Working Papers

FEDERAL RESERVE BANK OF BOSTON™

No. 24-9

Explaining the Great Moderation Exchange Rate Volatility Puzzle

Vania Stavrakeva and Jenny Tang

Abstract:
In this paper, we study how the volatility of both realized and expected macroeconomic variables relates to the variation in exchange rate volatility through the prism of the Great Moderation hypothesis. We find significant heterogeneity in exchange rate trend volatility across currency pairs despite decreases in the volatility of expected future interest rate differentials and of realized yields themselves. We argue that time variation in the relationship between macroeconomic variables and exchange rates has prevented the Great Moderation in realized yield volatility from translating to a decrease in exchange rate volatility. Considering a Campbell-Shiller-type decomposition of exchange rate changes into forward-looking components linked to inflation, policy rate, and currency risk premia expectations, we find that the Great Moderation in volatility of expected yield differentials cannot explain the patterns in exchange rate volatility we observe. The main drivers of these patterns were trends in the volatility of the currency risk premium component and in the covariance between the components capturing the strength of the Fama puzzle and the expected responsiveness of monetary policy to inflation.

JEL Classifications: E44, F31, G15
Keywords: Exchange rates, international finance, volatility trends, risk premia, Fama puzzle

---

Vania Stavrakeva (vstavrakeva@london.edu) is an assistant professor of economics at the London Business School. Jenny Tang (jenny.tang@bos.frb.org) is a vice president and economist at the Federal Reserve Bank of Boston.

The authors thank Nikhil Rao for providing invaluable research assistance on this project. They also thank Pierre-Olivier Gourinchas, Hélène Rey, Kenneth Rogoff, and the participants at various seminars and conferences for their useful comments.

This version: February 2024 **https://doi.org/10.29412/res.wp.2024.09**

1 Introduction

Exchange rate volatility is a key source of macroeconomic and financial uncertainty. It affects production and import/export decisions of firms and even long-run productivity growth for countries with lower levels of financial development (see Aghion et al. (2009)). It also affects the desire of financial firms to intermediate cross-country flows given its impact on the perceived riskiness of cross-currency trades (see Kalemli-Ozcan, Papaioannou, and Peydro (2010)). The interaction between sizable foreign currency borrowing and increased exchange rate volatility often is the harbinger of financial and balance-of-payment crises (see Bruno and Shin (2015), Barajas et al. (2017) and Chui, Kuruc, and Turner (2018)). Not surprisingly, policymakers often directly or indirectly target exchange rate volatility, given its importance for trade/external demand and financial markets' depth and stability, .

Despite the importance of exchange rate volatility, its drivers are not well understood. Notable exceptions in the empirical literature are the papers by Rogoff (2007), Ilzetzki, Reinhart, and Rogoff (2019), and Ilzetzki, Reinhart, and Rogoff (2020), who study the volatility of several currency crosses in the context of the volatility of macroeconomic and financial variables.

Inspired by these studies, we attempt to further explain the time-varying volatility of the seven most liquid currency crosses against the USD (the AUD, CAD, CHF, DEM/EUR, GBP, JPY, and NZD) in the context of the time trends in the volatility of *realized* and *expected* macroeconomic variables.

We have data from slightly more than five decades, which cover several periods of heightened macroeconomic volatility: the oil shocks in the 1980s, the global financial and European sovereign debt crises, the COVID-19 pandemic, and the post-COVID high-inflation period.

We first document the trends in exchange rate volatility and find significant cross-currency heterogeneity. Consistent with the findings in Ilzetzki, Reinhart, and Rogoff (2020), we confirm that there is a persistent downward trend in exchange rate volatility for the CHF, DEM/EUR, and JPY against the USD that has continued over the high-inflation period since COVID-19. However, there appear to be upward trends for the currency of commodity exporters—the AUD, CAD, and NZD—with the trend for the NZD appearing only in the most recent part of the sample.[1]

Next, we revisit the pattern of declining macroeconomic volatility since the mid-1980s, known as the Great Moderation, by extracting common factors from the time-varying volatil-

[1]The GBP does not fit the pattern of either group and appears to have undergone a regime shift, with a sharp drop in volatility in the early 2000s but slight upward trends in volatility both before and after this structural break.

ity of several key macroeconomic variables in both country i and the United States for each currency pair—namely, inflation, the quarterly change in 10-year yields, the quarterly growth rate of industrial production, and the change in the unemployment rate. Three factors capture almost all the variation in the time-varying volatility of these eight series. Using a rotation of the factors that provides a clear interpretation of each one results in factors that have roughly equal importance in explaining the overall variation in volatility. These include a Great Moderation factor, which captures declines in the volatility of yields mainly and to a lesser degree declines in the volatility of non-US inflation; a Global Financial Crisis (GFC) factor, which captures the increased volatility during the GFC, primarily of US inflation; and a COVID-19 factor, which captures the increased volatility of unemployment and industrial production over the COVID-19 period.[2]

We then examine the extent to which these same macroeconomic forces can explain the time-varying exchange rate volatility. We do so by first estimating time-varying relationships among exchange rate changes and these macroeconomic variables. We find that over time, the average adjusted R^2 across currency pairs from these regressions ranges from 23 to 37 percent and regularly exceeds 50 percent. We then construct the fitted values based on these time-varying relationships, which capture both the time variation in the estimated coefficients and the time variation in the macroeconomic series themselves. We show that the volatility of these fitted values indeed co-moves closely with the exchange rate volatility, explaining a large fraction of the overall exchange rate volatility and the volatility trends. To isolate the impact of the volatility of the macroeconomic variables on exchange rate volatility, we construct a second fitted value measure that fixes the estimated coefficients at their average over time and construct its volatility. Notably, the volatility of this measure decreases over time and closely tracks the Great Moderation volatility factor, although it explains only a small fraction of overall exchange rate volatility. This result suggests that the time-varying relationships between exchange rates and macroeconomic variables and how they interact with the level of the macroeconomic variables is key to how macroeconomic volatility propagates to exchange rate volatility.

After studying the link between the volatility of *realized* macroeconomic variables and exchange rate volatility, we turn to the link between the volatility of *expected* macroeconomic

[2]The Great Moderation literature identifies several potential drivers of lower real growth or real rate volatility. They range from better policies and better inventory management to "good luck." See Benati and Surico (2009), Summers (2005), and Morley and Singh (2016) for a more recent review of the Great Moderation literature. Note that these papers focus on a period before the GFC. As we document in this paper, the volatility patterns have changed since the GFC, and the most robust result is around a Great Moderation of realized yield volatility. Our paper also relates to the literature studying the Mussa puzzle, which argues that exchange rate volatility is disconnected from macroeconomic volatility in the post-Bretton Woods period (for recent research on this topic, see Itskhoki and Mukhin 2022).

variables and exchange rates. Exchange rates, like any other asset price, are a forward-looking variable and, as such, are a function of revisions in expectations about macroeconomic variables and risk premia. The dynamics of the volatility of expected macroeconomic variables can differ from those of realized macroeconomic variables and can shed more light on the link between exchange rate volatility and macroeconomic volatility.

We decompose the volatility of exchange rates using a novel econometric procedure to estimate a well-known exchange rate change decomposition. Using a simple accounting identity as a starting point, we break down nominal exchange rate changes into a lagged interest rate differential, a lagged currency expected excess return, and changes in expectations over the paths of relative short-term nominal interest rates, relative inflation rates, and excess returns.[3] To estimate the exchange rate change components, we estimate a vector autoregression (VAR), augmented with additional constraints that ensure the VAR-based expectations closely match consensus forecasts from surveys of professional forecasters.[4,5]

Calculating the various exchange rate components by generating expectations that closely match the expectations of professional forecasts is an improvement over the existing, unconstrained VAR approach for two reasons. First, it helps alleviate a well-known downward-bias problem that arises from using small samples when estimating autoregressive VAR coefficients; doing so leads to unrealistically flat medium- and long-run forecasts—a major issue when computing exchange rate components that are *undiscounted* sums of revisions in expectations over future outcomes at all horizons. Second, recent studies argue that professional forecasters' or investors' expectations, as revealed in surveys, correlate strongly with investors' positions in a manner consistent with theory, thus implying that these survey forecast data are a good proxy for the beliefs of the marginal trader.[6]

Once we calculate the various exchange rate change components, we perform a variance-

[3]Throughout the paper, we use "expected excess returns" and "currency risk premia" interchangeably, though we never make any assumptions that would limit the interpretation of expected excess returns to being purely risk premia. Unless otherwise specified, the short-term nominal interest rates in our analysis are rates on three-month government debt, which we often refer to as policy rates.

[4]The estimation technique we use has been employed previously to decompose government bond yields, but to our knowledge, we are the first to use it to decompose exchange rates (see Kim and Wright 2005, Wright 2011, Kim and Orphanides 2012, Piazzesi, Salomao, and Schneider 2015, and Crump, Eusepi, and Moench 2018).

[5]This paper relates closely to studies that decompose the exchange rate using a similar accounting identity (see Froot and Ramadorai 2005, Engel and West 2005; 2006, Engel, Mark, and West 2008, Engel and West 2010, Evans 2012, and Engel 2014; 2016). Some of these papers also perform a variance-covariance decomposition but differ in other respects. Namely, they focus on decomposing the real exchange rate level, do not decompose *trends* in exchange rate volatility over time, and, most importantly, do not use survey data in the estimation of the forward-looking components.

[6]See Stavrakeva and Tang (2023) for exchange rate expectations, De Marco, Macchiavelli, and Valchev (2022) for interest rate expectations, and Greenwood and Shleifer (2014) and Giglio et al. (2021) for equity returns expectations.

covariance decomposition of the exchange rate change at a quarterly frequency. We find that the interest rate and inflation components are approximately 0.27 and 0.17 times as volatile as the nominal exchange rate change itself. The *subjective* currency risk premium component explains the majority of exchange rate volatility.

Notably, we also find that two of the covariance terms are important drivers of the overall exchange rate volatility. Over the full sample (1990 through 2023), higher expected future interest rates in country i relative to the United States are associated with higher expected future excess returns from being long the three-month government bond of country i and short the US three-month government bond. This covariance term has contributed to lower exchange rate volatility and echoes the well-known Fama puzzle (see Fama 1984), namely that a higher realized excess return from being long currency i and short the USD is associated with a higher interest rate differential in country i relative to the United States. Another way to interpret this result is that agents expect to make positive profits from the carry trade strategy. A stronger Fama puzzle, reflected in this covariance being more negative, translates into lower exchange rate volatility. The average contribution of this component to overall exchange rate variance over our sample was -24 percent.[7]

A second covariance term that has, on average, contributed to lower exchange rate change volatility implies that higher expected future interest rates in country i relative to the United States are associated with expected future inflation that is higher in country i than in the United States, which is consistent with short-term rates being predominantly driven by monetary policy that raises rates when inflation is high. The average contribution of this covariance term to exchange rate volatility was –18 percent.

Next, we turn to trend volatility (and co-movement) of the subcomponents, which sum up to the trend volatility of realized exchange rate changes. We see that the Great Moderation period's decrease in the volatility of realized yields does not translate into lower volatility of the revisions in expectations over the policy rate path for five of the eight countries. This could be due to either the role of forward guidance or increased sensitivity of market expectations to news. That being said, the volatility of the revisions in expectations over the *relative* policy rates has decreased for five of the seven currency crosses due to the higher covariance over time between the expected policy rate paths in country i and in the United States. In other words, it appears that global monetary policy has become more correlated with US monetary policy, and this is reflected in market expectations. We further find

[7]Note that in contrast to the Fama puzzle and the carry trade literature, our results assume subjective expectations, which allows for deviation from full information rational expectations (FIRE), and we consider expectations of the entire future path of subjective currency risk premia and interest rates. For recent research studying the drivers of subjective currency risk premia, see Stavrakeva and Tang (2023) and Kalemli-Ozcan and Varela (2022).

that the volatility of the component that captures revisions in expectations over the *relative* inflation paths actually increased for all currency crosses except one.

