



UNIVERSITY
OF WARSAW



FACULTY OF
ECONOMIC SCIENCES

WORKING PAPERS

No. 1/2024 (437)

DOES IT MATTER IF THE FED GOES CONVENTIONAL OR UNCONVENTIONAL?

MARCIN KOLASA
GRZEGORZ WESOŁOWSKI

WARSAW 2024



Does it matter if the Fed goes conventional or unconventional?

Marcin Kolasa¹, Grzegorz Wesolowski²

¹ SGH Warsaw School of Economics and International Monetary Fund

² University of Warsaw, Faculty of Economic Sciences

Corresponding authors: marcin.kolasa@sgh.waw.pl, g.wesolowski@uw.edu.pl

Abstract: We investigate the domestic and international consequences of three types of Fed monetary policy instruments: conventional interest rate (IR), forward guidance (FG) and large scale asset purchases (LSAP). We document empirically that they can be seen as close substitutes when used to meet macroeconomic stabilization objectives in the US, but have markedly different spillovers to other countries. This is because each of the three monetary policy instruments transmits differently to asset prices and exchange rates of small open economies. The LSAP by the Fed lowers the term premia both in the US and in other countries, and results in bigger exchange rate adjustments compared to conventional policy. Importantly for international spillovers, LSAP is typically associated with a more accommodative reaction of other countries' monetary authorities, especially in emerging market economies. We demonstrate how these findings can be rationalized within a stylized dynamic theoretical framework featuring a simple form of international bond market segmentation.

Keywords: monetary policy, forward guidance, quantitative easing, international spillovers

JEL codes: E44, E52, F41

Acknowledgments: This paper benefited from discussions with J.M. Figueres, R. Reis, H. Rey and F. Smets. The authors also acknowledge useful comments from the participants to the CEF annual meeting in Nice and ICEA conferences in Siena and Warsaw. The project was financed by the Polish National Science Center research grant No. 2021/43/B/HS4/00355. The views expressed herein are those of the authors and not those of the institutions they are affiliated with.

Working Papers contain preliminary research results. Please consider this when citing the paper. Please contact the authors to give comments or to obtain revised version. Any mistakes and the views expressed herein are solely those of the authors

1 Introduction

Over the recent decades, and mainly in response to challenges brought by the Global Financial Crisis (GFC) and the Covid-19 pandemic, the US monetary policy conduct has been substantially transformed. As the Fed could no longer rely solely on adjusting the current policy rates due to their becoming constrained by the effective lower bound, two new types of tools have gained traction, possibly entering the policy toolbox for longer. One of them was the forward guidance (FG), which was already used during the dot-com recession, but has become increasingly popular since the GFC. The other one was large-scale asset purchases (LSAP) by the Fed, often referred to as quantitative easing (QE). It is widely believed that these two relatively new policies helped avoid deeper recessions and deflation during the turbulent first two decades of the current century (see, e.g., Bernanke, 2020).

As a matter of fact, there are many reasons to believe that FG and LSAP can be close substitutes to short-term interest rate-based (IR) conventional monetary policy, at least if the central bank objective is defined as to stabilize macroeconomic activity and inflation. On theoretical grounds, the very forward-looking nature of the New Keynesian IS curve suggests substitutability between IR and FG (Eggertsson and Woodford, 2003). Moreover, if bond markets are segmented so that changes in the relative supply of long-term bonds affect the term premia, LSAP can generate qualitatively similar expansionary effects to IR-based policy (Chen et al., 2012; Gertler and Karadi, 2013; Kiley, 2014). These considerations can be formalized using the increasingly popular concept of the shadow rate as a summary statistics of the monetary policy stance (Wu and Xia, 2016).

However, while the equivalence claim may be appealing in a closed economy context, its international validity is less clear. Structural model-based analyses of Fed unconventional policies, exemplified by papers by Alpanda and Kabaca (2020) and Kolasa and Wesołowski (2020), have come to different conclusions on the international effects of QE.¹ Depending on the assumed form of international bond market segmentation, LSAP by the Fed could generate similar or quite distinct spillovers to other countries compared to the standard IR policy. Another complicating factor is that unconventional policies by major central banks have often sparked non-standard monetary responses in other countries, especially emerging market economies (EMEs), which sometimes resorted to exchange rate interventions, capital control measures, or policies affecting domestic credit conditions.

The empirical literature that could be used to assess the differences between conventional and unconventional monetary policy spillovers suffers from the comparability issues. The vast pre-GFC papers on the effects of Fed policies did not include the unconventional measures. Similarly, many studies focusing on LSAP do not offer a direct and coherent comparison to conventional policies.² Among notable exceptions, Curcuru et al. (2018)

¹Model-based analyses focusing on the spillovers of the ECB unconventional policies include Cova et al. (2019), Mouabbi and Sahuc (2019) and Hohberger et al. (2019).

²There is vast empirical literature documenting international spillovers of conventional US monetary

compare LSAP to IR, arguing that the former has smaller effects on the US dollar exchange rate. Miranda-Agrippino and Rey (2022) look at global effects of US monetary policy before and after the GFC, finding them to be quite similar. In a paper concurrent to ours, Georgiadis and Jarocinski (2023) compare the international consequences of four types of US monetary shocks as identified by Jarocinski (2021), documenting stronger spillovers for those that can be associated with unconventional measures.

Against this backdrop, this paper makes two types of contributions. The first and major one is empirical, offering new evidence on international spillovers of US monetary policy. In contrast to most of the earlier literature, we focus directly on the reactions of both financial and macroeconomic variables using a panel of small open economies that include both emerging markets and advanced economies (AEs). We also directly compare the effects of all three types of Fed policies (IR, FG and LSAP) using shocks identified within the same coherent econometric framework. More specifically, we rely on the factors estimated by Swanson (2020), who extends the high-frequency identification method worked out by Gurkaynak et al. (2005) to include LSAP shocks, and use them in local projections a la Jordà (2005). Another distinguishing feature of our analysis is that we perform the so-called Kitagawa-Blinder-Oaxaca (KBO) decomposition (Kitagawa, 1955; Blinder, 1973; Oaxaca, 1973) to distill the importance of local monetary policy responses in determining international spillovers of Fed policies.

Our main findings in this empirical part can be summarized as follows. Starting with the effects of the three types of Fed policies on the US economy, we confirm that all of them can stimulate economic activity and inflation. This is despite strong evidence that each instrument operates on different parts of the yield curve, with the IR policy generating an immediate (though persistent) fall in the short-term rates, FG affecting these rates with some lag, while LSAP depressing the term premium. In contrast, the three types of US monetary shocks have quite different international spillovers. Most notably, LSAP by the Fed significantly affects long-term bond prices in other countries, compressing the term premia and leading to much stronger exchange rate adjustments when compared to FG, and even more so to IR policies. Another striking feature of the US LSAP, and distinguishing it from the other two types of policies, is that it triggers a much deeper conventional monetary accommodation abroad, manifesting itself in a sharp and persistent fall in other countries' short-term rates. Consistently with this easing of financial conditions and exchange rate response, the Fed LSAP transmits more powerfully than FG and IR to private spending abroad, but has a more adverse effect on small open economies' net exports. This result has non-trivial implications for evaluation of spillovers of the recent round of policy tightening by the Fed, which consisted of a steep increase in the Fed Funds Rate and only a gradual balance sheet reduction. The latter

policy, see e.g. Mackowiak (2007), Banerjee et al. (2016), Dedola et al. (2017), Iacoviello and Navarro (2018), and Ricco et al. (2020). A few recent papers that focus on the international consequences effects of Fed's LSAP include Tillmann (2016), Bhattarai et al. (2021), Miranda-Agrippino and Nenova (2022), and Kolasa and Wesolowski (2023).

– as documented by Smith and Valcarcel (2023) – had a relatively moderate impact on financial markets as compared with an immediate and pronounced effects of past LSAP announcements. Hence, our results imply that the recent Fed tightening should spill over to other economies less than the accommodation in response to the GFC or the Covid-19 pandemic.

We also document important differences between how advanced and emerging market economies are affected by the Fed policies. For the EMEs, the effects of US LSAP stand out even more, generating stronger adjustments in the term premia, exchange rates, and private spending in comparison to IR and FG. Moreover, LSAP is strongly accommodated by EMEs central banks, but not by their counterparts in AEs. Based on the KBO decompositions, we find some evidence that the differences in how other central banks respond to US monetary shocks, and LSAP in particular, can significantly affect their international spillovers.

Our second type of contribution is more theoretical and offers a simple conceptual framework to make sense of the empirical results. The model we sketch out is inspired by Andres et al. (2004) and Chen et al. (2012), who assume a simple form of market segmentation that makes short and long-term bonds imperfect substitutes, and by the recent open economy extension of this setup proposed by Kolasa and Wesołowski (2020). The framework helps rationalize why, from the perspective of macroeconomic stability of the US economy, one can consider the three Fed policies as close substitutes, at least when their use is not hampered by binding constraints such as the effective lower bound. This is because, despite working through different channels, each of these instruments can stimulate spending of at least some groups of agents, and hence the aggregate demand. At the same time, different Fed instruments may have very different implications for other countries and their spillovers may heavily depend on the reaction of other central banks. In particular, the model implies that all types of monetary easing by the Fed are likely to generate a contraction in economic activity abroad unless sufficiently accommodated by the recipient country's monetary authority, and that the required degree of accommodation may be particularly high for the LSAP-style policies. More generally, the presented theoretical arguments call for conditioning on local policy response when analyzing US monetary policy spillovers.

The rest of this paper is structured as follows. Section two presents the empirical strategy and the data. Our main empirical findings are discussed in Section three. Section four develops a simple IS curve-based framework to explain some of the key empirical results. Section five concludes.

2 Empirical strategy and data

In order to analyze the effects of Fed policies, we estimate a set of local projections. As proxies for the three distinct types of US monetary policy shocks, we use the factors

identified by Swanson (2020), who extends the high-frequency approach of Gurkaynak et al. (2005) to separately identify surprise changes in the conventional policy, forward guidance, and quantitative easing. We proceed in three steps. First, to analyze the extent to which these shocks can be considered as substitutes from the US economy's perspective, we estimate the models that focus on the US and global variables only. Second, we investigate international spillovers of the Fed policies by conducting panel estimations for sixteen small open economies. Finally, we dig into the foreign-domestic monetary interactions by using the so-called Kitagawa-Blinder-Oaxaca (KBO) decomposition (Kitagawa, 1955; Blinder, 1973; Oaxaca, 1973). Below we describe these econometric frameworks in more detail and present the dataset.

