σ_{me}	1.01
θ	1.00				

Notes: This table shows the Brooks-Gelman-Rubin Potential Scale Reduction Factor (PSRF) for the parameters for the emerging markets. Values below 1.2 are regarded as indicative of convergence.

Table D2: Convergence – U.S.

Param	PSRF	Param	PSRF	Param	PSRF
ϕ_π	1.00	ω	1.01	σ_z	1.00
ϕ_y	1.01	ρ_z	1.01	σ_u	1.01
γ	1.01	ρ_u	1.00	σ_m	1.01
γ_y	1.00	ρ_m	1.00	σ_g	1.00
ρ_r	1.00	ρ_g	1.00	σ_x	1.00
ρ_t	1.00	ρ_x	1.01	σ_{me}	1.00
θ	1.00				

Notes: This table shows the Brooks-Gelman-Rubin Potential Scale Reduction Factor (PSRF) for the parameters for the emerging markets. Values below 1.2 are regarded as indicative of convergence.

D5. Quantitative Results – Detail

Table D3: Priors and Posteriors for the Parameters – Emerging Markets

		Posterior Distribution			Prior Distribution		
		Mode	5%	95%	Type	Mean	Std
Structural Parameters							
Price Calvo prob fix.	θ	0.80	0.77	0.85	B	0.75	0.05
Openness	ω	0.10	0.06	0.16	B	0.20	0.05
Mon. pol resp. to inflation	ϕ_π	0.01	0.00	0.02	N	0.50	0.25
Mon. pol resp. to output	ϕ_y	0.92	0.51	1.17	N	0.25	0.10
Fiscal resp. to govt debt	γ_d	-0.01	-0.12	0.11	N	0.50	0.25
Fiscal resp. to output	γ_y	0.43	0.27	0.65	N	-0.10	0.2
AR coeff. monetary rule	ρ_t	0.91	0.89	0.94	B	0.50	0.10
AR coeff. fiscal rule	ρ_r	0.01	0.00	0.02	B	0.50	0.10
Exogenous Processes							
AR coeff. demand	ρ_z	0.986	0.980	0.990	B	0.50	0.10
AR coeff. markup	ρ_u	0.837	0.741	0.839	B	0.99	0.001
AR coeff. mon. policy	ρ_m	0.794	0.697	0.849	B	0.50	0.10
AR coeff. gov. spend	ρ_g	0.228	0.197	0.282	B	0.50	0.10
AR coeff. ex. rate	ρ_x	0.348	0.292	0.425	B	0.50	0.10
St. dev. demand	σ_z	0.040	0.036	0.049	IG	0.50	0.20
St. dev. markup	σ_u	0.250	0.202	0.399	IG	0.50	0.20
St. dev. mon. policy	σ_m	0.323	0.291	0.358	IG	0.50	0.20
St. dev. gov. spend	σ_g	1.625	1.339	1.901	IG	0.50	0.20
St. dev. ex. rate	σ_x	5.263	4.788	5.838	IG	0.50	0.20
Measurement error	σ_{me}	1.575	1.493	1.687	IG	0.50	0.20

Notes: This table shows the posterior modes, medians, and 90% posterior credible sets, and prior moments for the parameters for the emerging markets. The Prior Distribution "Type" indicates the prior density function: N for Normal, B for Beta, IG for Inverse Gamma.

Table D4: Priors and Posteriors for the Parameters – U.S.