What emerges as the Great Moderation exchange rate volatility puzzle is that the forward-looking inflation and policy rate components from the exchange rate change decomposition do not directly contribute to the decrease in exchange rate volatility of CHF, DEM/EUR, and JPY because they have jointly pushed toward higher exchange rate trend volatility. The opposite is true for the commodity-producing currencies AUD, CAD, and NZD, where the inflation and policy rate components contribute to the lower exchange rate volatility trend while the overall exchange rate volatility for these countries actually increased over the sample.

Starting with the three crosses where we see a significant decrease in trend volatility (CHF, DEM/EUR, and JPY), the main source of the decrease in this volatility appears to be the declining variance of the currency risk premium term.[8] This paper does not shed additional light on why the volatility of the revisions in expectations over the subjective excess currency return has decreased over time for these three financial center currencies. Doing so requires a structural model of the subjective currency risk premium, which is beyond the scope of this paper, whose goal is to document trends in the volatility of exchange rates and their subcomponents in a model-free way. Theoretical papers that microfound the currency risk premium include Hassan (2013), Colacito et al. (2018), Farhi and Gabaix (2016), Stavrakeva and Tang (Forthcoming b; 2023) and Gourinchas and Rey (2022), among many others. They are a good starting point for disentangling the source of this decline in the volatility of the currency risk premium component of financial center currencies.[9]

Regarding the currencies of the commodity producers, the first main source of higher exchange rate trend volatility is the weakening of the Fama puzzle. Baillie and Bollerslev (2000), Burnside (2019), and Engel et al. (2022) find similar results using realized exchange rate changes and interest rate differential, which is more in line with the original puzzle. Prior to the GFC, the commodity currencies we consider, particularly NZD and AUD, were the currencies of the "receiving" country in the carry trade, where the United States was the "funding" country. The weakening of the expected Fama puzzle in the recent period for these currencies could be driven by smaller carry trade positions resulting from narrowing

[8]Additionally, for the CHF and DEM/EUR, the strengthening of the Fama puzzle also contributed to lower volatility, as did the forward-looking relative yield component for CHF to a limited extent.

[9]Among this list of papers, Stavrakeva and Tang (Forthcoming b; 2023) are the only two that also feature a model that deviates from FIRE (that is, a model of the subjective rather than objective currency risk premium), which maps more directly to the exercise we perform in this paper, granted the significant deviation from FIRE previously documented in survey data of exchange rate expectations (see, for example, Stavrakeva and Tang (Forthcoming a)).

interest rate differentials with respect to the United States and from the smaller risk-bearing capacity of global banks since the GFC due to more regulation. Smaller carry trade positions mechanically would be associated with less severe carry trade unravelling episodes, which are often the source of sizable depreciation of the currency of the "receiving" countries. The fewer tail events there are, in terms of currency depreciation, the lower the expected carry trade returns should be, given that the carry trade is less risky (see, for example, Brunnermeier, Nagel, and Pedersen 2009 and Dobrynskaya 2014), thus weakening the expected Fama puzzle for commodity producers.[10]

The second reason for the higher exchange rate trend volatility of the commodity producers is the weakening of the relationship between expected relative inflation and policy rate paths. This result potentially reflects that monetary policy has been expected to respond less to domestic inflation movements over time, which can be the result of monetary policy becoming more effective, as inflation expectations have become better anchored. Thus, smaller movements in interest rates are needed to achieve the target inflation. Note that this result also remains over the recent high-inflation episode.

Finally, our trend volatility results are robust to excluding the COVID-19 and GFC periods or to excluding tail events associated with extreme exchange rate change movements.

The paper proceeds as follows. Section 2 presents facts about exchange rate volatility and *realized* macroeconomic volatility. Section 3 outlines a decomposition of exchange rate changes that links exchange rate volatility to *expected* macroeconomic volatility and relies on only a definition of the expected excess one-period currency returns. Section 3.1 describes our survey-augmented VAR methodology, which is used to construct the components of the decomposition outlined in the previous section, and discusses the survey data that we use. Section 4 presents a broad overview of the results from our decomposition and the baseline variance-covariance decomposition of the volatility of exchange rate changes. Section 5 discusses the drivers of trends in realized time-varying exchange rate change volatility through the prism of the decomposition components. Section 6 concludes.

2 Exchange Rate and Macroeconomic Volatility

In this section, we construct time-varying exchange rate and macroeconomic volatility measures and document the patterns over the past five decades. Moreover, we attempt to understand the extent to which changes in the volatility of *realized* macroeconomic variables transmit to exchange rate volatility and the key channels involved in this relationship.

[10]Some of the theoretical papers we cite in the preceding paragraph also provide a microfoundation for the carry trade, which would be consistent with this explanation.

First, we present plots of the quarterly exchange rate change volatility. We use monthly data from January 1973 through July 2023. s_t is the log of the nominal exchange rate defined as units of currency i per USD, and the one-quarter exchange rate change is constructed as $s_t - s_{t-3}$. The currencies we study against the USD are the CHF, JPY, GBP, DEM/EUR, AUD, CAD, and NZD. Figure 1 presents rolling variances of these changes using a 60-month rolling window, along with time trends starting in 1973 and 1998 (over the last 50 and 25 years, respectively).

If one considers the whole sample, there is a large degree of heterogeneity across currency pairs. Exchange rate volatility has been trending downward for the large financial centers' currencies: the DEM/EUR, CHF, and JPY. For the GBP, there appears to be a regime shift in which exchange rate volatility fell abruptly in the mid- to late 1990s, followed by a slight upward trend since then. The opposite appears to be true for the largest commodity producers. The volatility of the AUD and of the CAD against the USD appears to have increased over time, while there is not much of a trend in the volatility of the NZD.

The lack of consistent patterns in exchange rate volatility across currencies might seem puzzling, given that it has been hypothesized that macroeconomic volatility has decreased over time. Recent sizable macroeconomic shocks due to the GFC and COVID-19 pandemic have cast doubt on whether the Great Moderation period of macroeconomic volatility has come to an end. This could explain the heterogeneous trends we observe in exchange rate volatility.

To address this hypothesis, we re-examine whether we indeed see a great moderation of macroeconomic volatility in the country pairs that we consider. For each country pair, we perform a principal component analysis of the 60-month rolling variances of key macroeconomic variables in each country and extract the three most important components. The set of variables we consider are included in the following matrix:

$$\mathbf{X}_t = [\pi^{i}_{t,t-3}, \pi^{us}_{t,t-3}, \Delta ur^{i}_{t,t-3}, \Delta ur^{us}_{t,t-3}, \Delta y^{10y,i}_{t,t-3}, \Delta y^{10y,us}_{t,t-3}, \Delta ip^{i}_{t,t-3}, \Delta ip^{us}_{t,t-3}],$$

where $\pi_{t,t-3}$ is the one-quarter inflation rate, $\Delta ur_{t,t-3}$ is the quarterly change in the unemployment rate, $\Delta y^{10y}_{t,t-3}$ is the quarterly change of the 10-year government debt yield, and $\Delta ip_{t,t-3}$ is the quarterly change of the log industrial production index.

The rotated factors are plotted in Figure 2, for which we use a varimax rotation that produces factors such that each variable loads primarily on a single factor—a method that produces factors that are easier to interpret. They explain jointly the vast majority of the variation in the macroeconomic series—from 79 to 95 percent of the overall variation in the rolling volatilities of these macroeconomic variables—with the three factors being about equally important in explanatory power. One of the three factors is always downward trending, so we label it as the Great Moderation factor. It explains 22 to 38 percent of the overall variation. The variables that load the most on this factor are the quarterly changes in long-term yields for both country i and the United States and, to a lesser degree, inflation in country i. The second factor captures the heightened volatility of macroeconomic variables during the GFC, which is why we label it the GFC factor. It explains 15 to 33 percent of the overall variation. The variable that loads the most on this factor is US inflation. Finally, the last macroeconomic variance factor is elevated only during the COVID-19 pandemic, and we label it the COVID factor. It explains 25 to 47 percent of the overall variation. The variables that load the most on this factor are the unemployment rate and the industrial production of the United States and of country i, for most countries.

Next, we examine which one of these macroeconomic volatility factors, if any, can explain the link between macroeconomic volatility and exchange rate volatility. We do so by performing a two-stage exchange rate change volatility decomposition, as a function of the volatility of realized macroeconomic variables, accounting for a time-varying relationship between macroeconomic variables and exchange rates.

We recognize that over 50 years, it is inevitable that the relationship between exchange rates and macroeconomic variables has changed. In light of this acknowledgment, we first estimate a time-varying relationship between the quarterly log exchange rate change and the macroeconomic variables in $\mathbf{X}_t$ using rolling regressions with a window of 60 months. We can then express the exchange rate change as follows:

$$\Delta s_{t,t-3} = \beta_t \mathbf{X}_t + \varepsilon_t, \tag{1}$$

where β_t is a row vector estimated by regressing y_t on $\mathbf{X}_t$ for $t \in [t, t-59]$. If the relationship between the macroeconomic variables and the exchange rate is stable over time, $\beta_t \mathbf{X}_t$ will remain close to $\beta_{avg} \mathbf{X}_t$, the full-sample average of β_t, and the link between exchange rate volatility and macroeconomic volatility will be entirely captured by the volatility of the realized macroeconomic variables $\mathbf{X}_t$. Since the principal components we construct are also a linear combination of the time-varying variance of the realized macroeconomic variable, then the variance of $\beta_t \mathbf{X}_t$ should be captured by a subset of our macroeconomic volatility factors. However, if β_t is very volatile, then the time-varying relationship between exchange rates and macroeconomic variables can play a crucial role in explaining the overall volatility of $\beta_t \mathbf{X}_t$. As a result, even if we find that the volatility $\beta_{avg} \mathbf{X}_t$ is trending downward—for example, driven by the Great Moderation volatility factor—the volatility of $\beta_t \mathbf{X}_t$ can still trend upward due to time variation in the relationship between exchange rates and macro variables, β_t, and how β_t interacts with the level of the macroeconomic variables.

We start by reporting the adjusted R^2s in Figure 3 from the first-stage rolling regressions of exchange rate changes on the macroeconomic variables.[11] The explanatory power of the macroeconomic variables exhibits large variations over time. The average adjusted R^2 across countries ranges from 23 to 37 percent, with the explanatory power reaching as much as 50 percent. The adjusted R^2 is much lower (less than 10 percent) in a full-sample regression, suggesting important time variation in the relationship between macroeconomic variables and the exchange rate change.

Based on equation (1), we can examine the importance of macroeconomic volatility as an explanatory variable of exchange rate volatility by plotting the variances of $s_{t,t-3}$ and $\beta_t \mathbf{X}_t$ in Figure 4. The figure indicates that, indeed, macroeconomic volatility can explain a sizable fraction of the exchange rate volatility, which is expected given the high adjusted R^2s we observe in the rolling regressions. Moreover, the trends and overall co-movement of $Var(s_{t,t-3})$ and $Var(\beta_t \mathbf{X}_t)$ are similar, with the exception of GBP/USD, implying that macroeconomic volatility has contributed to the exchange rate volatility patterns that we observe.