While examining the effects of the three types of Fed policy shocks on the US economy, we focus on four macroeconomic time series that represent the standard real and nominal business cycle patterns as well as reflect the central bank actions. These are the GDP, CPI, short-term interest rate and term premium. More specifically, for each of these four variables we estimate the following local projections (Jordà, 2005):

$$y_{t+h} - y_{t-1} = \alpha_h + \varepsilon_t \beta_h + \gamma_h \mathbf{x}_t + \nu_{t+h}, \quad (1)$$

for horizons $h = 0, \dots, 8$ quarters, where y_t is one out of the four endogenous variables in period t and ε_t is a vector of the three monetary policy shocks that hit the economy at time t . The first two are the original Swanson factors representing conventional monetary policy and forward guidance, whereas the latter is defined as the Swanson LSAP factor multiplied by dummy variable d_t that equals one after 2009q1, i.e., when the Fed actually conducted quantitative easing, and zero otherwise. Vector \mathbf{x}_t consists of the following control variables: two lags of the dependent variable, two lags of the Swanson factors, dummy variable d_t , the time trend, the Swanson LSAP factor multiplied by $1 - d_t$, contemporaneous and two lags of oil prices, two lags of VIX, and, in the case of the term premium regressions, two lags of the US GDP, CPI growth and the Fed funds rate. Finally, ν_{t+h} are the regression residuals while α_h , β_h and γ_h are the estimated parameters.

Turning to international spillovers of Fed policies, they are analyzed using panel projections of the form:

$$y_{j,t+h} - y_{j,t-1} = \alpha_{j,h} + \varepsilon_t \beta_h + \gamma_h \mathbf{x}_{j,t} + \nu_{j,t+h} \quad (2)$$

for $h = 0, 1, 2, \dots, 8$, where $y_{j,t}$ is the time t realization of one of the following nine macroeconomic and financial variables in country j : GDP, consumption, investment, net exports contribution to GDP, CPI, 3-month interest rate, 3-year government bond yield, the nominal exchange rate against the US dollar and the term premium, while ε_t is a vector of the three US monetary policy shocks as defined above. The vector of controls in our baseline specification includes the dummy variable d_t , the time trend, the Swanson LSAP factor multiplied by $1 - d_t$, 2 lags of the dependent variable, 2 lags of the Swanson factors, con-

temporaneous and 2 lags of GDP in the OECD countries to capture the impact of the global business cycle, and (unless already included as lags of the dependent variable) 2 lags of GDP growth, CPI inflation, the short-term interest rate and the nominal exchange rate against the US dollar. Finally, $\nu_{j,t+h}$ are the regression residuals while $\alpha_{h,j}$, β_h and γ_h are the estimated parameters, where $\alpha_{j,h}$ denotes the country fixed effects. As a general rule, the choice of control variables was based on the information criteria. In particular, we verified that, for majority of regressions, our baseline specification is superior to including more lags (four instead of two) and alternative subsets of controls. As it will be discussed later, other specifications tend to lead to similar results.

The last part of our empirical investigation focuses on domestic-foreign monetary policy interactions to verify the extent to which domestic monetary policy may attenuate the impact of US monetary policy shocks. One of the tools we use is the KBO decomposition as in Cloyne et al. (2020), which boils down to running a two-step regression. In the first stage, we estimate, separately for each of the three monetary policy shock, a panel model with the short-term interest rate $R_{j,t}$ as the dependent variable:

$$R_{j,t+h} - R_{j,t-1} = \alpha_{i,j,h} + \Theta_{i,j}^h \varepsilon_t^i + (\mathbf{x}_{j,t} - \bar{\mathbf{x}}_j) \gamma_{i,h} + \nu_{i,j,t+h} \quad (3)$$

where j is a country index, i indexes the three US monetary policy shocks, and a bar indicates the mean value. This specification resembles equation 2, except that it allows for heterogeneous impact of US monetary policy shocks on domestic monetary policy captured by country-specific parameters $\Theta_{i,j}^h$. Furthermore, the control variables are expressed in differences from their means.

In the second-stage regressions, parameters $\Theta_{i,j}^h$ estimated in the first stage allow to disentangle the indirect country-specific spillovers from the direct effects of the Fed shocks that are common for all countries in the sample:

$$y_{j,t+h} - y_{j,t-1} = \alpha_{i,j,h} + \beta_h^i \varepsilon_t^i + \varepsilon_t^i \left(\Theta_{i,j}^h - \bar{\Theta}_i^h \right) \theta_{\varepsilon,i}^h + \varepsilon_t^i (\mathbf{x}_{j,t} - \bar{\mathbf{x}}_j) \theta_{x,i}^h + (\mathbf{x}_{j,t} - \bar{\mathbf{x}}_j) \gamma_{i,h} + \nu_{i,j,t+h} \quad (4)$$

where $\beta_h^i \varepsilon_t^i$ measures the direct (average) spillovers as in equation 2, $\bar{\Theta}_i^h$ denotes the average of $\Theta_{i,j}^h$ estimates across all countries, and $\theta_{\varepsilon,i}^h$ are the estimated parameters measuring the indirect spillover effect that varies in domestic monetary policy responsiveness to the Fed shocks. In these regressions, we control for heterogeneity in country characteristics captured by $\mathbf{x}_{j,t} - \bar{\mathbf{x}}_j$ and their interactions with monetary policy shocks ε_t^i , similarly to the procedure described in Cloyne et al. (2020).

As estimating equation 4 with a set of control variables described for the baseline panel model defined by equation 2 would induce a large number of explanatory variables and hence too few degrees of freedom, we restrict their number and also include only one monetary policy shock i for each regression instead of all three of them at the same time. In order to check the robustness of this approach, we compare the direct effects resulting

from this choice with the impulse responses given by the baseline estimation of equation 2.

As far as the data is concerned, we use quarterly time series spanning the period 2001q1-2019q4. The dataset consists of sixteen small open economies, which are inflation targeters with floating exchange rates. Seven of them are advanced economies (Australia, Canada, Israel, Korea, New Zealand, Norway, Sweden) and nine can be classified as emerging economies (Brazil, Chile, Colombia, Czechia, Hungary, India, Indonesia, Mexico, Poland). All variables are listed and described in Table 1.

Table 1: List of variables in local projection models

Variable Description	Data source	Data description
GDP - expenditure approach (log)	OECD	VOBARSA
Consumption - expenditure approach (log)	OECD	VOBARSA
Investments- expenditure approach (log)	OECD	VOBARSA
Net exports contribution	OECD	VOBARSA
CPI index (log)	OECD	CPI: 01-12 - All items; seasonal adj. TRAMO/SEATS
Short-term interest rates	OECD, Bloomberg	Per cent per annum
Exchange rate against the US dollar (log)	BIS	BIS/xru_current/
VIX index	Bloomberg	N/A
Term premia in SOE's	Bloomberg	own estimates based on Adrian et al. (2013)
LSAP factor	Swanson (2020)	
Federal funds rate factor	Swanson (2020)	
Forward guidance factor	Swanson (2020)	
GDP in the US	Fred	GDPC1
CPI in the US	Fred	CPIAUCSL
Short-term interest rates	Bloomberg	
Term premium in the US	NY Fed	Adrian et al. (2013) model

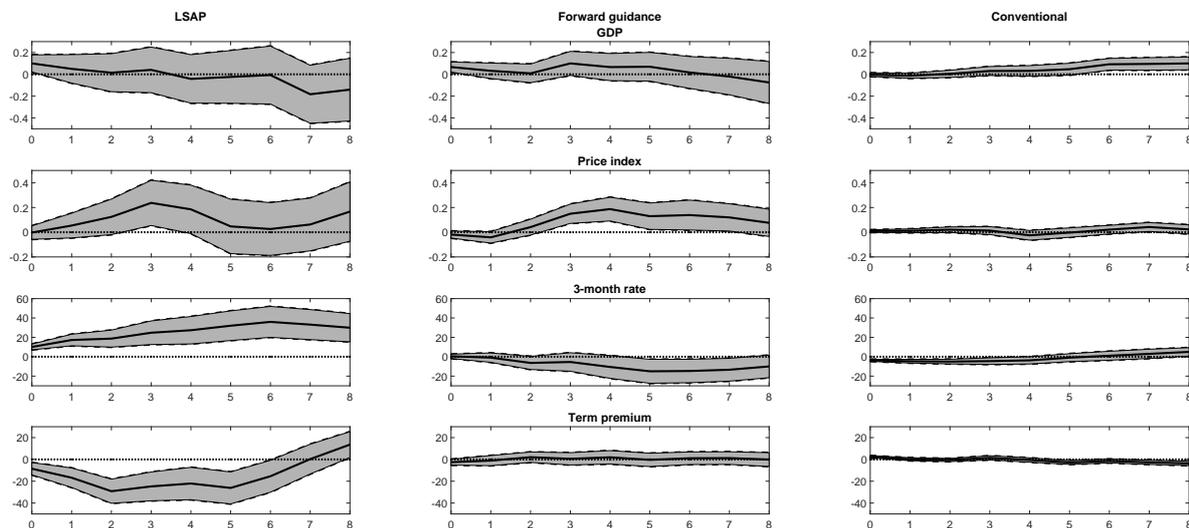
3 Empirical results

This section presents the empirical evidence of the effects of Fed monetary policy on both US and foreign financial and macroeconomic variables. One of the focal points of this paper is that central banks in small open economies (SOEs) can substantially affect international spillovers of Fed monetary policy, both quantitatively and qualitatively. To illustrate this, we also present our results for subsamples of advanced and emerging market economies. The rationale for distinguishing between these two groups comes from the differences in their monetary policy space and fragility to capital flows – both factors likely to affect how central banks respond to the Fed policy. Finally, we apply the KBO decomposition to formally account for cross-country heterogeneity in domestic policy reactions to foreign monetary shocks.

3.1 Domestic effects

To investigate the effects of different types of Fed policy on the US economy, we run regressions defined by equation 1. As the original Swanson (2020) factors are not directly comparable, we standardize their size such that all accommodative policy shocks have a maximum impact on GDP equal 0.1% over a 2-year horizon. As shown by Figure 1, all three policies (short-term rate, forward guidance and LSAP) lead to GDP and price increases, even though their transmission mechanisms vary. In line with intuition, LSAP lowers immediately and persistently the term premium, a conventional shock works through a persistent decrease in the short-term interest rate, while forward guidance lowers the short-term rate only gradually as the central bank delivers policy easing that it promised earlier.

Figure 1: Impulse responses in the United States



Note: Local projection panel estimation for the United States. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The shaded area depicts 68% confidence bands.