		Posterior Distribution			Prior Distribution		
		Mode	5%	95%	Type	Mean	Std
Structural Parameters							
Price Calvo prob fix.	θ	0.87	0.52	0.94	B	0.75	0.05
Openness	ω	0.16	0.07	0.33	B	0.20	0.05
Mon. pol resp. to inflation	ϕ_π	1.57	1.22	3.15	N	0.50	0.25
Mon. pol resp. to output	ϕ_y	0.46	0.24	0.86	N	0.25	0.10
Fiscal resp. to govt debt	γ_d	1.51	0.37	3.01	N	0.50	0.25
Fiscal resp. to output	γ_y	0.47	0.14	1.83	N	-0.10	0.2
AR coeff. monetary rule	ρ_t	0.50	0.20	0.56	B	0.50	0.10
AR coeff. fiscal rule	ρ_r	0.952	0.949	0.99	B	0.50	0.10
Exogenous Processes							
AR coeff. demand	ρ_z	0.953	0.878	0.989	B	0.50	0.10
AR coeff. markup	ρ_u	0.877	0.807	0.960	B	0.99	0.001
AR coeff. mon. policy	ρ_m	0.675	0.383	0.548	B	0.50	0.10
AR coeff. gov. spend	ρ_g	0.538	0.376	0.980	B	0.50	0.10
AR coeff. ex. rate	ρ_x	0.911	0.690	0.981	B	0.50	0.10
St. dev. demand	σ_z	0.377	0.199	0.969	IG	0.50	0.20
St. dev. markup	σ_u	0.492	0.183	1.172	IG	0.50	0.20
St. dev. mon. policy	σ_m	3.701	2.400	8.858	IG	0.50	0.20
St. dev. gov. spend	σ_g	0.536	0.423	0.652	IG	0.50	0.20
St. dev. ex. rate	σ_x	5.285	3.519	10.163	IG	0.50	0.20
Measurement error	σ_{me}	13.053	9.956	11.480	IG	0.50	0.20

Notes: This table shows the posterior modes, medians, and 90% posterior credible sets, and prior moments for the parameters for the U.S. The Prior Distribution “Type” indicates the prior density function: N for Normal, B for Beta, IG for Inverse Gamma.

E. U.S. monetary policy on emerging markets – Detail

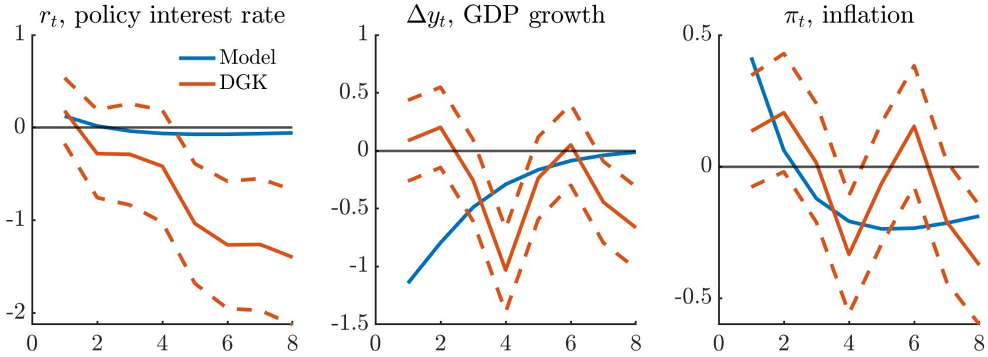
Table E1: Parameters – U.S. Monetary Policy Shock

Parameter		Value
Risk-aversion coefficient	σ	1
Discount factor	β	0.99
Frisch labor supply elasticity	$1/\nu$	1
Returns to scale	α	0.75
Openness	ω	0.1
Elasticity home-foreign	η	1.5
Elasticity btwn varieties	ϵ	6
Price Calvo prob fix.	θ	0.75
AR coeff r_t^* shock	ρ_{r^*}	0.75
Slope NK Phillips curve	κ	0.23

Notes: This table shows the parameters for the U.S. monetary policy shock on emerging markets results shown in Table 3 and Figure E1.

Figure E1: Fiscal led: Impulse Responses to U.S. Monetary Policy Shock

1 percentage point U.S. interest rate shock, percent



Notes: This figure shows in red the estimated quarterly impulse responses to a 1 percentage point U.S. monetary policy shock from De Leo *et al.* (2023) Figure 3. In blue are the model estimates for a 1 percentage point shock to the world interest rate r_t^* in the *fiscal led* policy regime with $\phi_\pi = 0.3$, $\gamma_d = 0.5$, and the remaining parameters given in Table E1. See Table 3 and text for further details.

F. Welfare and optimal monetary policy in fiscal-led regime – Detail

Productivity shocks. In this case a firm produces with the technology

$$y_{Hit} = A_t n_{it}^{1-\alpha}, \tag{F1}$$

where $a_t \equiv \log A_t$ is aggregate productivity common to all domestic firms which follows an AR(1) process: $a_t = \rho_a a_{t-1} + \sigma_a \varepsilon_{a,t}$, $\varepsilon_{a,t} \sim N(0,1)$.