Next, we examine the extent to which the volatility of the macroeconomic variables alone, captured by $\beta_{avg} \mathbf{X}_t$, can explain the patterns we observe or whether time variation in β_t is key. Notably, when we plot $Var(\beta_{avg} \mathbf{X}_t)$ in Figure 5, we find that it is downward sloping and greatly resembles the Great Moderation volatility factor. However, $Var(\beta_{avg} \mathbf{X}_t)$ itself can explain only a small fraction of $Var(\beta_t \mathbf{X}_t)$. These results imply that the reason exchange rate volatility has not decreased over time involves the changing relationship between macroeconomic variables and currencies. If the relationship had remained stable over time, as measured by the average rolling regression coefficients, then the Great Moderation volatility factor would be the channel through which macroeconomic volatility is transmitted to exchange rate volatility, and we would have observed a Great Moderation–driven decrease in exchange rate volatility.

In this section, we considered whether the volatility of *realized* macroeconomic variables can explain exchange rate volatility. Exchange rates are forward-looking variables, and therefore the key driver of exchange rates should be macroeconomic news, which makes traders revise their expectations for macroeconomic variables. The volatility of these revisions in expectations for macroeconomic variables due to news might show patterns that are different

[11] The results are similar if we use relative macroeconomic variables, thus decreasing the number of regressors by half. However, since we would like to make our results comparable to the macroeconomic volatility factors obtained from a PCA of non-relative variables, we choose to use non-relative variables in the rolling regressions as well.

from those in the volatility of realized macroeconomic variables.

3 Forward-looking Exchange Rate Decomposition

In this section, we examine the connection between exchange rate volatility and the revision in expectations for the path of macroeconomic variables by performing a well-known exchange rate decomposition in the spirit of the Campbell and Shiller (1988) decomposition. The decomposition can be derived from a definition of the expected excess return from taking a long position in a one-quarter, risk-free bond denominated in USD and a simultaneous short position in a one-quarter, risk-free bond denominated in currency i. We define the expected excess return from this trade as:

$$\lambda_t \equiv \check{E}_t \Delta s_{t+1} - \tilde{\imath}_t, \tag{2}$$

where $\tilde{\imath}_t$ represents the relative one-quarter interest rate differential calculated as country i minus the United States. We use the tilde in the same way with respect to other variables. $\check{E}_t$ is the expectations operator that can capture any beliefs that are consistent with the law of iterated expectations (LIE). Later in the paper, we discipline the beliefs with survey data on expectations from professional forecasters.

Using this definition, we can write the actual change in the exchange rate as:

$$\Delta s_t = \tilde{\imath}_{t-1} + \lambda_{t-1} + \Delta s_t - \check{E}_{t-1} \Delta s_t. \tag{3}$$

Iterating equation (3) forward, we derive the following expression for the level of the nominal exchange rate:

$$s_t = -\check{E}_t \sum_{k=0}^{\infty} \left[\tilde{\imath}_{t+k} + \lambda_{t+k}\right] + \lim_{K \to \infty} \check{E}_t s_{t+K}. \tag{4}$$

Taking the first difference of equation (4) and combining the resulting expression with equation (3) implies that the forecast error can be expressed as:

$$\begin{aligned} \Delta s_t - \check{E}_{t-1} \Delta s_t = & -\underbrace{\sum_{k=0}^{\infty} \left(\check{E}_t \tilde{\imath}_{t+k} - \check{E}_{t-1} \tilde{\imath}_{t+k}\right)}_{\varphi_t^{EH,F}} - \underbrace{\sum_{k=0}^{\infty} \left(\check{E}_t \lambda_{t+k} - \check{E}_{t-1} \lambda_{t+k}\right)}_{\varphi_t^{\lambda,F}} \\ & + \underbrace{\check{E}_t \lim_{K \to \infty} s_{t+K} - \check{E}_{t-1} \lim_{K \to \infty} s_{t+K}}_{\varphi_t^{LR}}. \end{aligned} \tag{5}$$

Equation (5) allows us to express the realized exchange rate change in terms of lagged interest rate differentials and expected excess returns in addition to changes in expectations in (1) contemporaneous and future relative short-term rates, $\varphi_t^{EH,F}$; (2) contemporaneous and future expected excess returns, $\varphi_t^{\lambda,F}$; and (3) long-run nominal exchange rate levels, φ_t^{LR}. If the real exchange rate is trend stationary, the change in expectations over long-run real exchange rate levels will be zero, and φ_t^{LR} will reflect changes in expectations over long-run relative price levels or the entire future path of relative inflation starting from the contemporaneous surprise. More precisely,

$$\begin{aligned}\varphi_t^{LR} &= \lim_{K\to\infty} \check{E}_t\left(s_{t+K}-s_{t-1}\right) - \lim_{K\to\infty} \check{E}_{t-1}\left(s_{t+K}-s_{t-1}\right)\\ &= \lim_{K\to\infty}\sum_{k=0}^{K}\left(\check{E}_t\left[\Delta q_{t+k}+\tilde{\pi}_{t+k}\right]-\check{E}_{t-1}\left[\Delta q_{t+k}+\tilde{\pi}_{t+k}\right]\right)\\ &= \sum_{k=0}^{\infty}\left(\check{E}_t\tilde{\pi}_{t+k}-\check{E}_{t-1}\tilde{\pi}_{t+k}\right),\end{aligned}$$

where the growth rate of the real exchange rate is defined as $\Delta q_{t+k+1} = \Delta s_{t+k+1} - \tilde{\pi}_{t+k+1}$, and $\tilde{\pi}$ is the inflation rate in country i minus the inflation rate in the United States. Combining equations (2) and (5) implies that:

$$\Delta s_t = \underbrace{\tilde{\imath}_{t-1} - \varphi_t^{EH,F}}_{\varphi_t^{EH}} + \underbrace{\lambda_{t-1} - \varphi_t^{\lambda,F}}_{\varphi_t^{\lambda}} + \varphi_t^{LR}. \tag{6}$$

3.1 Estimating the Components

To compute the terms in our decomposition, we need expectations for interest rates, inflation, and exchange rates in all future dates starting in period t. To obtain estimates of these expectations, we would ideally like to have a proxy for the beliefs of the marginal trader.

We choose to proxy these beliefs using data on consensus (that is, average) professional forecasts for exchange rates, three-month interest rates, and inflation at various horizons obtained from Blue Chip and Consensus Economics.

There are several reasons why using survey data on expectations is desirable.

First, the data can mitigate a well-known empirical bias: Estimated autoregressive VAR coefficients tend to be biased downward when small samples are used. This bias leads to flat medium- to long-run forecasts (see Jarocinski and Marcet (2011) and the references within the paper). The bias is particularly problematic when using the VAR-based expectations to calculate the components of the exchange rate change decomposition because they are functions of *undiscounted* infinite sums of expectations. More recent studies mitigate this bias by using long-run priors (see Giannone, Lenza, and Primiceri (2019)) or informative priors on the observables (see Jarocinski and Marcet (2011)), among other methods.

Second, survey data on professional forecasts have been shown to correlate with investors' positions in a theory-consistent way. Stavrakeva and Tang (2023) show that Consensus Economics exchange rate forecasts are consistent with the positions and, hence, beliefs of the average trader in the over-the-counter (OTC) market, which is the largest foreign exchange rate market. De Marco, Macchiavelli, and Valchev (2022) show that during the European sovereign debt crisis, European banks' sovereign debt positions were higher when the bank expected the sovereign bond to have lower yields (higher prices) in the future. The authors also use Consensus Economics survey data to proxy bankers' beliefs. These papers argue that the Consensus Economics survey data are consistent with market participants' positions and, hence, provide support for why they can be used as a proxy for the beliefs of marginal traders, whose expectations are represented in the exchange rate decomposition in equation (6).

Ideally, we would like to have the survey-based forecasts at every horizon in the future. However, survey data on expectations are not available at every horizon. To overcome this obstacle, we use an approach first developed in the term structure literature that decomposes long-term government bond yields into term premia and expectations hypothesis components.[12] More specifically, to obtain the forecasts, we estimate a survey-data augmented VAR described in Section A of the Appendix that can be interpreted as a way to interpolate and extrapolate the average professional forecasts for horizons that are not available in the surveys. The VAR is fairly rich and contains standard macroeconomic variables used to forecast exchange rates, yields, and inflation. Our approach is novel in that we impose additional constraints ensuring that the VAR-based forecasts closely match consensus professional forecasts. More precisely, in addition to minimizing the sum of squared residuals from the VAR, we minimize the sum of squared differences between the survey data expectations and the VAR-implied expectations. For more details, see Section A of the Appendix.

3.2 Fit of the Estimated VAR-based Expectations

To assess the VAR model's ability to fit the survey forecasts, Table 1 presents the ratios of root-mean-square errors (RMSEs) between our baseline model-implied forecasts and actual survey measures to the same measure for a simple OLS estimation of the VAR without the additional survey-matching equations. These relative RMSEs are presented for three-month

[12]Kim and Wright (2005), Kim and Orphanides (2012), Piazzesi, Salomao, and Schneider (2015), and Crump, Eusepi, and Moench (2018) use US survey data to estimate US term premia, while Wright (2011) uses survey data to estimate term premia for a set of developed countries that largely overlaps with the set considered in this study.

interest rates, nominal exchange rates, and inflation.[13] The model augmented with survey data should, by definition, produce a better fit of the survey data expectations, indicated by values of less than one in this table. The measures of fit in this table illustrate that the improvement can be substantial.

In general, the results in this table show that a standard estimate of the VAR, one that excludes survey data, poorly mimics the behavior of private-sector forecasts, particularly for horizons longer than one quarter or the current year.[14] For horizons of a year or longer, our baseline estimates fit the survey data with RMSEs that are only about one-third of the RMSEs of an estimation without survey data and often even smaller.

Figures 6 through 11 plot survey forecasts against model-implied fits for a few select countries for both the VAR with and without survey data; we refer to the latter specification as the OLS specification. One can clearly see how augmenting the VAR model with survey data improves several qualitative aspects of the model-implied forecasts. One notable feature seen in Figure 6 is that, unlike with the estimation without forecast data, including survey forecasts in the estimation results in no violations of the ZLB in 12-month-ahead, three-month bill rate forecasts. Figure 7 shows that the model without forecast data produces long-horizon, three-month interest rate forecasts that are unrealistically smooth and low for the United States and Germany/the eurozone. By contrast, our model, because it uses survey data in the estimation, more closely mimics the variation in long-horizon survey forecasts.

The one-year-ahead inflation forecasts seen in Figure 8 are realistically less volatile when we add survey data to the estimation, particularly for the United Kingdom and Germany/the eurozone. Figure 9 shows that the estimation with survey data matches the slow-moving downward trend in long-horizon inflation forecasts over this sample. An estimation without survey data produces counterfactual long-horizon forecasts that trend upward for Germany/the eurozone over time.

Lastly, Figures 10 and 11 show that our VAR specification is capable of producing a very close fit of exchange rate level forecasts, even at a 24-month horizon, and currency premia based on survey data for a variety of currencies.

[13] Note that although we match relative interest rates in the estimation, this table presents statistics of the fit of country-specific interest rates.

[14] When evaluating these fits, it is important to consider that the number of observations decreases with the forecast horizon and that the longest forecast horizons suffer the most. For example, due to the timing of the survey, data for the two-year horizon are generally available only annually and can include as few as 10 to 20 observations, depending on the country.

4 The Exchange Rate Change Sub-components: A Broad Overview

In this section, we first plot and discuss the subcomponents of the exchange rate change decomposition, then we perform a variance-covariance decomposition of the quarterly exchange rate change based on equation (6).