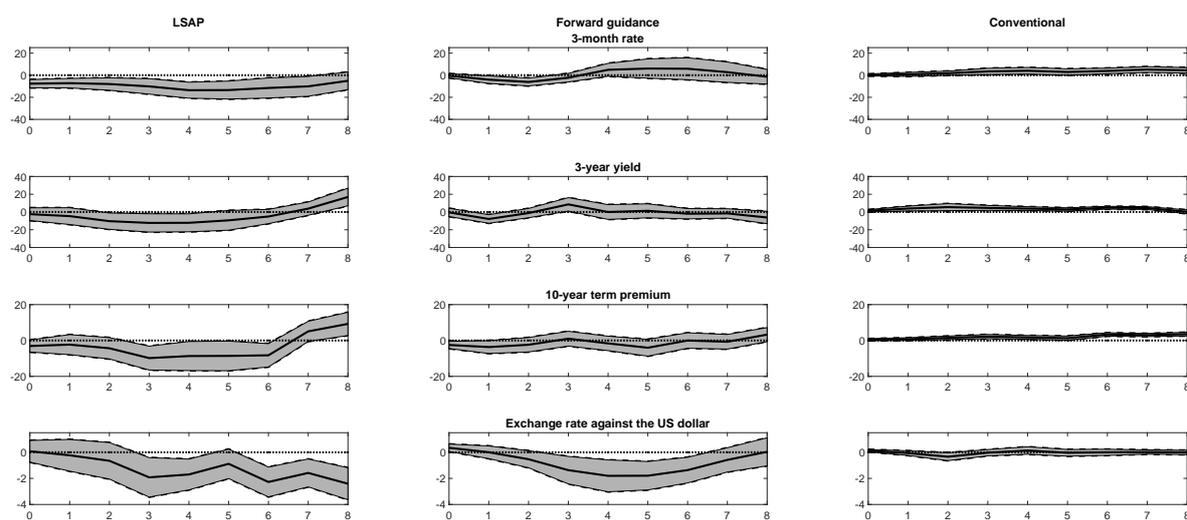
Notwithstanding that both economic activity and prices increase after any type of monetary accommodation, there are some differences in the responses. In particular, GDP growth resulting from the LSAP shock is very short-lived and its estimation is relatively imprecise. The latter may be due to the fact that we observe only three major QE episodes in the sample. On the other hand, forward guidance seems to have relatively long-lasting and positive impact on GDP and prices, even though we do not control for information effects that have been recently discussed in the literature (see e.g. Jarociński and Karadi, 2020; Miranda-Agrippino and Ricco, 2021). Finally, the impact of a conventional shock seems to be most persistent and precisely estimated in the case of US GDP, but its effect on prices is delayed and weak.

All in all, despite the reported differences, we conclude that all three monetary policy instruments used by the Fed can be perceived as substitutes in the closed economy context, in the sense that each of them can provide stimulus to US economic activity. It is also reassuring that they transmit in a way that is intuitive and consistent with standard theoretical models.

3.2 International spillovers

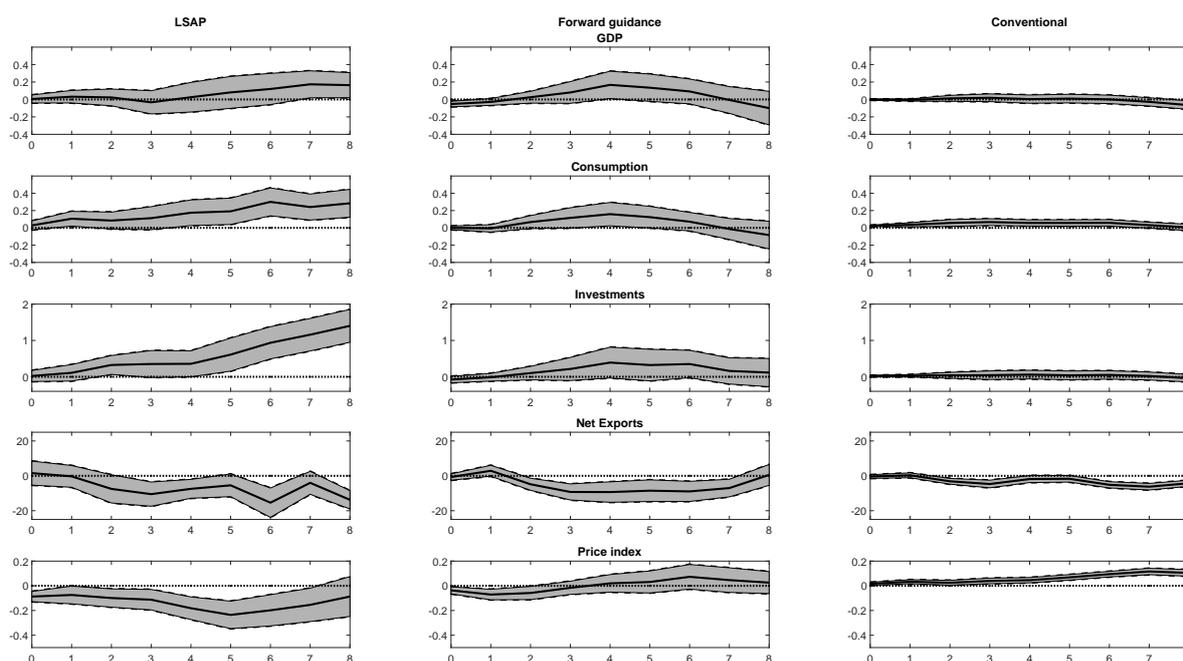
We next move to international spillovers of Fed policies, which is the main focus of this paper. Figures 2 and 3 present the responses of financial and macroeconomic variables to US monetary policy shocks, normalized as described in section 3.1. As one could expect, all three types of US monetary easing lead to exchange rate appreciation in small open economies, although its scale and timing differs across the policy types. The exchange rate reaction is strongest and most protracted after the LSAP, significant but less persistent following the forward guidance, and fairly weak in response to a conventional shock. As argued by Kolasa and Wesołowski (2020), these discrepancies are consistent with international segmentation of bond markets, where investors use mainly long-term bonds to take position in foreign currency. As a result, the exchange rate is relatively more sensitive to long-term yields than to short-term rates. This segmentation also manifests itself in a high degree of international synchronization in the term premia if we condition on the LSAP, but not on other monetary shocks.

Figure 2: Impulse responses of financial variables in small open economies



Note: Local projection panel estimation for 16 small open economies. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The shaded area depicts 68% confidence bands.

Figure 3: Impulse responses of macro variables in small open economies



Note: Local projection panel estimation for 16 small open economies. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The shaded area depicts 68% confidence bands.

Exchange rate appreciation worsens international price competitiveness and consequently net exports, which is conducive to lowering domestic GDP. Central banks in SOEs can counteract this effect by lowering the short-term interest rates. Not surprisingly then, domestic monetary policy accommodation is strongest after the shock associated with the policy generating most prominent appreciation, i.e., the LSAP. As discussed above, this type of Fed intervention leads also to a substantial fall in the term premium, and hence in long-term yields in SOEs. Consequently, consumption and investment increase, and the scale of these movements is proportional to monetary policy accommodation in SOEs, i.e., it is the strongest and most persistent after the LSAP shock, followed by the effects of forward guidance. In contrast, the reaction of domestic demand to conventional monetary shocks is much weaker as this type of Fed policy does not seem to improve financial conditions in other economies: if anything, yields go up in this case. As all types of US monetary policy tend to boost domestic demand and deteriorate net exports of other economies, the effects on their GDP is ambiguous and, according to our results, mostly insignificant. The next section will demonstrate that this average result for a broad set of countries hides important heterogeneity since the GDP response may depend on country-specific monetary policy.

3.3 Advanced versus emerging market economies

It is well known that interest rates in the US and other countries comove. Table 2 illustrates this point by reporting the correlation between the 3-month interest rate or the 10-year term premia in the US and the first principal component of the same indicators in either advanced or emerging market economies. Clearly, the degree of synchronization with the US is very high, especially on the long end of the yield curve and for advanced economies.

Table 2: Correlation between selected variables in the US and 1st principal components of their counterparts in small open economies

	3-month rate	10-year term premium
First principal component: Advanced Economies	0.74***	0.98***
First principal component: Emerging Economies	0.70***	0.93***
<i>N</i>	80	44

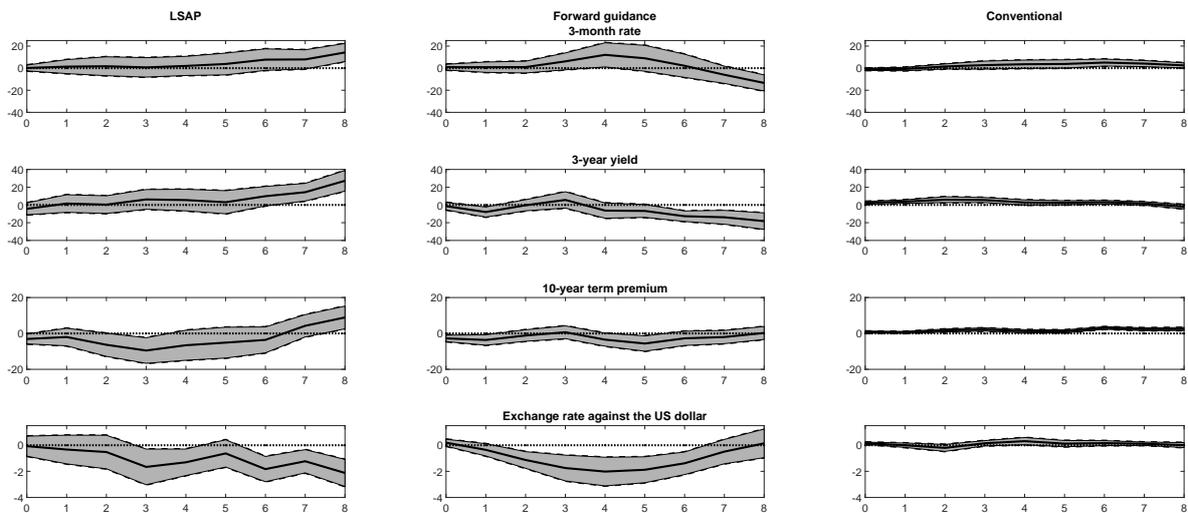
t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Correlation between term premia refers to years 2009-2020.