As shown in Appendix C, firms optimal pricing gives

$$\pi_{H,t} = -\frac{(1-\theta)(1-\beta\theta)}{\theta}\left(\frac{1-\alpha}{1-\alpha+\alpha\epsilon}\right)\widehat{mc}_t + \beta\mathbb{E}_t\pi_{H,t+1} \tag{F2}$$

Labor market equilibrium requires

$$L_t = \int n_{it}di = \left(\frac{Y_t}{A_t}\right)^{\frac{1}{1-\alpha}}\int\left(\frac{P_{Hit}}{P_{Ht}}\right)^{-\frac{\epsilon}{1-\alpha}}di. \tag{F3}$$

As in Appendix C, variations in $\log\int\left(\frac{P_{Hit}}{P_{Ht}}\right)^{-\frac{\epsilon}{1-\alpha}}di$ are of second order, so

$$y_t = a_t + (1-\alpha)n_t, \tag{F4}$$

and

$$\widehat{mc}_t = -\left(\sigma_\omega + \frac{\nu+\alpha}{1-\alpha}\right)\widetilde{y}_t, \tag{F5}$$

where $\widetilde{y}_t \equiv y_t - y_t^n$. Therefore

$$\pi_{H,t} = \kappa\widetilde{y}_t + \beta\mathbb{E}_t\pi_{H,t+1}. \tag{F6}$$

Following Galí (2015), the natural level of output is

$$y_t^n = \frac{1+\nu}{\sigma_\omega(1-\alpha)+\nu+\alpha} a_t. \tag{F7}$$

As shown in Appendix C, the IS curve is

$$y_t = \mathbb{E}_t y_{t+1} - 1/\sigma_\omega(r_t - \mathbb{E}_t \pi_{H,t+1}). \tag{F8}$$

Substituting from (F7) gives

$$y_t - y_t^n = \mathbb{E}_t y_{t+1} - \mathbb{E}_t y_{t+1}^n - 1/\sigma_\omega(r_t - \mathbb{E}_t \pi_{H,t+1}) - \frac{1+\nu}{\sigma_\omega(1-\alpha)+\nu+\alpha}(a_t - \mathbb{E}_t a_{t+1}) \tag{F9}$$

$$\widetilde{y}_t = \mathbb{E}_t \widetilde{y}_{t+1} - 1/\sigma_\omega(r_t - \mathbb{E}_t \pi_{H,t+1}) - \frac{1+\nu}{\sigma_\omega(1-\alpha)+\nu+\alpha}(1-\rho_a) a_t \tag{F10}$$

$$= \mathbb{E}_t \widetilde{y}_{t+1} - 1/\sigma_\omega\left(r_t - \mathbb{E}_t \pi_{H,t+1} - \psi_a a_t\right), \tag{F11}$$

where $\psi_a \equiv -\sigma_\omega \left(\frac{1+\nu}{\sigma_\omega(1-\alpha)+\nu+\alpha}\right)(1-\rho_a)$.

The law of motion for government debt in terms of the output gap is

$$d_t = \frac{1}{\beta}\left[d_{t-1} - \pi_t + y_{t-1} - y_t + r_{t-1} - (1-\beta)\tau_t\right] \tag{F12}$$

$$= \frac{1}{\beta}\left[d_{t-1} - \pi_t + y_{t-1} - y_{t-1}^n - (y_t - y_t^n) + r_{t-1} - (1-\beta)\tau_t - \left(\frac{1+\nu}{\sigma_\omega(1-\alpha)+\nu+\alpha}\right)(a_t - a_{t-1})\right] \tag{F13}$$

$$= \frac{1}{\beta}\left[d_{t-1} - \pi_t + \widetilde{y}_{t-1} - \widetilde{y}_t + r_{t-1} - (1-\beta)\tau_t - \left(\frac{1+\nu}{\sigma_\omega(1-\alpha)+\nu+\alpha}\right)(a_t - a_{t-1})\right]. \tag{F14}$$