We start by plotting the country-specific subcomponents of $\varphi_t^{EH,F}$=$\varphi_t^{EH,F,i}$-$\varphi_t^{EH,F,us}$ and $\varphi_t^{LR} = \varphi_t^{LR,i} - \varphi_t^{LR,us}$. Figure A1 plots $\varphi_t^{EH,F,i}$ against the quarterly change of the 10-year government yield. We find a very strong positive correlation ranging from 0.6 to 0.8. This correlation implies that upward revisions of expectations over the entire future path of short-term rates in the United States coincide with increases in US 10-year yields. This is reassuring because 10-year yields themselves consist of the change of future short-term rate expectations and term premia, where the former should correlate very strongly with our $\varphi_t^{EH,F,i}$ measure if our measure correctly captures market expectations. Figure A2 in the Appendix plots $\varphi_t^{LR,i}$ against actual quarterly inflation. The correlation between the two series ranges from 0.3 to 0.7, where higher inflation is associated with upward revisions of the expected future inflation path of the given country, as one might expect.

Delving deeper into the exchange rate change subcomponents, Figures A3, A4, and A5 plot Δs_t against the currency risk premia components (both lagged and forward-looking), the interest rate differential components (both lagged and forward-looking), and the inflation forward-looking component, respectively. One can clearly see that the lagged components are much less volatile than the forward-looking components and that changes in expected future currency risk premia are the most volatile component.

To explore this finding more formally, we perform a variance-covariance decomposition over the entire sample of the exchange rate change based on our estimated components in equation (6). The purpose of this decomposition is to assess how much the different components of the nominal exchange rate change and how much the interactions (covariances) between them contribute to the overall variation in exchange rates over the whole sample.

Note that using our decomposition, we can express the variance of the exchange rate change as the sum of variances and the covariances of all the exchange rate change components as follows:

$$\begin{aligned} Var\left(\Delta s_t\right) =& Var\left(\varphi_t^{EH}\right) + Var\left(\varphi_t^{\lambda}\right) + Var\left(\varphi_t^{LR}\right) \\ &+ 2Cov\left(\varphi_t^{EH}, \varphi_t^{\lambda}\right) + 2Cov\left(\varphi_t^{EH}, \varphi_t^{LR}\right) + 2Cov\left(\varphi_t^{LR}, \varphi_t^{\lambda}\right). \end{aligned} \tag{7}$$

The estimates of these variances and covariances for each currency against the USD are reported in Table 2.

Over the entire sample, the ratios of variances, averaged across all currencies against the USD, are $\frac{Var\left(\varphi_t^{EH}\right)}{Var(\Delta s_t)} = .27$, $\frac{Var\left(\varphi_t^{LR}\right)}{Var(\Delta s_t)} = .17$, and $\frac{Var\left(\varphi_t^{\lambda}\right)}{Var(\Delta s_t)} = 1.08$. Importantly, we note that the forward-looking components that reflect new information received in period t ($-\varphi_t^{EH,F} - \varphi_t^{\lambda,F} + \varphi_t^{LR}$) are generally as volatile as the exchange rate change itself.

We observe the following patterns regarding the covariance terms in equation (7). The term $Cov\left(\varphi_t^{EH}, \varphi_t^{\lambda}\right)$ is negative, on average, over our sample and contributes to a lower exchange rate variance.[15] A negative value of $Cov\left(\varphi_t^{EH}, \varphi_t^{\lambda}\right)$ means that higher expected future interest rates in country i relative to the United States (higher $\varphi_t^{EH,F}$) are associated with higher expected future excess returns from being long the three-month government bond of country i and short the US three-month government bond (lower $\varphi_t^{\lambda,F}$). In terms of magnitude, it can be a very important component of the exchange rate change variance-covariance decomposition, where $2\frac{Cov\left(\varphi_t^{EH},\varphi_t^{\lambda}\right))}{Var(\Delta s_t)}$ ranges from –0.58 to 0.03, with an average value across all currency pairs of –0.24.

This result is consistent with the Fama puzzle, namely that a higher realized excess return from being long currency i and short the USD is associated with a higher interest rate differential in country i relative to the United States. It also supports the carry trade literature's finding that portfolios that are long high interest rate currencies and short low interest rate currencies tend to have high excess returns and Sharpe ratios on average (see the references in Brunnermeier, Nagel, and Pedersen 2009 and Burnside 2019).

The negative $Cov\left(\varphi_t^{EH}, \varphi_t^{LR}\right)$ term also contributes to lower exchange rate change volatility and implies that higher expected future interest rates in country i relative to the United States (higher $\varphi_t^{EH,F}$) are associated with higher expected future inflation in country i relative to the United States (higher φ_t^{LR}). This is consistent with short-term rates being predominantly driven by monetary policy that raises rates when inflation is high. This component can also be a very important driver of the overall variation in the exchange rate change. $2\frac{Cov\left(\varphi_t^{EH},\varphi_t^{LR}\right))}{Var(\Delta s_t)}$ ranges from –0.49 to –0.06, with an average value across all currency pairs of –0.18.

Finally, $Cov\left(\varphi_t^{LR}, \varphi_t^{\lambda}\right)$ tends to be negative but fairly small, in absolute value, for many currency pairs, with the exception of JPY and CHF, for which it is the most negative. A negative value implies that a higher expected inflation path in country i relative to the United States is associated with higher expected excess returns from being long the USD and short currency i going forward ($\varphi_t^{\lambda,F}$). $2\frac{Cov\left(\varphi_t^{LR},\varphi_t^{\lambda}\right))}{Var(\Delta s_t)}$ ranges from –0.35 to 0.08, with an

[15]It is positive for the currencies of the carry trade "funding" countries with respect to the USD, CHF, and JPY, but also very small.

average value across all currency pairs of –0.1.

To summarize, using a subjective-belief-based estimation of a forward-looking exchange rate decomposition, we find that the most volatile component of exchange rate changes is the component related to the expected future excess returns. This result highlights the importance of allowing for sizable subjective currency risk premia in our exchange rate models. Moreover, the volatility of the interest rate and inflation components is still sizable. However, more notable is the importance of the covariance terms across the various exchange rate subcomponents. As we discuss in the next section, these covariance terms play an important role in explaining the volatility trends for some currencies.

5 Decomposing Exchange Rate Volatility Trends

In this section, we use our decomposition to analyze the drivers of trends in exchange rate volatility. To do so, we construct estimates of the rolling variance-covariance decomposition given by equation (7) with rolling windows of 20 quarters, the same five-year window used in Section 2.

We present the results from this rolling variance-covariance decomposition in Figures 12 through 17. In each figure, we also include the rolling variance of the exchange rate change itself to clearly show the contribution of each component of the variance decomposition. The estimated time trends are shown as a dashed line in each figure, and the estimated trend coefficients are presented in Table 3. The sum of the trends of the rolling volatility of the subcomponents equals the trend of the rolling volatility of the exchange rate change.

Note that the sample we use in this section is shorter than the sample in Section 2 due to survey data availability and roughly covers the last 25 years.[16] Relative to the longer sample, the exchange rate change volatility trends remain the same, with the exception of GBP, for which we observe an increase in exchange rate change volatility of the GBP/USD currency cross over the last 25 or so years.

Even in this more recent sample, some reflections of the Great Moderation are visible in the declining volatility of the overall interest rate component, φ_t^{EH}, of exchange rate changes for almost all currencies, with the exception of the DEM/EUR and JPY. Given that in Section 2 we showed that the Great Moderation volatility factor captures mostly the volatility of long-term realized yield changes, we will disentangle this result further.

There are three potential explanations why the volatility of φ_t^{EH} has decreased. First, as Ilzetzki, Reinhart, and Rogoff (2020) argue, the lower volatility of revisions in expectations

[16] For details, see the Data Appendix.

over relative monetary policy rates can be potentially explained by the decline in policy rates toward the zero lower bound (ZLB) and the subsequent ZLB period.[17] When interest rates are close to or at the ZLB, the amount of downward revision in expectations for policy rates in the short and medium run is limited, which mechanically lowers the variance of φ_t^{EH}. Second, the increased transparency of how central banks set policy rates has further contributed to better policy rate forecasts and, thus, smaller revisions of policy rate expectations (see Middeldorp 2011). Finally, realized interest rates and revisions in expectations for policy rate paths might co-move more over time.

Table 6 and the corresponding Figure 18 explore each of these possible explanations by breaking down the volatility of φ_t^{EH}.[18] The table shows that the rolling volatilities of realized short-term rates, i_{t-1}^{i}, have fallen for all countries, capturing the Great Moderation factor. However, by contrast, the component capturing the revisions in expectations over the infinite short-term rate path, $\varphi_t^{EH,F,i}$, has become more volatile for many countries, including the United States, perhaps reflecting a greater sensitivity of policy rate expectations to macroeconomic and monetary policy news, in particular. As a result, the volatility of $\varphi_t^{EH,i}$ has increased for most countries. From Table 6, we can see that the last channel, a stronger covariance of $\varphi_t^{EH,i}$ and $\varphi_t^{EH,us}$ over time potentially due to a greater coordination in monetary policy, has driven a declining trend in the overall volatility of the *relative* past and expected future interest rates, φ_t^{EH}, for most countries against the United States.

Going back to Table 3, the Great Moderation puzzle emerges here as a disconnect between the volatility trends in the interest rate component and the trends in overall exchange rate volatility. As we did before, we observe a negative trend in the estimated variance of the exchange rate primarily for the financial center currencies, the CHF, DEM/EUR, and JPY. However, volatility has increased for commodity producers' currencies (AUD, CAD and NZD) as well as for the GBP. Looking at the trends in the interest rate component, we see that the currencies that saw the greatest decreases in interest rate component volatility, the AUD, and NZD, experienced the greatest increases in exchange rate volatility. Similarly, while the DEM/EUR and JPY saw flat or even slight increases in the volatility of the interest rate components of exchange rate changes, overall exchange rate volatility for these two currencies decreased by a fair amount over this sample.

Except in the case of the AUD, the volatility of the forward-looking relative inflation expectations component, φ_t^{LR}, has increased over time due to the ZLB when monetary policy

[17] Ilzetzki, Reinhart, and Rogoff (2020) conjecture that the lower volatility of monetary policy rates is an important reason why we observe a downward trend in the volatility of USD/JPY and USD/EUR.

[18] For the US-specific components, the trend estimates still differ slightly across currencies due to differences in sample ranges.

was constrained and inflation expectations across countries might have diverged and also due to the post–COVID-19 high-inflation period. The higher volatility trend φ_t^{LR}, together with a less negative co-movement between φ_t^{LR} and φ_t^{λ}, is the main reason why the GBP exchange rate volatility has increased over the last 25 years—that is, inflation expectations played a crucial role. The picture is quite different for other crosses.

Exchange rates involving other financial center currencies—the CHF, DEM/EUR, and JPY—became less volatile, despite smaller declines (or even increases) of the volatility of the interest rate component, an increase in the volatility of the inflation component, and less negative co-movement between φ_t^{LR} and φ_t^{λ} (with the exception of the JPY). This was the case due to declining volatility of past and expected future currency risk premia. There is also a small contribution from a decreasing covariance between the currency risk premia and interest rate components or a strengthening of the Fama puzzle for the CHF and the DEM/EUR.

The AUD and NZD, and to a lesser extent the CAD, saw increases in volatility, despite declines in the volatility of the interest rate components, primarily due to more positive covariances between φ_t^{EH} and φ_t^{LR} and between φ_t^{EH} and φ_t^{λ}. The fact that $Cov(\varphi_t^{EH}, \varphi_t^{LR})$ became less negative implies that forecasters expected policy rates to be less reflective of inflation differential expectations. A slight reversal of this upward trend is visible in the high-inflation COVID-19 period, as expected. This phenomenon may be consistent with the fact that as inflation expectations have become better anchored, central banks have not needed to respond as much to inflation in order to achieve their inflation targets. The more positive covariance between φ_t^{EH} and φ_t^{λ} indicates a weakening and even disappearing of the Fama puzzle for these commodity currencies. Baillie and Bollerslev (2000) and Burnside (2019) also find that the forward premium puzzle (that is, the result that a currency appreciates when the interest rate of that country is relatively higher) has disappeared over time. Burnside (2019) argues that the observed trend in the estimated forward premium coefficients coincides with lower carry trade returns. Lastly, increased volatility of the currency risk premium component, φ_t^{λ}, also contributed to the increased volatility of the CAD, but not the AUD or NZD.