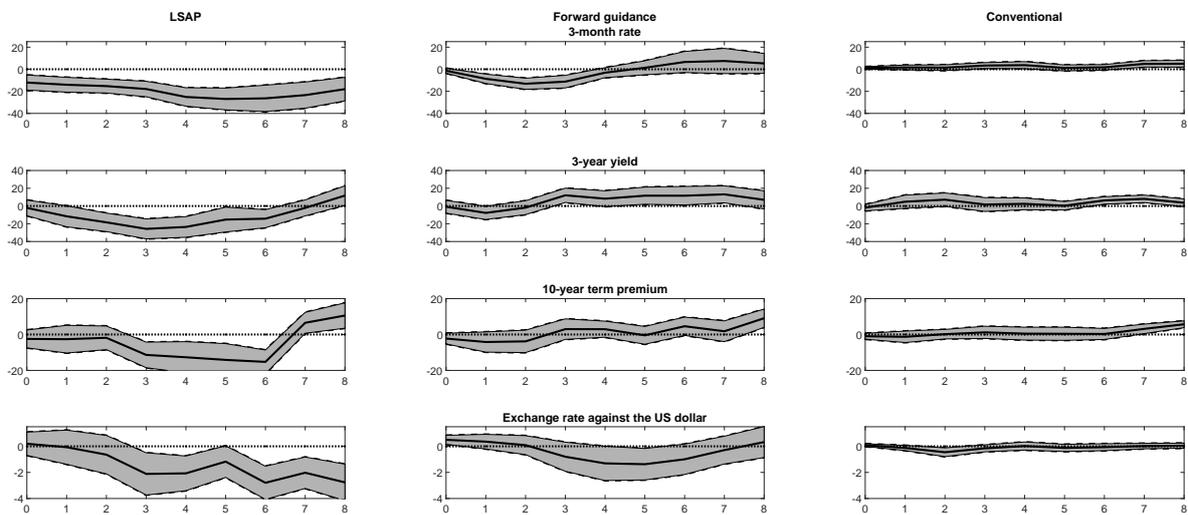
However, the picture painted by unconditional correlations can be misleading and simply reflect the global nature of many macroeconomic shocks. Therefore, Figures 4 and 5 present the impulse responses of financial variables in SOEs to each of the three types of Fed policies, this time separately for advanced and emerging economies. Interestingly, our results indicate that advanced economies do not seem to accommodate Fed's easing. If anything, the reaction in the domestic policy rate is positive. In contrast, central banks in emerging markets lower their policy rates significantly and persistently in response to the US LSAP and, though to lesser extent, to US forward guidance. These differences between the two groups may reflect larger vulnerability of emerging market economies to volatile capital flows that, in line with the global financial cycle hypothesis, can be largely driven by the US monetary policy as documented by Miranda-Agrippino et al. (2020). EME central banks may try to lean against the strong appreciation pressure associated with these flows by lowering their policy rates.

Figure 4: Impulse responses of financial variables in advanced small open economies



Note: Local projection panel estimation for 7 advanced small open economies. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The shaded area depicts 68% confidence bands.

Figure 5: Impulse responses of financial variables in emerging small open economies

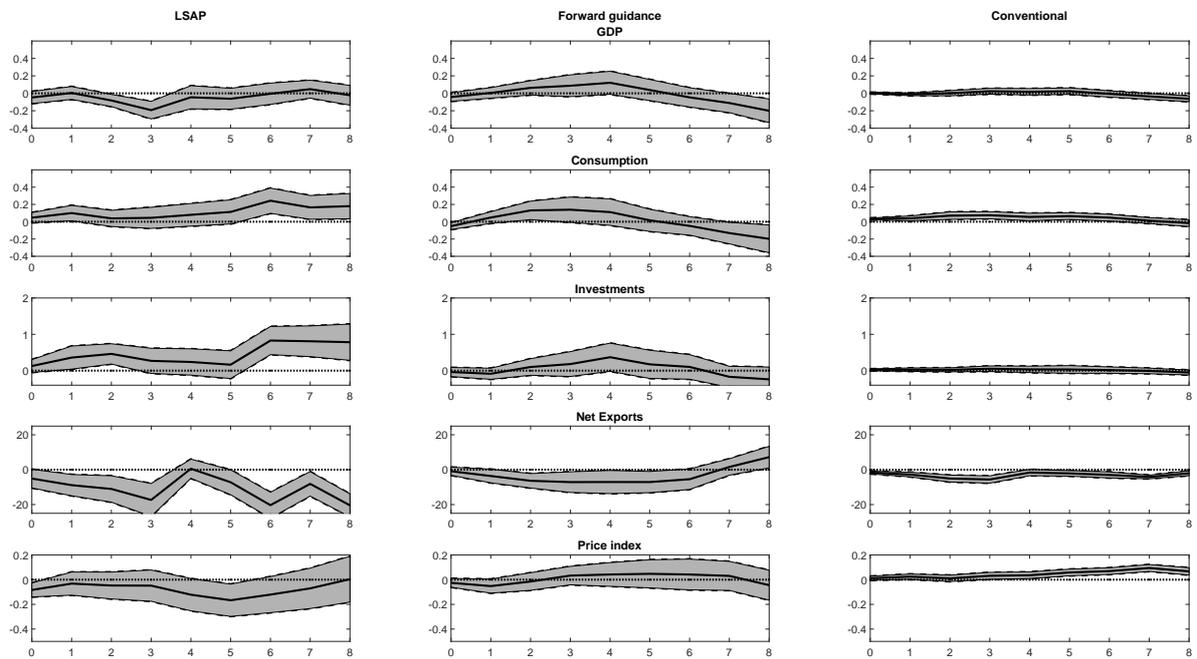


Note: Local projection panel estimation for 9 emerging small open economies. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The shaded area depicts 68% confidence bands.

Our estimations point also to important differences in the responses of macroeconomic variables in AEs and EMEs (see Figures 6 and 7) that can also be, at least partially, rationalized by diverse monetary policy reactions. Both consumption and investment increase in response to all three US monetary shocks more in EMEs than in AEs, consistently with

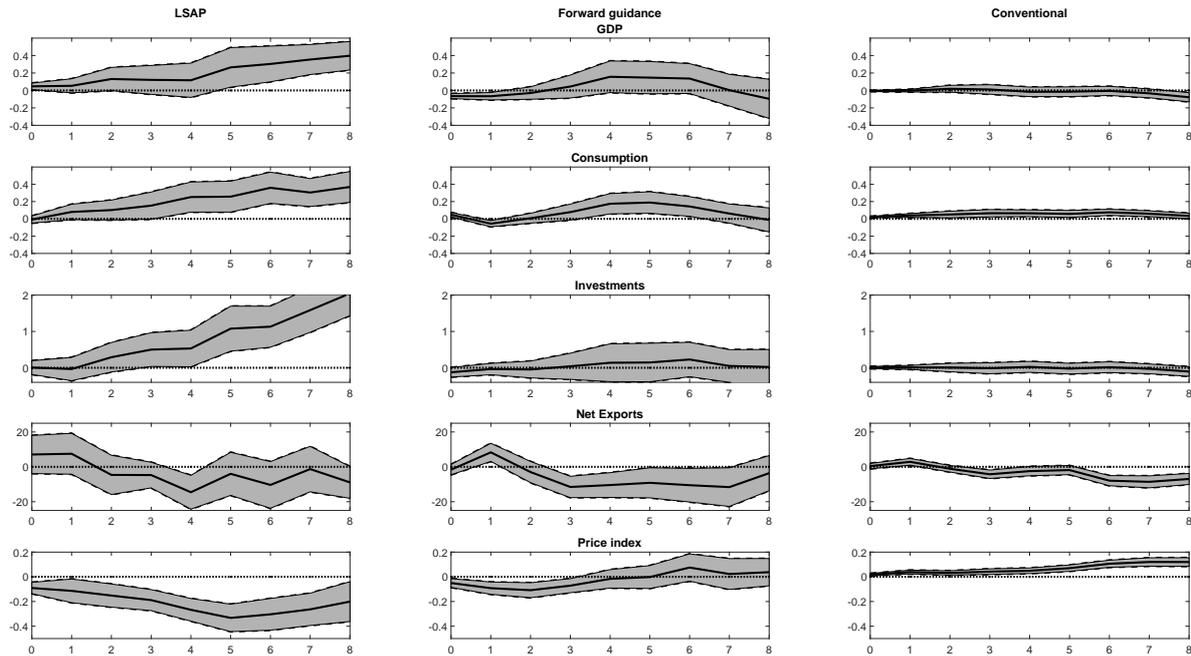
more accommodating policy in the former group. As a result, our results point to some increase in GDP in EMEs and much more muted response of this variable in AEs.

Figure 6: Impulse responses of macro variables in advanced small open economies



Note: Local projection panel estimation for 7 advanced small open economies. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The shaded area depicts 68% confidence bands.

Figure 7: Impulse responses of macro variables in emerging small open economies



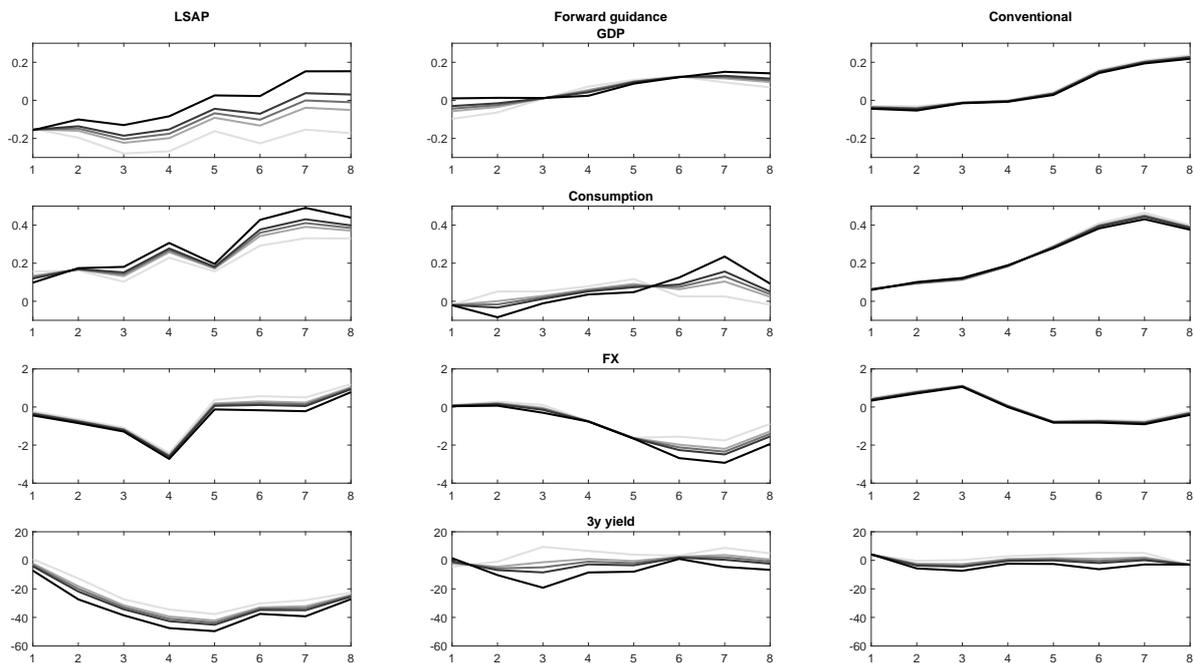
Note: Local projection panel estimation for 9 emerging small open economies. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The shaded area depicts 68% confidence bands.