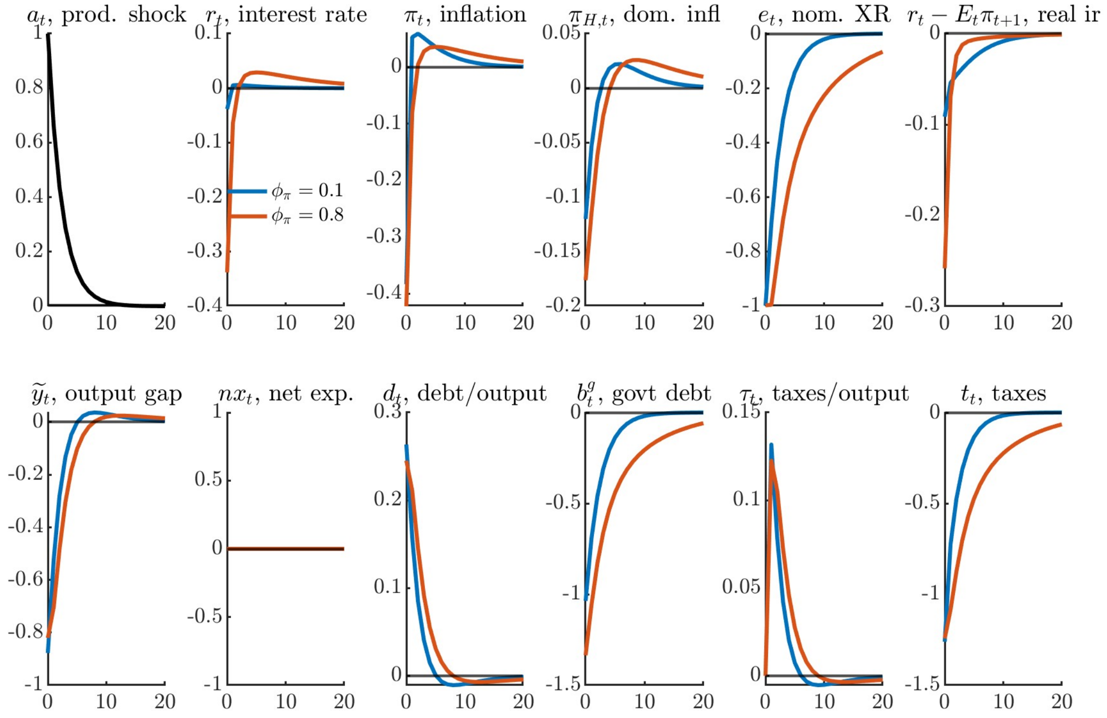
Table F1: Parameters – Welfare

Parameter		Value
Risk-aversion coefficient	σ	1
Discount factor	β	0.99
Frisch labor supply elasticity	$1/\nu$	1
Returns to scale	α	0.25
Openness	ω	0.3
Elasticity home-foreign	η	1
Elasticity btwn varieties	ϵ	6
Price Calvo prob fix.	θ	0.75
AR coeff prod. shock	ρ_a	0.66
AR coeff markup shock	ρ_u	0.66
Slope NK Phillips curve	κ	0.08
Weight on output gap	υ	0.01

Notes: This table shows the parameters for the welfare analysis results shown in Figures 9 and F1-F4. See text for further detail.