We conclude this section with two robustness checks to show that the trends we have discussed are not driven by extreme events. First, Table 4 estimates the volatility trend for the exchange rate change and its subcomponents, excluding any observations in which the five-year rolling window includes a quarter from either the Great Financial Crisis (2007:Q4 through 2009:Q2) or the acute phase of the COVID-19 pandemic (2020:Q1 and 2020:Q2). Second, Table 5 estimates the volatility trend for the same variables, excluding any observations in which the five-year rolling window includes a “tail” event. We define such an event as a quarter when the exchange rate change was in the top or bottom 1 percent of the full sample, with the percentiles computed on a currency-by-currency basis. The excluded periods for either of these definitions generally cover about 30 to 40 percent of the sample.

As Tables 4 and 5 show, our results are robust to excluding these events. We continue to see a divergence of trends in recent decades between the three major financial centers and the commodity producers in our sample. The disconnect between the volatility trends in the interest rate component and the trends in overall exchange rate volatility are also still present. Lastly, for the commodity currencies, we see even stronger trends in the covariances between exchange rate subcomponents, namely that expected policy rates became less reflective of inflation differential expectations and an even stronger trend related to the disappearance (and even reversal) of the Fama puzzle.

6 Conclusion

In this paper, we explore the relationship between exchange rate volatility and *realized* and *expected* macroeconomic volatility over the last 50 years and the last 25 years. We find significant heterogeneity in both the volatility trends of exchange rate changes and the explanations for these trends.

Regarding the contribution of *realized* macroeconomic volatility to exchange rate change volatility, we find that if one allows for a time varying relationship between macroeconomic variables and exchange rate changes, then the trend in exchange rate volatility closely tracks the volatility of the time-varying contribution of the macroeconomic variables to the exchange rate movement. However, this co-movement is driven by the time-varying coefficients and their interaction with the level of the macroeconomic variables rather than the lower macroeconomic volatility of the macroeconomic variables themselves. In other words, nonlinear effects are key.

Turning to the link between exchange rate volatility and the volatility of *expected* macroeconomic variables, we find very heterogeneous drivers of exchange rate volatility trends across currency pairs. The currencies of three of the largest financial centers—the CHF, DEM/EUR, and JPY against the USD—saw declines in volatility that are larger than what can be explained by the relationships between these exchange rates and macro variables alone. Indeed, we find the decrease in exchange rate trend volatility for these currency crosses is due to a large decline in the volatility of expected future currency risk premia.

Commodity producer currencies, particularly the AUD, CAD, and NZD against the USD, saw increased volatility, despite the drop in macro volatility during the Great Moderation. The main explanation for the increase in trend volatility rests on the weakening of the Fama puzzle and on expectations of smaller policy rate responses to movements in inflation.

References

Aghion, Philippe, Philippe Bacchetta, Romain Ranciere, and Kenneth Rogoff. 2009. "Exchange Rate Volatility and Productivity Growth: The Role of Financial Development." *Journal of Monetary Economics* 56:494–513.

Baillie, Richard and Tim Bollerslev. 2000. "The forward premium anomaly is not as bad as you think." *Journal of International Money and Finance* 19:471–488.

Barajas, Adolfo, Sergio Restrepo, Roberto Steiner, Juan Camilo Medellín, and César Pabón. 2017. "Currency Mismatches and Vulnerability to Exchange Rate Shocks: Nonfinancial Firms in Colombia." IMF Working Papers 2017/263, International Monetary Fund, Washington, DC.

Benati, Luca and Paolo Surico. 2009. "Inventory Shocks and the Great Moderation." *American Economic Review* 99:1636–52.

Brunnermeier, Markus K., Stefan Nagel, and Lasse H. Pedersen. 2009. "Carry Trades and Currency Crashes." NBER Chapters, National Bureau of Economic Research, Inc.

Bruno, Valentina and Hyun Song Shin. 2015. "Cross-Border Banking and Global Liquidity." *Review of Economic Studies* 82:535–564.

Burnside, Craig. 2019. "Exchange Rates, Interest Parity, and the Carry Trade." *Oxford Research Encyclopedia of Economics and Finance* .

Campbell, John Y. and Robert J. Shiller. 1988. "Stock Prices, Earnings, and Expected Dividends." *Journal of Finance* 43 (3):661–676.

Chui, Michael, Emese Kuruc, and Philip Turner. 2018. "Leverage and currency mismatches: Non-financial Companies in the Emerging Markets." *The World Economy* 41 (12):3269–3287.

Colacito, Riccardo, Mariano Croce, Federico Gavazzoni, and Robert Ready. 2018. "Currency Risk Factors in a Recursive Multicountry Economy." *The Journal of Finance* 73 (6):2719–56.

Crump, Richard K., Stefano Eusepi, and Emanuel Moench. 2018. "The Term Structure of Expectations and Bond Yields." Staff Report 775, Federal Reserve Bank of New York, New York.

Cushman, David O. and Tao Zha. 1997. "Identifying monetary policy in a small open economy under flexible exchange rates." *Journal of Monetary Economics* 39 (3):433–448.

De Marco, Filippo, Marco Macchiavelli, and Rosen Valchev. 2022. "Beyond Home Bias: International Portfolio Holdings and Information Heterogeneity." *The Review of Financial Studies* 35 (9):4387—4422.

Dobrynskaya, Victoria. 2014. "Downside Market Risk of Carry Trades." *Review of Finance* 18 (5):1885–1913.

Engel, Charles. 2014. "Exchange Rates and Interest Parity." In *Handbook of International Economics*, vol. 4, edited by Elhanan Helpman, Gita Gopinath, and Kenneth Rogoff. Amsterdam: Elsevier, 453–522.

———. 2016. "Exchange Rates, Interest Rates, and the Risk Premium." *American Economic Review* 106 (2):436–474.

Engel, Charles, Katya Kazakova, Mengqi Wang, and Nan Xiang. 2022. "A reconsideration of the failure of uncovered interest parity for the U.S. dollar." *Journal of International Economics* 136.

Engel, Charles, Nelson C. Mark, and Kenneth D. West. 2008. "Exchange Rate Models Are Not as Bad as You Think." In *NBER Macroeconomics Annual 2007*, vol. 22, edited by Daron Acemoglu, Kenneth Rogoff, and Michael Woodford. Chicago: University of Chicago Press, 381–441.

Engel, Charles and Kenneth D. West. 2005. "Exchange Rates and Fundamentals." *Journal of Political Economy* 113 (3):485–517.

———. 2006. "Taylor Rules and the Deutschmark: Dollar Real Exchange Rate." *Journal of Money, Credit and Banking* 38 (5):1175–1194.

———. 2010. "Global Interest Rates, Currency Returns, and the Real Value of the Dollar." *American Economic Review* 100 (2):562–67.

Evans, Martin D. D. 2012. "Exchange-Rate Dark Matter." IMF Working Paper 12/66, International Monetary Fund.

Fama, Eugene. 1984. "Forward and Spot Exchange Rates." *Journal of Monetary Economics* 14:319–338.

Farhi, Emmanuel and Xavier Gabaix. 2016. "Rare Disasters and Exchange Rates." *Quarterly Journal of Economics* 131 (1):1–52.

Froot, Kenneth A. and Tarun Ramadorai. 2005. "Currency Returns, Intrinsic Value, and Institutional-Investor Flows." *Journal of Finance* 60 (3):1535–1566.

Giannone, Domenico, Michele Lenza, and Giorgio Primiceri. 2019. "Currency forecasters are heterogeneous: confirmation and consequences." *Journal of the American Statistical Association* 114 (526):565–580.

Giglio, Stefano, Matteo Maggiori, Johannes Stroebel, and Stephen Utkus. 2021. "Five Facts about Beliefs and Portfolios." *American Economic Review* 111 (5):1481–1522.

Gourinchas, Pierre-Olivier and Hélène Rey. 2022. "Exorbitant Privilege and Exorbitant Duty." CEPR Discussion Papers 16944, C.E.P.R. Discussion Papers.

Greenwood, Robin and Andrei Shleifer. 2014. "Expectations of Returns and Expected Returns." *Review of Financial Studies* 27 (3):714–746.

Gürkaynak, Refet S., Brian Sack, and Jonathan H. Wright. 2007. "The U.S. Treasury Yield Curve: 1961 to the Present." *Journal of Monetary Economics* 54 (8):2291–2304.

Hassan, Tarek. 2013. "Country Size, Currency Unions, and International Asset Returns." *Journal of Finance* 68 (6):2269–2308.

Ilzetzki, Ethan, Carmen Reinhart, and Kenneth Rogoff. 2019. "Exchange Arrangements Entering the 21st Century: Which Anchor Will Hold?" *Quarterly Journal of Economics* 134:599–646.

Ilzetzki, Ethan, Carmen M. Reinhart, and Kenneth S. Rogoff. 2020. "Will the Secular Decline in Exchange Rate and Inflation Volatility Survive COVID-19?" *Brookings Papers on Economic Activity* 51 (3 (Fall)):279–332.

Itskhoki, Oleg and Dmitry Mukhin. 2022. "The Mussa Puzzle and the Optimal Exchange Rate Policy." *Working Paper* .

Jarocinski, Marek and Albert Marcet. 2011. "Autoregressions in Small Samples, Priors about Observables and Initial Conditions." CEP Discussion Papers No 1061, Centre for Economic Performance, LSE.

Kalemli-Ozcan, Sebnem, Elias Papaioannou, and Jose-Luis Peydro. 2010. "What Lies Beneath the Euro's Effect on Financial Integration? Currency Risk, Legal Harmonization, or Trade?" *Journal of International Economics* 81 (1):75–88.

Kalemli-Ozcan, Sebnem and Liliana Varela. 2022. "Five Facts about the UIP Premium." CEPR Discussion Papers 16244, C.E.P.R. Discussion Papers.

Kim, Don H. and Athanasios Orphanides. 2012. "Term Structure Estimation with Survey Data on Interest Rate Forecasts." *Journal of Financial and Quantitative Analysis* 47 (1):241–272.

Kim, Don H. and Jonathan H. Wright. 2005. "An Arbitrage-Free Three-Factor Term Structure Model and the Recent Behavior of Long-Term Yields and Distant-Horizon Forward Rates." Finance and Economics Discussion Series 2005-33, Board of Governors of the Federal Reserve System, Washington, DC.

Middeldorp, Menno. 2011. "Central bank transparency, the accuracy of professional forecasts, and interest rate volatility." Tech. rep.

Miranda-Agrippino, Silvia and Hélène Rey. 2020. "U.S. Monetary Policy and the Global Financial Cycle." *The Review of Economic Studies* 87 (6):2754–2776.

Morley, James and Aarti Singh. 2016. "Inventory Shocks and the Great Moderation." *Journal of Money, Credit and Banking* 48:699–728.

Piazzesi, Monika, Juliana Salomao, and Martin Schneider. 2015. "Trend and Cycle in Bond Premia." Mimeo.

Rogoff, Kenneth. 2007. "Impact of Globalization on Monetary Policy." *The New Economic Geography: Effects and Policy Implications* :265–305.

Stavrakeva, Vania and Jenny Tang. 2023. "Individual Beliefs, Demand for Currency and Exchange Rate Dynamics." Mimeo.

———. Forthcoming a. "A Fundamental Connection: Exchange Rates and Macroeconomic Expectations." *The Review of Economics and Statistics* .