3.4 KBO decomposition

Our results for the subgroups of advanced and emerging market economies suggest that the heterogeneity in domestic monetary policy responses can matter a lot for international spillovers of Fed policies. To investigate this issue further, we now conduct a KBO decomposition. Recall that, to perform this analysis, we need to limit the number of control variables. However, as we later verify in section 3.5, using this narrower set of controls does not impact much the results from the baseline model given by equation 2.

Figure 8 presents the KBO output for the main financial and macroeconomic variables. Each line corresponds to a various degree of domestic monetary policy accommodation following the Fed shock, and is calculated from the cross-country distribution of $\Theta_{i,j}^h$ in equation 4. More precisely, we present the Fed shocks (normalized as in the previous sections) multiplied by $\hat{\beta}_h^i + \kappa \hat{\sigma}_{\Theta_{i,j}^h} \hat{\theta}_{\epsilon,i}^h$, where parameters with hats refer to their estimated values, $\sigma_{\Theta_{i,j}^h}$ is the cross-country standard deviation of $\Theta_{i,j}^h$, and κ takes values -0.5, -0.25, 0, 0.25 and 0.5 that correspond to the different degrees of domestic monetary accommodation. In the figure, each line corresponds to a different value of κ . The darker the line is, the higher κ it corresponds to, and hence the more expansionary domestic policy it depicts.

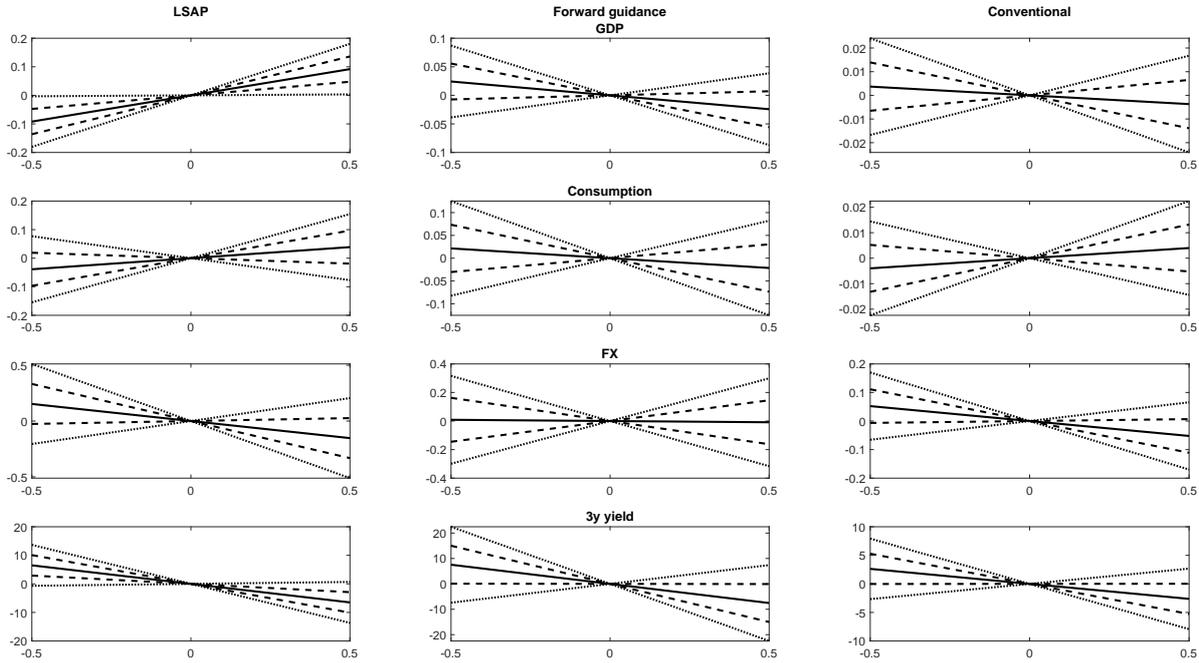
Figure 8: Impulse responses in small open economies depending on degree of domestic monetary accommodation



Note: Local projection panel estimation for 16 small open economies. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The darker the line is, the more accommodative domestic monetary policy is after the US accommodation.

As shown by Figure 8, domestic accommodation in response to Fed loosening translates into a lower path of bond yields. This has a significant effect on consumption and GDP after the LSAP shock. In these cases, more accommodative domestic monetary policy supports GDP. Figure 9 confirms that this impact is also statistically significant. Thus, the KBO evidence partly confirms the conclusions drawn from the estimations for subgroups of advanced and emerging market economies, but also suggests that other country-specific features (e.g., riskiness and related to it vulnerability to capital flows) may be at least equally important.

Figure 9: Significance of impulse responses in small open economies depending on degree of domestic monetary accommodation

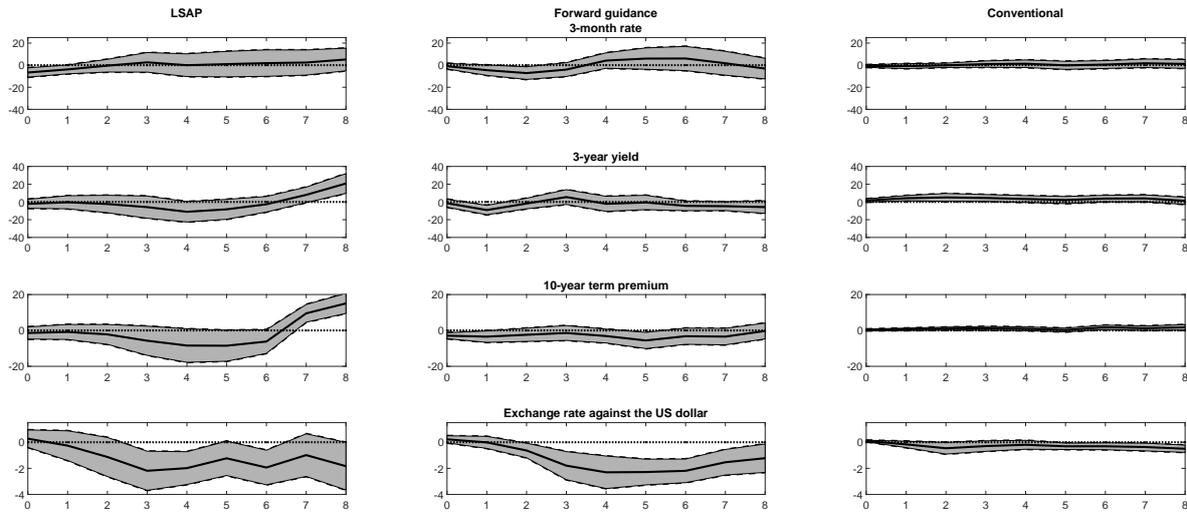


Note: The figure presents the differences of the responses in small open economies to US accommodative monetary policy from the mean response in the sample depending on the degree of domestic monetary policy accommodation which is depicted on the horizontal axis. More accommodative policies are described by positive values on the horizontal axis while more restrictive ones -- by negative values. All differences are calculated for the fourth quarter after the shock. The dashed lines depict \pm one standard deviation interval to the mean differences, while dotted lines: \pm two standard deviations interval. These results come from the local projection panel estimation for 16 small open economies. The US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%.

3.5 Robustness

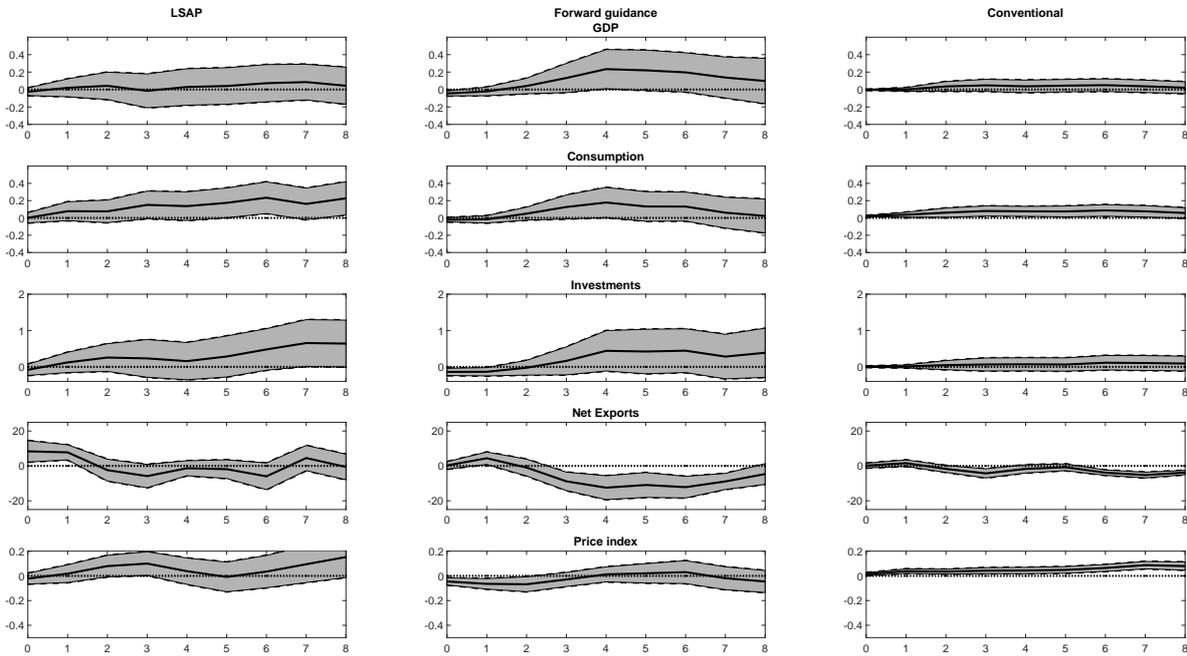
We check the robustness of our results by considering several other model specifications. In particular, we allow for more lags of exogenous variables (four instead of two), or remove some of the controls (e.g. exchange rate, selected macro variables, past shocks and time trend). We find that most of these alternative specification are inferior to the baseline according to the BIC criterion and they yield broadly similar results. A particularly important specification is the one with two lags of the endogenous variable, QE dummy, non-QE LSAP factor, as well as the current and two lags of OECD GDP as controls since it is the same as the one utilized in the KBO decomposition in the variant when each shock is taken separately (in contrast to including all shocks at the same time in the baseline). Figures 10 and 11 confirm that also this specification leads to results that are very similar to the baseline presented in Figures 2 and 3.