Figure F1: Fiscal led: Impulse Responses to Productivity Shock

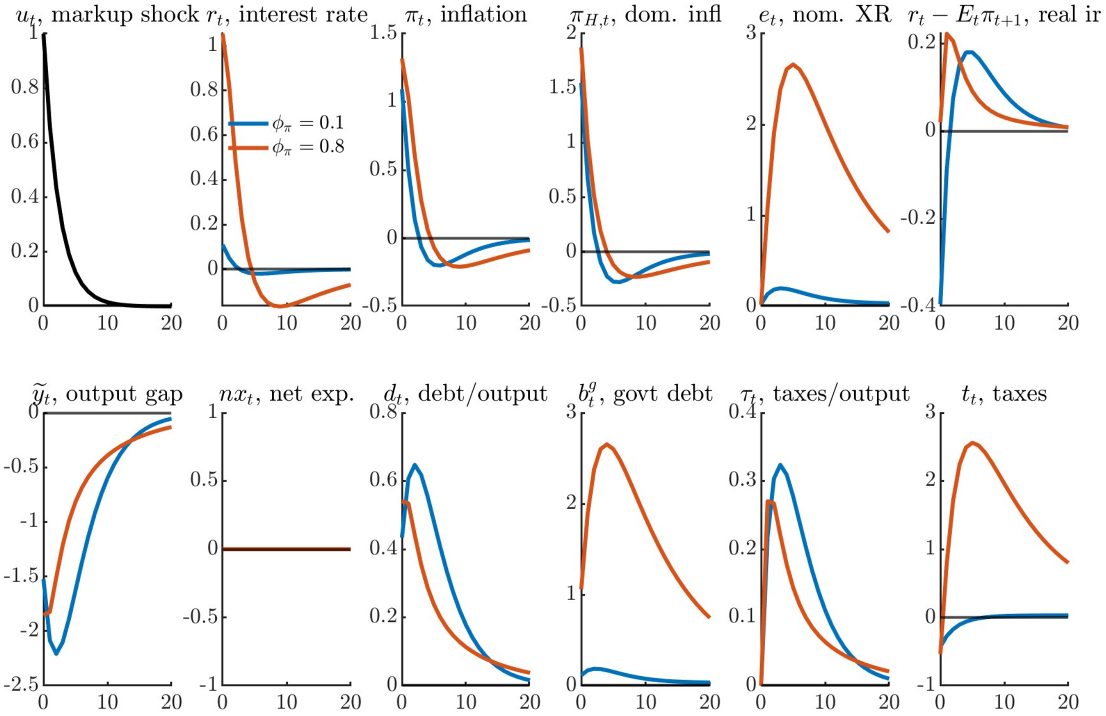
1 percent productivity shock, percent



Notes: This figure shows the impulse responses to a 1 percent productivity shock for the model in Section 6 with $\gamma_d = 0.5$ when varying $\phi_\pi < 1$, and the remaining parameters given in Table F1.

Figure F2: Fiscal led: Impulse Responses to Markup Shock

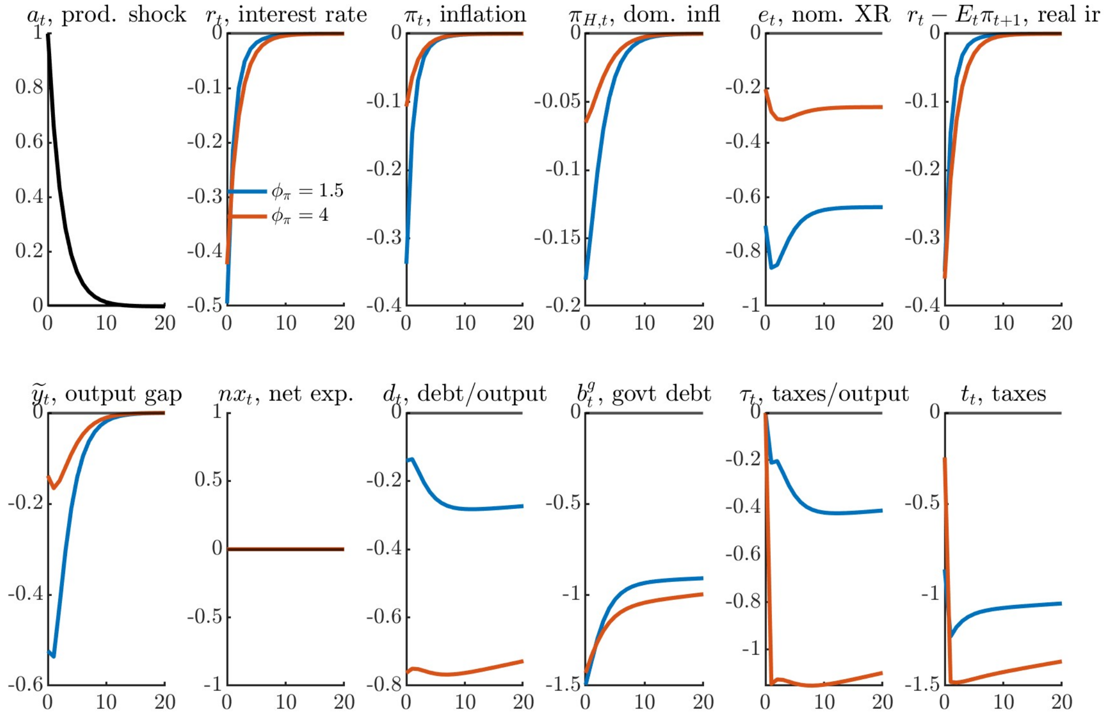
1 percentage point markup shock, percent