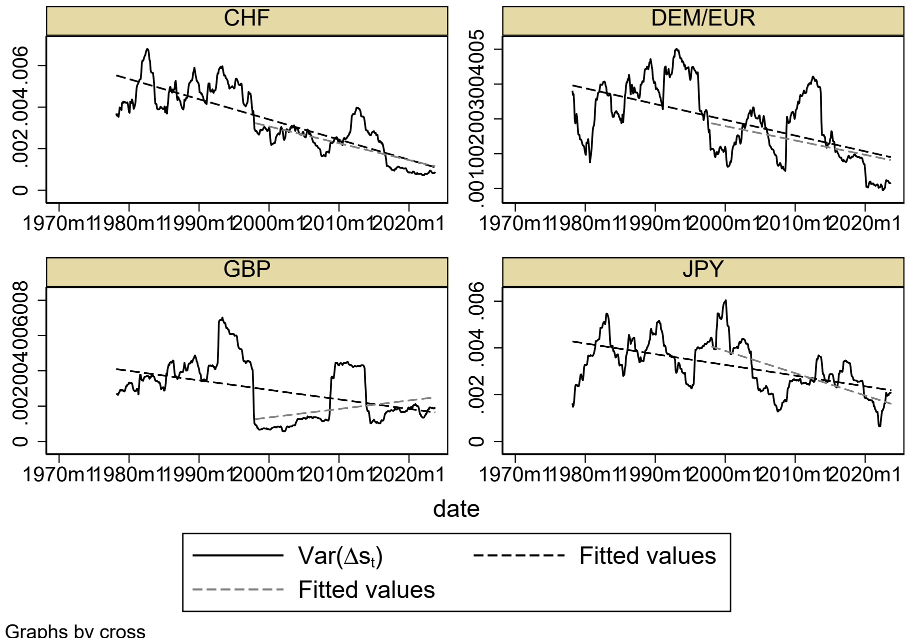
———. Forthcoming b. "The Dollar During the Great Recession: The Information Channel of US Monetary Policy and the Flight to Safety." *Journal of Finance* .

Summers, Peter. 2005. "What Caused The Great Moderation? Some Cross-Country Evidence." *Economic Review* .

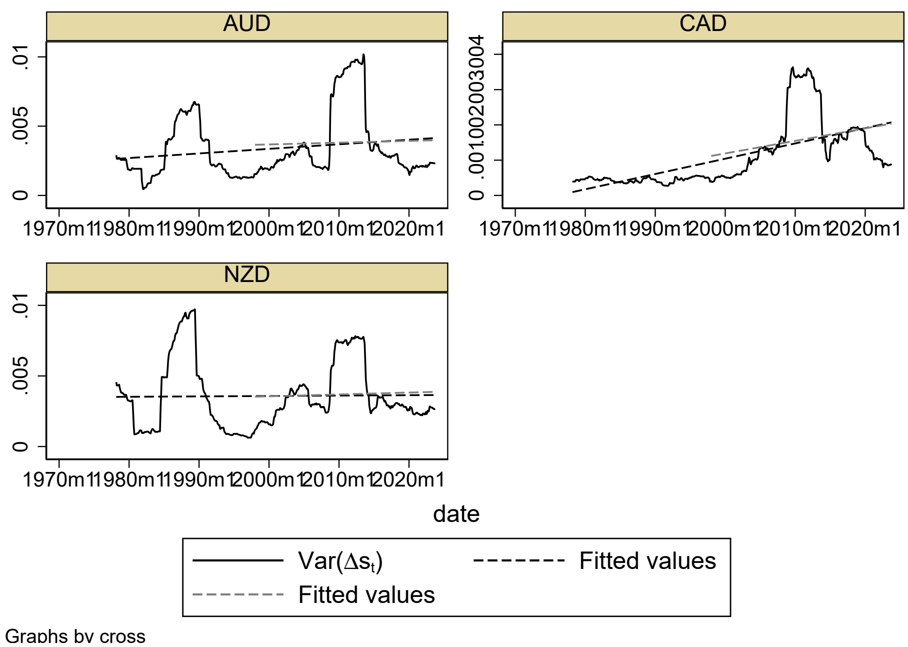
Wright, Jonathan H. 2011. "Term Premia and Inflation Uncertainty: Empirical Evidence from an International Panel Dataset." *American Economic Review* 101 (4):1514–34.

Tables and Figures

Figure 1: 60-month Rolling Variance of the Quarterly Exchange Rate Change



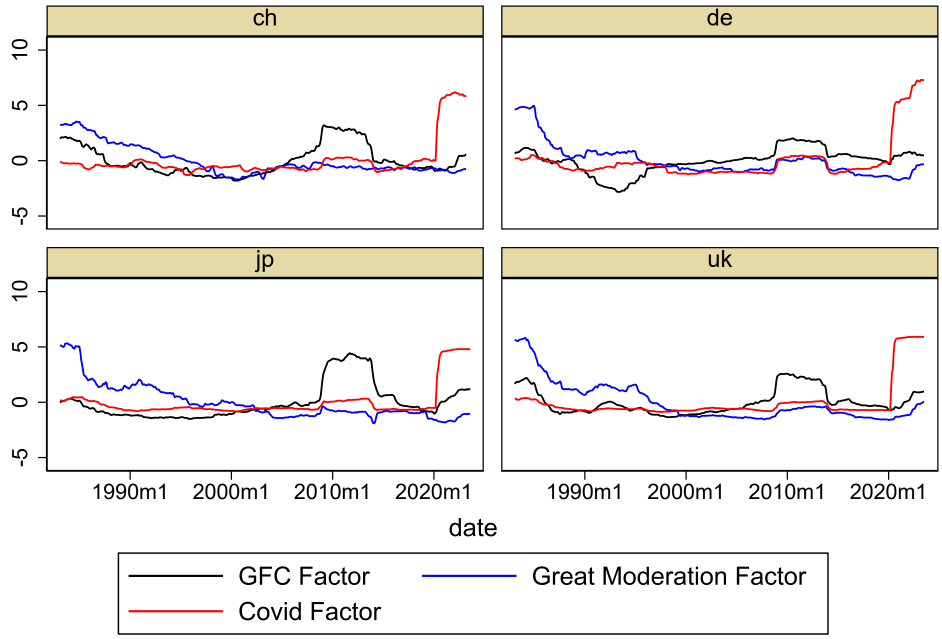
(a) Financial Centers



(b) Commodity Producers

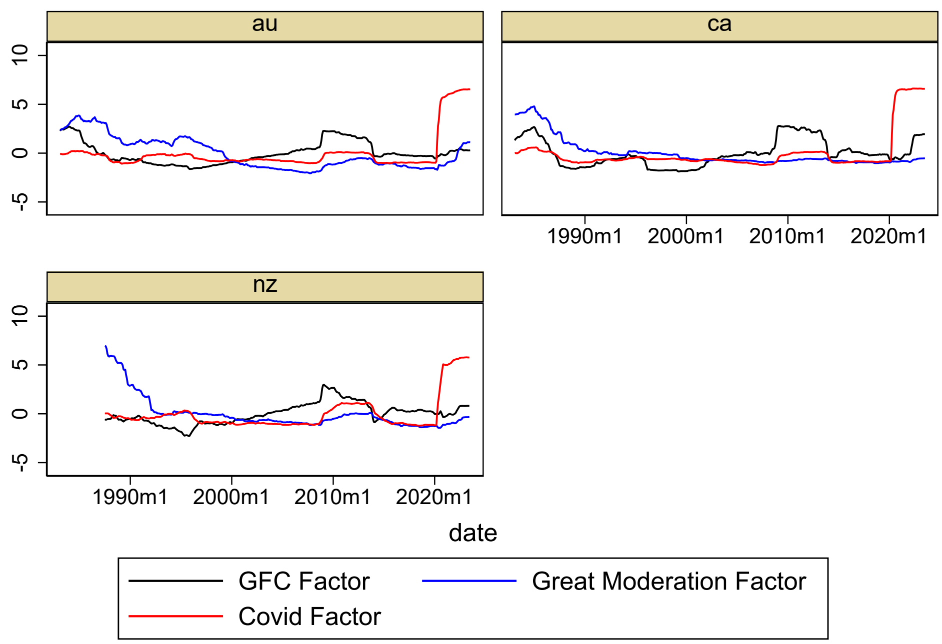
Source: Global Financial Data and authors' calculations.

Figure 2: Three Principal Components of the 60-month Rolling Variance of Macroeconomic Variables



Overall variance explained by the three factors: ch: .79; jp: .9; uk: .9; de: .85

(a) Financial Centers

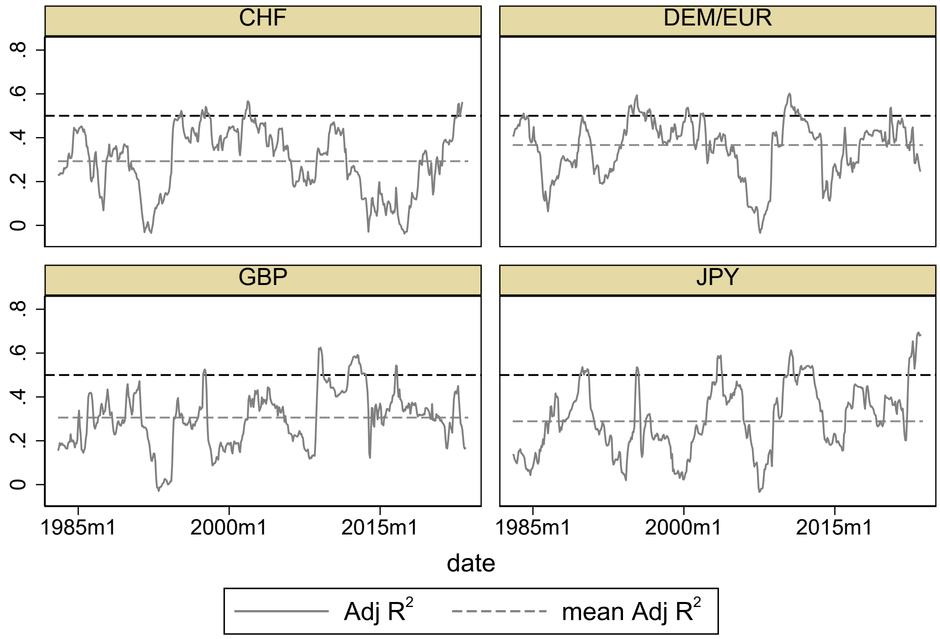


Overall variance explained by the three factors: au: .9; ca: .95; nz: .86

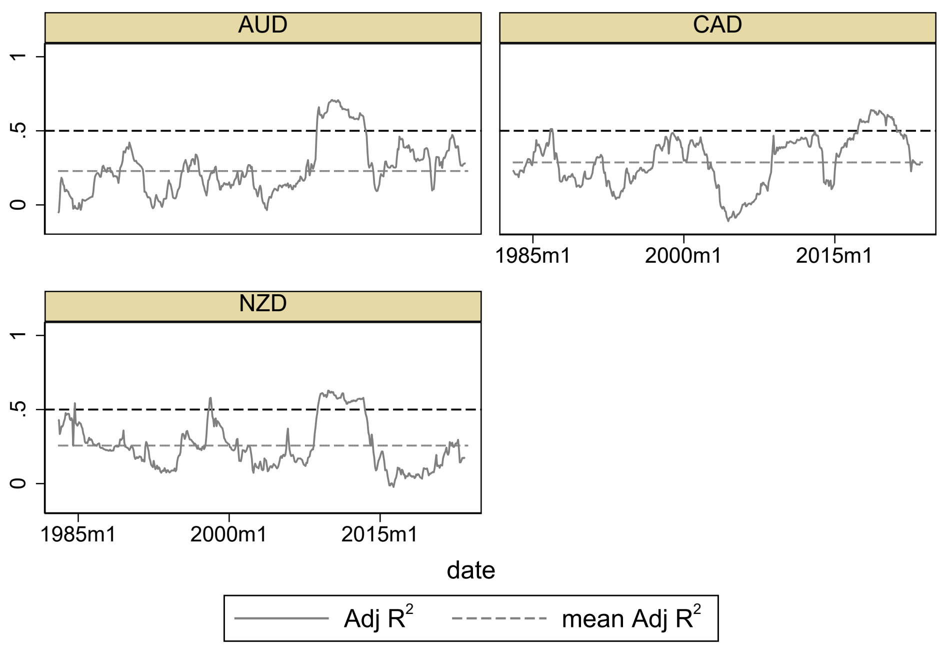
(b) Commodity Producers

Source: Authors' calculations.