Figure 10: Robustness: impulse responses of financial variables in small open economies



Note: Local projection panel estimation for 16 small open economies. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The shaded area depicts 68% confidence bands.

Figure 11: Robustness: impulse responses of macro variables in small open economies



Note: Local projection panel estimation for 16 small open economies. US LSAP, conventional and forward guidance shocks are taken from Swanson (2020). LSAP shock refers to the post-2009q1 period. Values of shocks are adjusted so that they lead to maximum US GDP increase by 0.1%. The shaded area depicts 68% confidence bands.

4 Simple conceptual framework

4.1 Environment

We now show how some of the empirical findings documented above can be rationalized within a simple model with segmented bond markets. For the ease of exposition, we assume that agents can trade only bonds with maturity of either one or two periods, and will refer to them as short and long-term bonds, respectively. As we show in the Appendix, this environment can be easily generalized to accommodate N types of zero-coupon bonds, where N indicates the maximum available maturity.

Our model economy is populated by two types of households. The first type, whom we call passive investors and whose mass is $0 \leq \omega < 1$, can only trade long-term bonds, holding them until maturity without incurring any additional costs. These bonds can be denominated either in domestic or foreign currency. They earn non-financial nominal income Y_t^P and consume c_t^P units of final goods. Their budget constraint can be written as

$$P_t c_t^P + \frac{B_t^P}{R_{2,t}} + Q_t \frac{B_t^{P*}}{R_{2,t}^*} \leq Y_t^P + B_{t-2}^P + Q_t B_{t-2}^{P*} \quad (5)$$

where B_t^P and B_t^{P*} denote, respectively, passive investors' domestic and foreign currency bond holdings, $R_{2,t}$ and $R_{2,t}^*$ indicate their (gross) yield-to-maturity, Q_t is the nominal exchange rate (expressed as domestic currency units per foreign currency), and P_t is the aggregate price level.

The second type of investors, dubbed active and having mass $1 - \omega$, can additionally trade in one-period bonds denominated in domestic currency. Moreover, whenever they take a position in long-term bonds, they incur transaction cost $\xi_t = \xi(\bar{B}_t^A)$ and $\xi_t^* = \xi(\bar{B}_t^{A*})$, where $\xi', \xi^* > 0$. The cost depends on aggregate bond holdings in the economy (indicated with bars), and hence are external to individual investors. Active investors' budget constraint is given by

$$P_t c_t^A + \frac{B_t^A}{R_{2,t}} (1 + \xi_t) + Q_t \frac{B_t^{A*}}{R_{2,t}^*} (1 + \xi_t^*) + \frac{D_t^A}{R_t} \leq Y_t^A + B_{t-2}^A + Q_t B_{t-2}^{A*} + D_{t-1}^A \quad (6)$$

where R_t is the one-period (gross) nominal interest rate that is controlled by the monetary authority and D_t^A denotes active investors' holdings of domestic currency bonds maturing next period. The latter includes not only one-period bonds, but also two-period bonds purchased in the previous period.

The government controls the total supply of bonds issued in domestic currency. The effective amount of bonds available to the private sector can be additionally affected by asset purchases conducted by the monetary authority (LSAP). In particular, whenever the central bank purchases long-term bonds, it does so by issuing reserves, which we assume

to be perfect substitutes of short-term bonds. As a result, for given total supply of bonds, LSAP will decrease the holdings of long-term bonds by the private sector, and increase their holdings of assets with one-period maturity.

The rest of the model follows the standard open economy New Keynesian setup with imperfect exchange rate pass-through, see e.g. Monacelli (2005). In particular, we assume that domestic and foreign goods are imperfect substitutes, so that the consumption basket is defined as (for $i = \{P, A\}$)

$$c_t^i = \left[\alpha^{\frac{1}{\eta}} (c_{F,t}^i)^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} (c_{H,t}^i)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \quad (7)$$

where $0 < \alpha < 1$ controls the steady state import penetration while $\eta > 0$ is the elasticity of substitution between domestic and imported goods.

Moreover, nominal rigidities in price setting imply that the monetary authority can affect not only the nominal, but also the real interest rate, and hence real allocations. For analytical simplicity, we assume that prices are perfectly sticky in the currency of destination markets (local currency pricing). This fixed price assumption is not necessary for our qualitative analysis offered below, but conveniently allows us to abstract away from endogenous responses of inflation.

While presenting below the key implications of our stylized model, we will rely on its log-linear approximation, using hats to indicate log-deviations of a given variable from its non-stochastic steady state. In what follows, we focus on selected and already transformed equilibrium conditions, leaving detailed derivations to the Appendix.

4.2 Key equilibrium conditions

No arbitrage between long and short-term bonds, derived from active agents' Euler conditions, imply the following relationship between the yield-to-maturity of long-term bonds, the short-term rate, and transaction costs

$$\hat{R}_{2,t} = \frac{1}{2} \left(\hat{R}_t + \mathbb{E}_t \hat{R}_{t+1} + \xi_t + \mathbb{E}_t \xi_{t+1} \right) \quad (8)$$

This equation allows us to interpret the (current and expected) transaction costs as the term premium, defined as the deviation of the long-term rate from the expectations hypothesis.

When combined with the first-order conditions describing optimal domestic currency bond holdings by passive and active investors, this no-arbitrage condition allows us to obtain the following aggregate Euler equation

$$\hat{\lambda}_t = \mathbb{E}_t \hat{\lambda}_{t+1} + \hat{R}_t + \omega \xi_t \quad (9)$$

where $\hat{\lambda}_t \equiv \omega \hat{\lambda}_t^P + (1-\omega) \hat{\lambda}_t^A$ is the population-weighted average marginal utility of consumption. Assuming the standard CRRA utility function that is separable in consumption

allows us to write

$$\hat{c}_t = \mathbb{E}_t \hat{c}_{t+1} - \frac{1}{\sigma} \left(\hat{R}_t + \omega \xi_t \right) \quad (10)$$

where σ is the degree of relative risk aversion and $\hat{c}_t \equiv \omega \hat{c}_t^P + (1 - \omega) \hat{c}_t^A$. Assuming that in the steady state per capita consumption is the same for passive and active households, c_t is simply the economy-wide consumption.

Combining the first-order conditions describing optimal domestic and foreign currency bond holdings by passive and active investors yields the following modified uncovered interest parity (UIP) condition

$$\hat{q}_t = \mathbb{E}_t \left\{ \hat{R}_t^* - \hat{R}_t + \xi_t^* - \xi_t \right\} + \mathbb{E}_t \hat{q}_{t+1} \quad (11)$$

where $q_t \equiv Q_t P_t^* / P_t$ is the real exchange rate. Note that, compared to the standard UIP condition, the equilibrium on the exchange rate market is also affected by the transaction costs associated with trade in long-term bonds, and hence by LSAP (beyond its impact on the expected interest rate path). This is a direct consequence of allowing for only long-term bonds to be internationally traded, consistently with empirical evidence on the UIP condition holding over long, but not short horizons (Chinn and Meredith, 2005).

4.3 Monetary policy equivalence in a closed economy

If we consider the limiting case of a large economy that can be effectively considered closed, goods market clearing implies that consumption must be equal to aggregate output. Using asterisks to indicate variables in such defined large country, we can write the following IS curve

$$\hat{y}_t^* = \mathbb{E}_t \hat{y}_{t+1}^* - \frac{1}{\sigma} \left(\hat{R}_t^* + \omega \xi_t^* \right) \quad (12)$$

or, after iterating forward

$$\hat{y}_t^* = -\frac{1}{\sigma} \sum_{s=0}^{\infty} \mathbb{E}_t \left\{ \hat{R}_{t+s}^* + \omega \xi_{t+s}^* \right\} \quad (13)$$

As the equation makes clear, monetary policy can affect the current level of economic activity by adjusting the current interest rate R_t^* (IR policy) or its future expectations represented by $\mathbb{E}_t R_{t+s}^*$, $s = 1, 2, \dots$ (FG). Additionally, the central bank can achieve similar outcomes by engaging in LSAP, through which it influences the current and expected future values of transaction costs $\mathbb{E}_t \xi_{t+s}^*$, $s = 0, 1, \dots$, i.e., the term premium. This is because transaction costs depend on bonds held by active households (recall that $\xi_t^* = \xi^*(B_t^{A*})$, $\xi^{*'} > 0$), and LSAP affects the effective supply of bonds to private agents.

Overall, the model implies the equivalence between IR, FG and LSAP policies in a closed economy setting, meaning that all of them can be used as substitutes if the goal is

to stimulate economic activity.