Notes: This figure shows the impulse responses to a 1 percent markup shock for the model in Section 6 with $\gamma_d = 0.5$ when varying $\phi_\pi < 1$, and the remaining parameters given in Table F1.

Figure F3: Monetary led: Impulse Responses to Productivity Shock

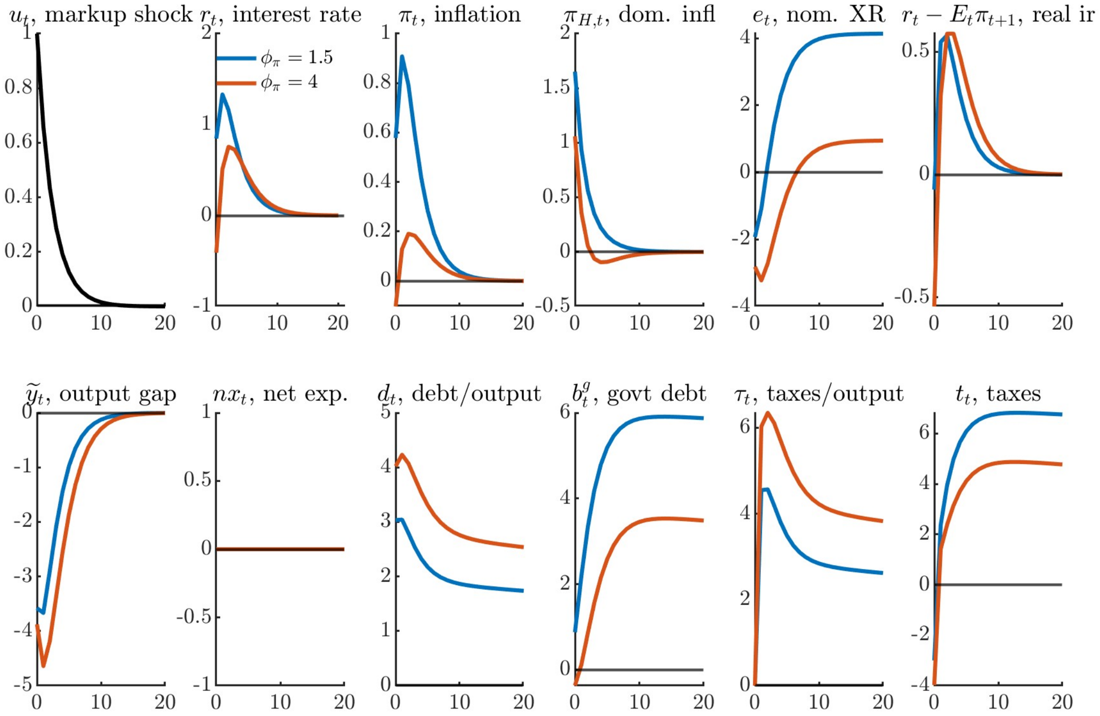
1 percentage point productivity shock, percent



Notes: This figure shows the impulse responses to a 1 percent productivity shock for the model in Section 6 with $\gamma_d = 1.5$ when varying $\phi_\pi > 1$, and the remaining parameters given in Table F1.

Figure F4: Monetary led: Impulse Responses to Markup Shock

1 percentage point markup shock, percent



Notes: This figure shows the impulse responses to a 1 percent markup shock for the model in Section 6 with $\gamma_d = 1.5$ when varying $\phi_\pi > 1$, and the remaining parameters given in Table F1.