Figure 3: 60-month Rolling Adj R^2 from Regressing the Exchange Rate Change on Macroeconomic Variables



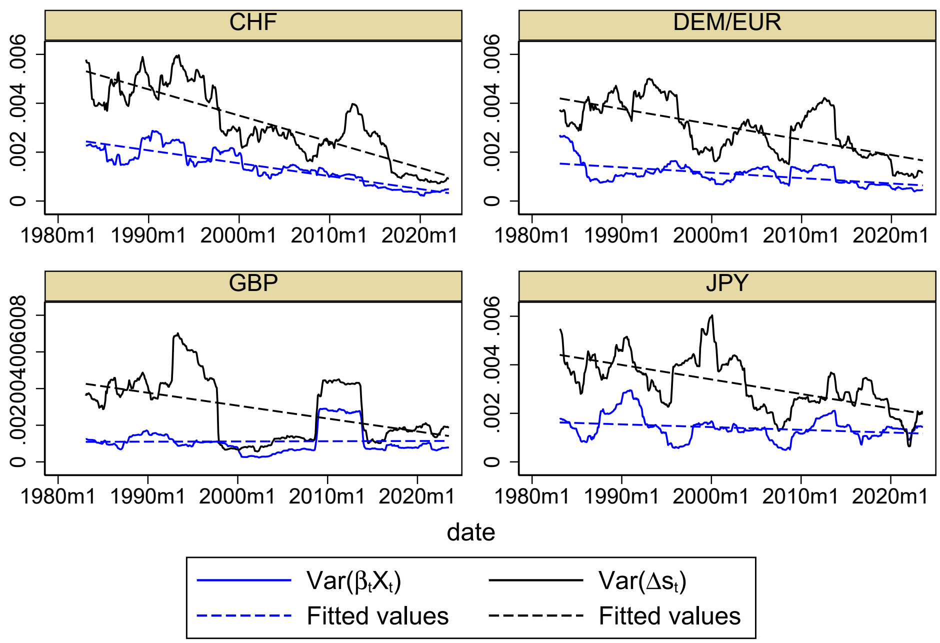
(a) Financial Centers



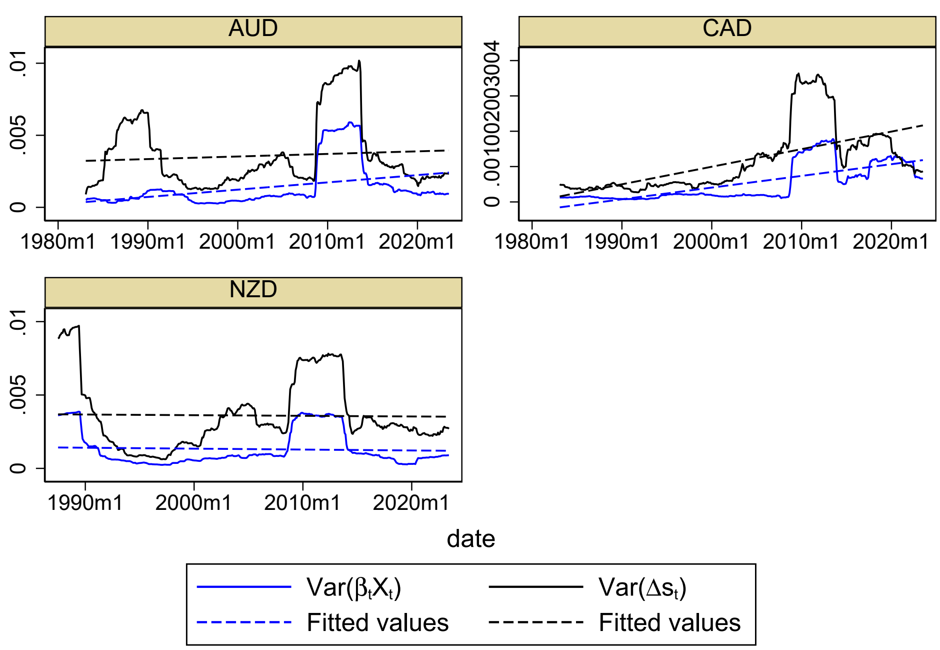
(b) Commodity Producers

Source: Authors' calculations.

Figure 4: 60-month Rolling Variance of the Quarterly Exchange Rate Change and the Fitted Values from Regressing the Exchange Rate Change on Macroeconomic Variables



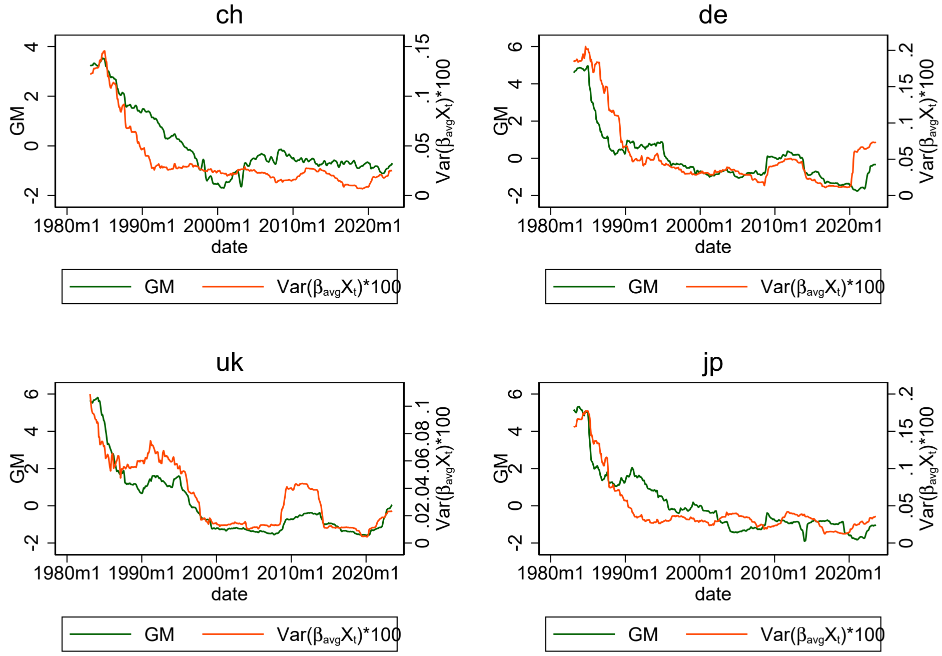
(a) Financial Centers



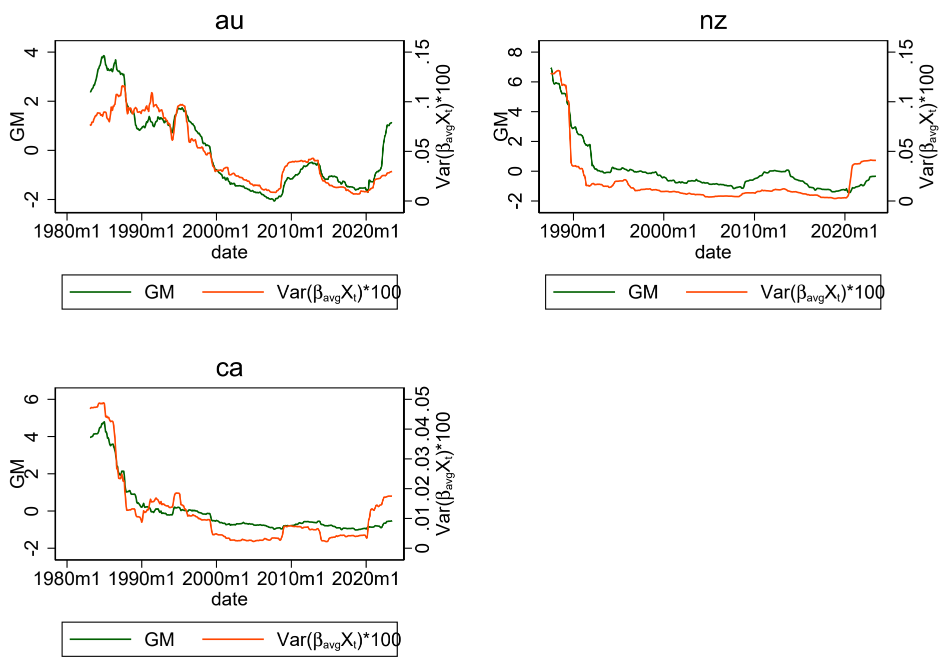
(b) Commodity Producers

Source: Global Financial Data and authors' calculations.

Figure 5: 60-month Rolling Variance of $\beta_{avg} X_t$ against the Great Moderation Factor



(a) Financial Centers



(b) Commodity Producers

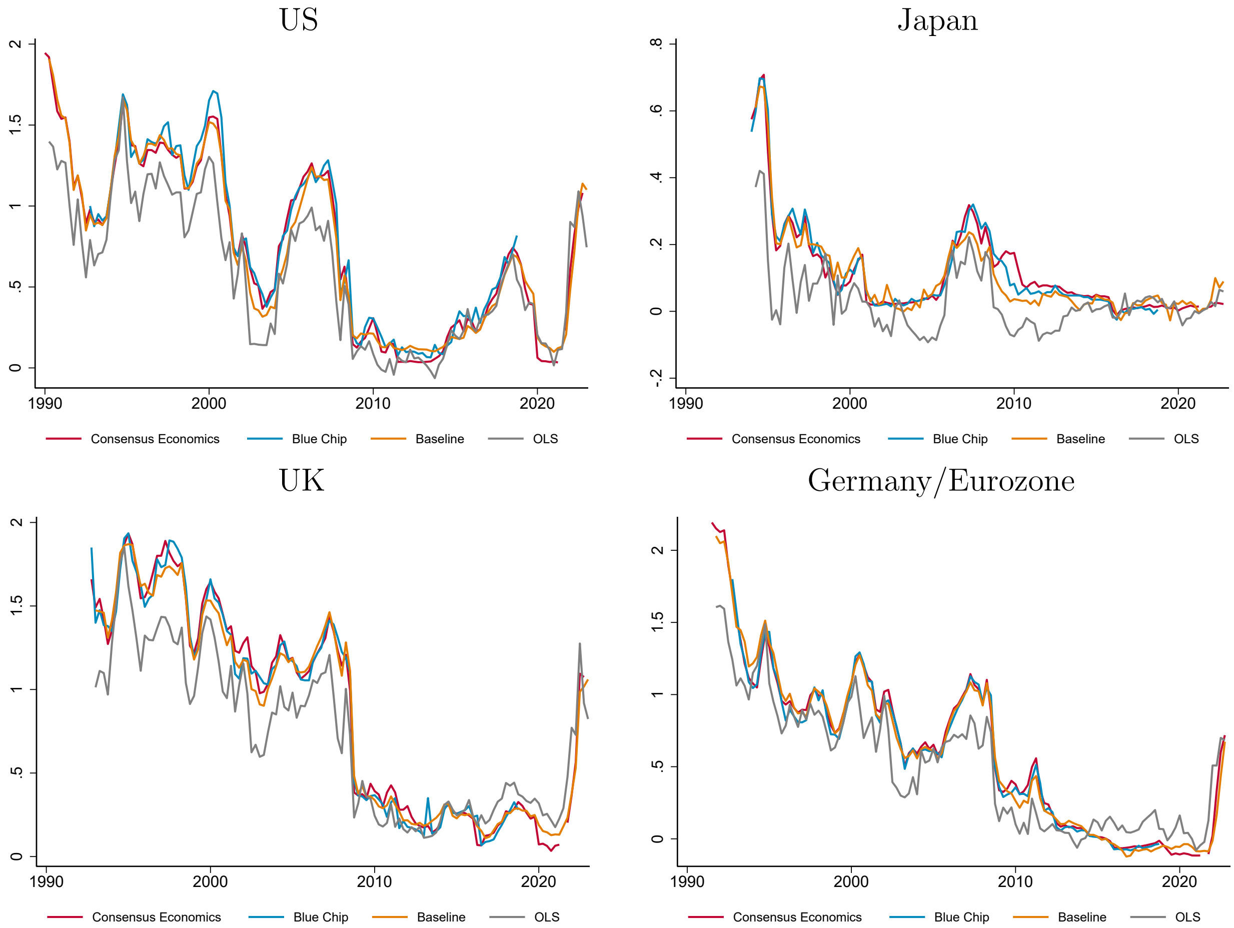
Source: Authors' calculations.