4.4 International spillovers

We now explore the effects of monetary policy conducted in a large country on a small open economy. The goods market clearing condition in the latter is³

$$y_t = \alpha y_t^* + (1 - \alpha)c_t + \alpha \eta q_t \quad (14)$$

Combining this condition with equation (10) yields the following open economy IS curve

$$\hat{y}_t = \mathbb{E}_t \hat{y}_{t+1} - \frac{1 - \alpha}{\sigma} \left(\hat{R}_t + \omega \xi_t \right) - \alpha \Delta \mathbb{E}_t \hat{y}_{t+1}^* - \alpha \eta \Delta \mathbb{E}_t \hat{q}_{t+1} \quad (15)$$

or, after iterating forward

$$\hat{y}_t = \alpha \hat{y}_t^* + \alpha \eta \hat{q}_t - \frac{1 - \alpha}{\sigma} \sum_{s=0}^{\infty} \mathbb{E}_t \left\{ \hat{R}_{t+s} + \omega \xi_{t+s} \right\} \quad (16)$$

The first two terms on the right-hand side of this equation highlight the standard two channels through which foreign shocks and policies transmit internationally: stronger foreign economic activity and weaker exchange rate support domestic output. Clearly, domestic output response is also affected by local financial conditions, both directly through their impact on consumption demand (the last term in the equation), and indirectly through their effect on the exchange rate. As the exchange rate is clearly endogenous to domestic policy reaction, it is instructive to eliminate the former from equation (15) using the UIP condition (11). If we further use the foreign IS curve (12) to eliminate foreign output, iterate forward and rearrange, we obtain

$$\begin{aligned} \hat{y}_t = & \alpha \left(\eta - \frac{1}{\sigma} \right) \sum_{s=0}^{\infty} \mathbb{E}_t \left\{ \hat{R}_{t+s}^* - \hat{R}_{t+s} \right\} + \alpha \left(\eta - \frac{\omega}{\sigma} \right) \sum_{s=0}^{\infty} \mathbb{E}_t \left\{ \xi_{t+s}^* - \xi_{t+s} \right\} \\ & - \frac{1}{\sigma} \sum_{s=0}^{\infty} \mathbb{E}_t \left\{ \hat{R}_{t+s} + \omega \xi_{t+s} \right\} \end{aligned} \quad (17)$$

The useful feature of this representation of the open economy IS curve is that it differs from its closed economy version (13) by including two additional terms. The first one can be interpreted as asynchronization of IR and FG policies as it is defined as the difference between the (current and future paths) of the policy rates in the domestic and foreign economy. The coefficient on this term can be positive or negative, depending on whether the elasticity of substitution between domestic production and imports η is higher or lower than the intertemporal elasticity of substitution σ^{-1} . Typical values of these parameters

³This formula follows from the derivations presented in Monacelli (2005), additionally exploiting the assumption that prices are perfectly sticky in local currency.

used in the macroeconomic literature imply a positive relationship, meaning that a more expansionary conventional policy or forward guidance abroad contribute negatively to domestic economic activity.

The second term in equation (17) reflects asynchronization in the term premia. This can naturally emerge if foreign LSAP is not matched by a similar policy introduced by the domestic central bank. However, the differences in the responses of transaction costs associated with domestic and foreign bonds, and hence in their term premia, also reflect international bond market segmentation at the shorter end of the yield curve. To see it, note that, if we allowed active agents to trade in short-term bonds denominated in foreign currency, the resulting short-term UIP condition would imply perfect equalization of transaction costs on domestic and foreign long-term bonds, and thus the second term in equation (17) would disappear. Again, typical parameter values used in the literature imply that the coefficient on this term is positive, and hence it contributes negatively to domestic economic activity when foreign term premia fall, as it is the case when the foreign central bank engages in LSAP.

4.5 Takeaways

The simple theoretical framework offers a number of insights on the domestic and international consequences of different types of monetary policy conducted by a large country's central bank like the US Fed. The model helps rationalize why, from the perspective of a large economy and if the goal is to stimulate aggregate economic activity, one can consider conventional interest rate policy, forward guidance and asset purchases as close substitutes, at least when the effective lower bound on the nominal interest rates can be ignored. While they work through different channels, and in particular the effectiveness of LSAP requires that some agents are unable to arbitrage away the differences between short and long-term bond yields, all three policies can stimulate spending of at least some groups of agents, and hence aggregate output.

At the same time, the three considered types of monetary policy can have quite different implications for economic activity abroad. In fact, one of the general conclusions following from the theoretical model-based analysis presented above is that the sign of international spillovers can crucially depend on the policy response in the recipient country. As our simple analytical framework reveals, conventional (IR and FG) monetary easing by the Fed is likely to generate a contraction in domestic economic activity in those countries whose central banks do not respond with sufficient monetary accommodation. Even larger monetary accommodation might be needed to avoid negative spillovers of US LSAP, especially in countries with shallow (or restricted) markets for short-term bonds denominated in local currency. All these considerations call for conditioning on the local monetary response when analyzing monetary policy spillovers, along the lines we followed in our empirical investigation.

5 Conclusions

Using a panel of advanced and emerging market economies, we have documented that US monetary policy shocks can have different international consequences depending on whether they concern the current interest rate decisions, forward guidance or large-scale asset purchases. Among these three types of Fed policy, the last one clearly stands out in that it generates larger exchange rate adjustments and is typically met with stronger accommodation by foreign central banks. These distinct features of the US LSAP have particularly important consequences for emerging market economies, which have shallower bond markets, and hence need to lean more heavily against capital flows driven by surprises in Fed decisions.

At a more general level, our analysis highlights the need to account for local monetary policy responses while describing international spillovers of US monetary policy. Again, this consideration seems to particularly apply to LSAP, which was accommodated by other central banks to different degrees, with important consequences for domestic effects. In the context of the recent policy tightening by the Fed, our results suggest that central banks around the world should be less concerned with its spillovers compared to the rounds of quantitative easing deployed earlier amidst the short term rate stuck at the effective lower bound.

References

- Adrian, Tobias, Richard K. Crump, and Emanuel Moench (2013) ‘Pricing the term structure with linear regressions.’ *Journal of Financial Economics* 110(1), 110–138
- Alpanda, Sami, and Serdar Kabaca (2020) ‘International Spillovers of Large-Scale Asset Purchases.’ *Journal of the European Economic Association* 18(1), 342–391
- Andres, Javier, J. David Lopez-Salido, and Edward Nelson (2004) ‘Tobin’s imperfect asset substitution in optimizing general equilibrium.’ *Journal of Money, Credit and Banking* 36(4), 665–90
- Banerjee, Ryan, Michael B. Devereux, and Giovanni Lombardo (2016) ‘Self-oriented monetary policy, global financial markets and excess volatility of international capital flows.’ *Journal of International Money and Finance* 68(C), 275–297
- Bernanke, Ben S (2020) ‘The new tools of monetary policy.’ *American Economic Review* 110(4), 943–983
- Bhattarai, Saroj, Arpita Chatterjee, and Woong Yong Park (2021) ‘Effects of US quantitative easing on emerging market economies.’ *Journal of Economic Dynamics and Control* 122, 104031
- Blinder, Alan S. (1973) ‘Wage Discrimination: Reduced Form and Structural Estimates.’ *Journal of Human Resources* 8(4), 436–455
- Chen, Han, Vasco Curdia, and Andrea Ferrero (2012) ‘The Macroeconomic Effects of Large-scale Asset Purchase Programmes.’ *Economic Journal* 122(564), F289–F315
- Chinn, Menzie D., and Guy Meredith (2005) ‘Testing Uncovered Interest Parity at Short and Long Horizons during the Post-Bretton Woods Era.’ NBER Working Papers 11077, National Bureau of Economic Research, Inc, January
- Cloyne, James S., Òscar Jordà, and Alan M. Taylor (2020) ‘Decomposing the Fiscal Multiplier.’ NBER Working Papers 26939, National Bureau of Economic Research, Inc, April
- Cova, Pietro, Patrizio Pagano, and Massimiliano Pisani (2019) ‘Domestic and International Effects of the Eurosystem Expanded Asset Purchase Programme: A Structural Model-Based Analysis.’ *IMF Economic Review* 67(2), 315–348
- Curcuru, Stephanie E., Steven B. Kamin, Canlin Li, and Marius del Giudice Rodriguez (2018) ‘International Spillovers of Monetary Policy : Conventional Policy vs. Quantitative Easing.’ International Finance Discussion Papers 1234, Board of Governors of the Federal Reserve System (U.S.), August

- Dedola, Luca, Giulia Rivolta, and Livio Stracca (2017) ‘If the Fed sneezes, who catches a cold?’ *Journal of International Economics* 108(S1), 23–41
- Eggertsson, Gauti B., and Michael Woodford (2003) ‘The Zero Bound on Interest Rates and Optimal Monetary Policy.’ *Brookings Papers on Economic Activity* 34(1), 139–235
- Georgiadis, Georgios, and Marek Jarocinski (2023) ‘Global Spillovers from Multi-dimensional US Monetary Policy.’ ECB Working Papers forthcoming, European Central Bank
- Gertler, Mark, and Peter Karadi (2013) ‘QE 1 vs. 2 vs. 3. . . : A Framework for Analyzing Large-Scale Asset Purchases as a Monetary Policy Tool.’ *International Journal of Central Banking* 9(1), 5–53
- Gurkaynak, Refet S, Brian Sack, and Eric Swanson (2005) ‘Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements.’ *International Journal of Central Banking* 1(1), 55–93
- Hohberger, Stefan, Romanos Priftis, and Lukas Vogel (2019) ‘The macroeconomic effects of quantitative easing in the euro area: Evidence from an estimated DSGE model.’ *Journal of Economic Dynamics and Control* 108(C), 103756
- Iacoviello, Matteo, and Gaston Navarro (2018) ‘ Foreign effects of higher U.S. interest rates.’ *Journal of International Money and Finance*
- Jarocinski, Marek (2021) ‘Estimating the Fed’s Unconventional Policy Shocks.’ Working Paper Series 20210, European Central Bank, August
- Jarociński, Marek, and Peter Karadi (2020) ‘Deconstructing Monetary Policy Surprises - The Role of Information Shocks.’ *American Economic Journal: Macroeconomics* 12(2), 1–43
- Jordà, Òscar (2005) ‘Estimation and Inference of Impulse Responses by Local Projections.’ *American Economic Review* 95(1), 161–182
- Kiley, Michael T. (2014) ‘The Aggregate Demand Effects of Short- and Long-Term Interest Rates.’ *International Journal of Central Banking* 10(4), 69–104
- Kitagawa, Evelyn M. (1955) ‘Components of a Difference Between Two Rates.’ *Journal of the American Statistical Association* 50(272), 1168–1194
- Kolasa, Marcin, and Grzegorz Wesołowski (2020) ‘International spillovers of quantitative easing.’ *Journal of International Economics* 126, 103330
- (2023) ‘Quantitative easing in the US and financial cycles in emerging markets.’ *Journal of Economic Dynamics and Control* 149(C), 104631

- Mackowiak, Bartosz (2007) 'External shocks, U.S. monetary policy and macroeconomic fluctuations in emerging markets.' *Journal of Monetary Economics* 54(8), 2512–2520
- Miranda-Agrippino, Silvia, and Giovanni Ricco (2021) 'The transmission of monetary policy shocks.' *American Economic Journal: Macroeconomics* 13(3), 74–107
- Miranda-Agrippino, Silvia, and Helene Rey (2022) 'The global financial cycle.' In 'Handbook of international economics,' vol. 6 (Elsevier) pp. 1–43
- Miranda-Agrippino, Silvia, and Tsvetelina Nenova (2022) 'A tale of two global monetary policies.' *Journal of International Economics* 136(C), 103606
- Miranda-Agrippino, Silvia, Tsvetelina Nenova, and Helene Rey (2020) 'Global Footprints of Monetary Policy.' Discussion Papers 2004, Centre for Macroeconomics (CFM), January
- Monacelli, Tommaso (2005) 'Monetary policy in a low pass-through environment.' *Journal of Money, Credit and Banking* 37(6), 1047–1066
- Mouabbi, Sarah, and Jean-Guillaume Sahuc (2019) 'Evaluating the Macroeconomic Effects of the ECB's Unconventional Monetary Policies.' *Journal of Money, Credit and Banking* 51(4), 831–858
- Oaxaca, Ronald (1973) 'Male-Female Wage Differentials in Urban Labor Markets.' *International Economic Review* 14(3), 693–709
- Ricco, Giovanni, Riccardo Degasperi, and Simon Hong (2020) 'The Global Transmission of U.S. Monetary Policy.' CEPR Discussion Papers 14533, C.E.P.R. Discussion Papers, March
- Smith, A. Lee, and Victor J. Valcarcel (2023) 'The financial market effects of unwinding the federal reserve's balance sheet.' *Journal of Economic Dynamics and Control* 146, 104582
- Swanson, Eric T (2020) 'Measuring the effects of federal reserve forward guidance and asset purchases on financial markets.' *Journal of Monetary Economics*
- Tillmann, Peter (2016) 'Unconventional monetary policy and the spillovers to emerging markets.' *Journal of International Money and Finance* 66(C), 136–156
- Wu, Jing Cynthia, and Fan Dora Xia (2016) 'Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound.' *Journal of Money, Credit and Banking* 48(2-3), 253–291

Appendix Key derivations

While presenting the derivations, we assume a more general environment in which agents have access to the whole array of bonds with different maturities up to N periods. The model described in the main text is obtained by setting $N = 2$.

Passive investors Passive investors can only purchase L -period bonds, where $L = 2, 3, \dots, N$, and hold them to maturity. Their budget constraint is

$$P_t c_t^P + \sum_{L=2}^N P_{L,t} B_{L,t}^P + \sum_{L=2}^N Q_t P_{L,t}^* B_{L,t}^{P*} \leq Y_t^P + \sum_{L=2}^N B_{L,t-L}^P + \sum_{L=2}^N Q_t B_{L,t-L}^{P*} \quad (\text{A.1})$$

Note that passive investors buy these bonds in the market, thus $P_{L,t} = (R_{L,t})^{-L}$, where $R_{L,t}$ is the L -period bond yield-to-maturity. The first-order conditions describing their optimal bond holdings are

$$\lambda_t^P = \beta^L (R_{L,t})^L \mathbb{E}_t \left\{ \lambda_{t+L}^P \frac{P_t}{P_{t+L}} \right\} \quad (\text{A.2})$$

$$\lambda_t^P = \beta^L (R_{L,t}^*)^L \mathbb{E}_t \left\{ \lambda_{t+L}^P \frac{P_t}{P_{t+L}} \frac{Q_{t+L}}{Q_t} \right\} \quad (\text{A.3})$$

where λ_t^P/P_t is the Lagrange multiplier on passive investors' budget constraint.

Active investors Active investors have additionally access to one-period bonds denominated in domestic currency, and they can also trade all types of long-term bonds on the secondary market. Whenever these agents take a position in long-term bonds, they incur transaction cost ξ_t on domestic currency bonds and ξ_t^* on foreign currency bonds, both of which are external to individual agents. Active investors' budget constraint is

$$P_t c_t^A + \frac{D_t^A}{R_t} + \sum_{i=2}^N P_{i,t} B_{i,t}^A (1 + \xi_t) + \sum_{i=2}^N P_{i,t} B_{i,t}^A (1 + \xi_t) \leq Y_t^A + D_{t-1}^A + \sum_{i=2}^N P_{i-1,t} B_{i,t-1} \quad (\text{A.4})$$

The first-order conditions associated with trade in bonds are

$$\lambda_t^A = \beta R_t \mathbb{E}_t \left\{ \lambda_{t+1}^A \frac{P_t}{P_{t+1}} \right\} \quad (\text{A.5})$$

$$\lambda_t^A P_{L,t} (1 + \zeta_t) = \beta \mathbb{E}_t \left\{ P_{L-1,t+1} \lambda_{t+1}^A \frac{P_t}{P_{t+1}} \right\} \quad (\text{A.6})$$

$$\lambda_t^A P_{L,t}^* (1 + \zeta_t^*) = \beta \mathbb{E}_t \left\{ P_{L-1,t+1}^* \lambda_{t+1}^A \frac{P_t}{P_{t+1}} \frac{Q_{t+1}}{Q_t} \right\} \quad (\text{A.7})$$

Note that $P_{1,t} = 1$ so that investors are indifferent between short-term bonds and long-term bonds that mature in one period.

Term structure Log-linearizing equation A.6 for maturity L can be written as

$$\hat{\lambda}_t^A + \hat{P}_{L,t} + \xi_t = \mathbb{E}_t \hat{P}_{L-1,t+1} + \mathbb{E}_t \hat{\lambda}_{t+1}^A - \mathbb{E}_t \hat{\pi}_{t+1} \quad (\text{A.8})$$

where $\pi_t \equiv P_t/P_{t-1}$ is (gross) inflation rate. If we iterate the equation above forward $L-1$ times, each time using bonds with maturity one period shorter, we obtain

$$\hat{\lambda}_t^A + \hat{P}_{L,t} + \sum_{s=0}^{L-1} \mathbb{E}_t \xi_{t+s} = \mathbb{E}_t \hat{\lambda}_{t+L}^A - \sum_{s=1}^L \mathbb{E}_t \hat{\pi}_{t+s} \quad (\text{A.9})$$

Similarly, iterating forward the log-linearized equation A.5 yields

$$\hat{\lambda}_t^A = \sum_{s=0}^{L-1} \mathbb{E}_t \hat{R}_{t+s} + \mathbb{E}_t \hat{\lambda}_{t+L}^A - \sum_{s=1}^L \mathbb{E}_t \hat{\pi}_{t+s} \quad (\text{A.10})$$

After combining the last two equations, we obtain

$$\hat{P}_{L,t} = - \sum_{s=0}^{L-1} \mathbb{E}_t \hat{R}_{t+s} - \sum_{s=0}^{L-1} \mathbb{E}_t \xi_{t+s} \quad (\text{A.11})$$

By applying the definition of yield-to maturity, we get the term structure of interest rates

$$\hat{R}_{L,t} = \frac{1}{L} \left(\sum_{s=0}^{L-1} \mathbb{E}_t \hat{R}_{t+s} + \sum_{s=0}^{L-1} \mathbb{E}_t \xi_{t+s} \right) \quad (\text{A.12})$$

Setting $L = 2$ yields equation 8 in the main text.

Aggregate Euler condition Log-linearizing equation A.2, which describes optimal domestic bond holdings by passive agents yields

$$\hat{\lambda}_t^P - L \hat{R}_{L,t} = \mathbb{E}_t \hat{\lambda}_{t+L}^P - \sum_{s=1}^L \mathbb{E}_t \hat{\pi}_{t+s} \quad (\text{A.13})$$

Let us define aggregate marginal utility as population-weighted geometric mean of marginal utility of the two types of agents, which after log-linearization reads

$$\hat{\lambda}_t \equiv \omega \hat{\lambda}_t^P + (1 - \omega) \hat{\lambda}_t^A$$

Using this definition with equations A.13 and A.10, we get

$$\hat{\lambda}_t = \omega L \hat{R}_{L,t} + (1 - \omega) \sum_{s=0}^{L-1} \mathbb{E}_t \hat{R}_{t+s} + \mathbb{E}_t \hat{\lambda}_{t+L}^A - \sum_{s=1}^L \mathbb{E}_t \hat{\pi}_{t+s} \quad (\text{A.14})$$

Now use equation A.12 to obtain

$$\hat{\lambda}_t = \sum_{s=0}^{L-1} \mathbb{E}_t \hat{R}_{t+s} + \omega \sum_{s=0}^{L-1} \mathbb{E}_t \xi_{t+s} + \mathbb{E}_t \hat{\lambda}_{t+L} - \sum_{s=1}^L \mathbb{E}_t \hat{\pi}_{t+s} \quad (\text{A.15})$$

This is equivalent to iterating forward the following formula

$$\hat{\lambda}_t = \hat{R}_t + \omega \xi_t + \mathbb{E}_t \hat{\lambda}_{t+1} - \mathbb{E}_t \hat{\pi}_{t+1} \quad (\text{A.16})$$

which is equation 9 used in the main text after we use the assumption of prices being perfectly sticky in the currency of destination markets.

UIP condition Log-linearizing equation A.3 and combining it with equation A.13 yields

$$L \hat{R}_{L,t} - \sum_{s=1}^L \mathbb{E}_t \hat{\pi}_{t+s} = L \hat{R}_{L,t}^* - \sum_{s=1}^L \mathbb{E}_t \hat{\pi}_{t+s}^* + \mathbb{E}_t \hat{q}_{t+L} - \hat{q}_t \quad (\text{A.17})$$

and can be interpreted as an L -horizon uncovered interest parity condition. If we use the term structure equation A.12 and its foreign equivalent to eliminate domestic and foreign long-term rates, we obtain

$$\sum_{s=0}^{L-1} \mathbb{E}_t \left\{ \hat{R}_{t+s} + \xi_{t+s} \right\} - \sum_{s=1}^L \mathbb{E}_t \hat{\pi}_{t+s} = \sum_{s=0}^{L-1} \mathbb{E}_t \left\{ \hat{R}_{t+s}^* + \xi_{t+s}^* \right\} - \sum_{s=1}^L \mathbb{E}_t \hat{\pi}_{t+s}^* + \mathbb{E}_t \hat{q}_{t+L} - \hat{q}_t \quad (\text{A.18})$$

This equation is equivalent to iterating forward the following formula

$$\hat{q}_t = \hat{R}_t^* + \xi_t^* - \mathbb{E}_t \hat{\pi}_{t+1}^* - \hat{R}_t - \xi_t - \mathbb{E}_t \hat{\pi}_{t+1} + \mathbb{E}_t \hat{q}_{t+1} \quad (\text{A.19})$$

which collapses to equation (11) in the main text when prices (expressed in local currency) are perfectly sticky.



UNIVERSITY OF WARSAW

FACULTY OF ECONOMIC SCIENCES

44/50 DŁUGA ST.

00-241 WARSAW

WWW.WNE.UW.EDU.PL