Table 1: Relative RMSEs of Survey Forecast Fit For Forecast-augmented VAR versus Standard OLS Estimation

			AU	CA	CH	DE	JP	NZ	UK	US
Exch Rate	BC	0Y	0.50	0.52		0.42	0.21		0.34	.
		1Y	0.38	0.33		0.34	0.19		0.39	.
		2Y	0.32	0.25		0.26	0.17		0.31	.
	BCF	3M	0.43	0.42	0.46	0.38	0.33		0.44	.
		6M	0.38	0.34	0.39	0.31	0.21		0.36	.
		12M	0.28	0.33	0.31	0.30	0.20		0.38	.
	CF	3M	0.40	0.29	0.35	0.31	0.27	0.39	0.40	.
		12M	0.25	0.19	0.25	0.20	0.16	0.27	0.29	.
		24M	0.25	0.14	0.22	0.16	0.18	0.22	0.26	.
3M Bill Rate	BC	0Y	0.43	0.42		0.33	0.38		0.37	0.46
		1Y	0.38	0.34		0.26	0.35		0.29	0.29
		2Y	0.33	0.26		0.27	0.36		0.25	0.30
		7-11Y								0.15
	BCF	3M	0.58	0.54	0.59	0.53	0.56		0.45	0.45
		6M	0.44	0.40	0.48	0.37	0.41		0.32	0.34
		12M	0.32	0.30	0.34	0.28	0.31		0.25	0.30
	CF	3M	0.59	0.79	0.59	0.56	0.55	0.81	0.46	0.59
		12M	0.21	0.39	0.34	0.27	0.37	0.42	0.25	0.32
		6-10Y	0.45	0.19	0.23	0.30	0.30	0.74	0.45	0.22
Inflation	BC	0Y	0.63	0.66		0.61	0.71		0.60	0.63
		1Y	0.25	0.31		0.21	0.34		0.20	0.29
		2Y	0.18	0.25		0.14	0.22		0.12	0.19
	CF	0Y	0.59	0.65	0.61	0.71	0.76	0.74	0.52	0.70
		1Y	0.29	0.36	0.31	0.23	0.38	0.44	0.24	0.28
		2Y	0.17	0.24	0.21	0.12	0.26	0.27	0.17	0.23
		6-10Y	0.34	0.36	0.33	0.28	0.25	0.36	0.25	0.28

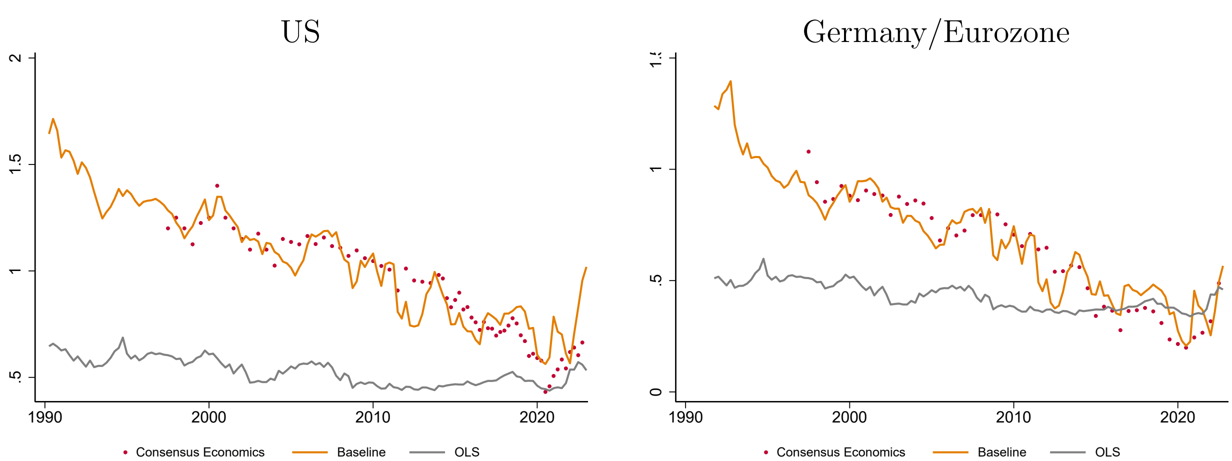
Note: Each value in this table is the ratio of the RMSE of the fit of survey forecasts for the forecast-augmented VAR divided by the same RMSE for OLS estimation of only the VAR data-generating process in (10) subject to the restrictions in (11).
Source: Authors' calculations.

Figure 6: Model-implied and Survey Forecasts: 3-month Bill Rate (12 Months Ahead)



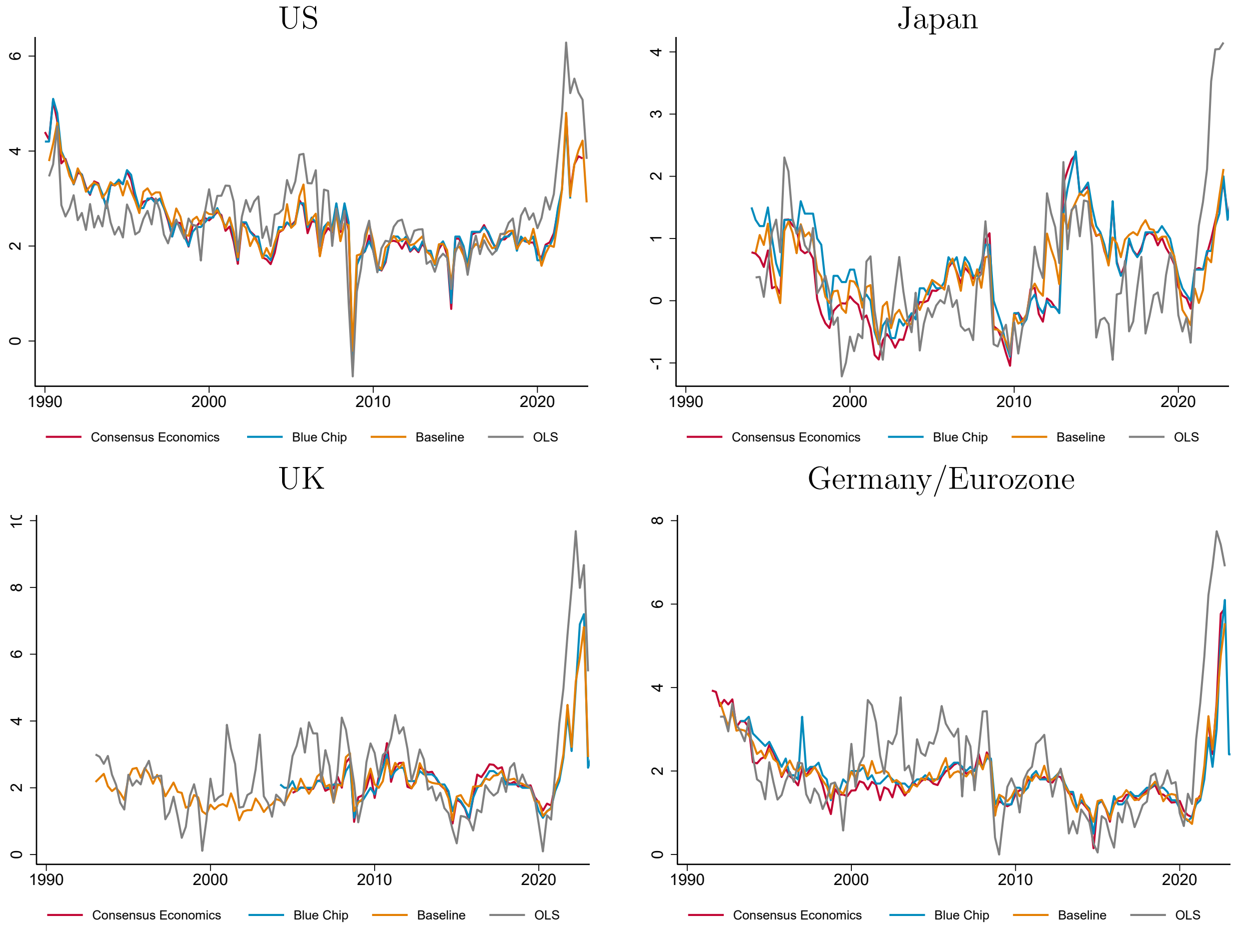
Source: Consensus Economics, Blue Chip Financial Forecasts, and authors' calculations.

Figure 7: Model-implied and Survey Forecasts: 3-month Bill Rate (6–10 Years Ahead)



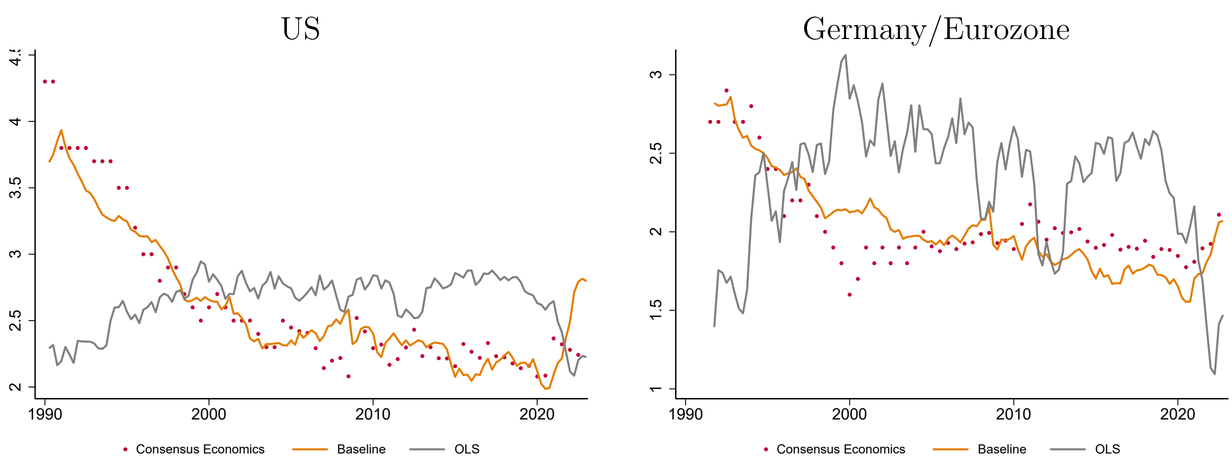
Source: Consensus Economics and authors' calculations.

Figure 8: Model-implied and Survey Forecasts: Inflation (1 Year Ahead)



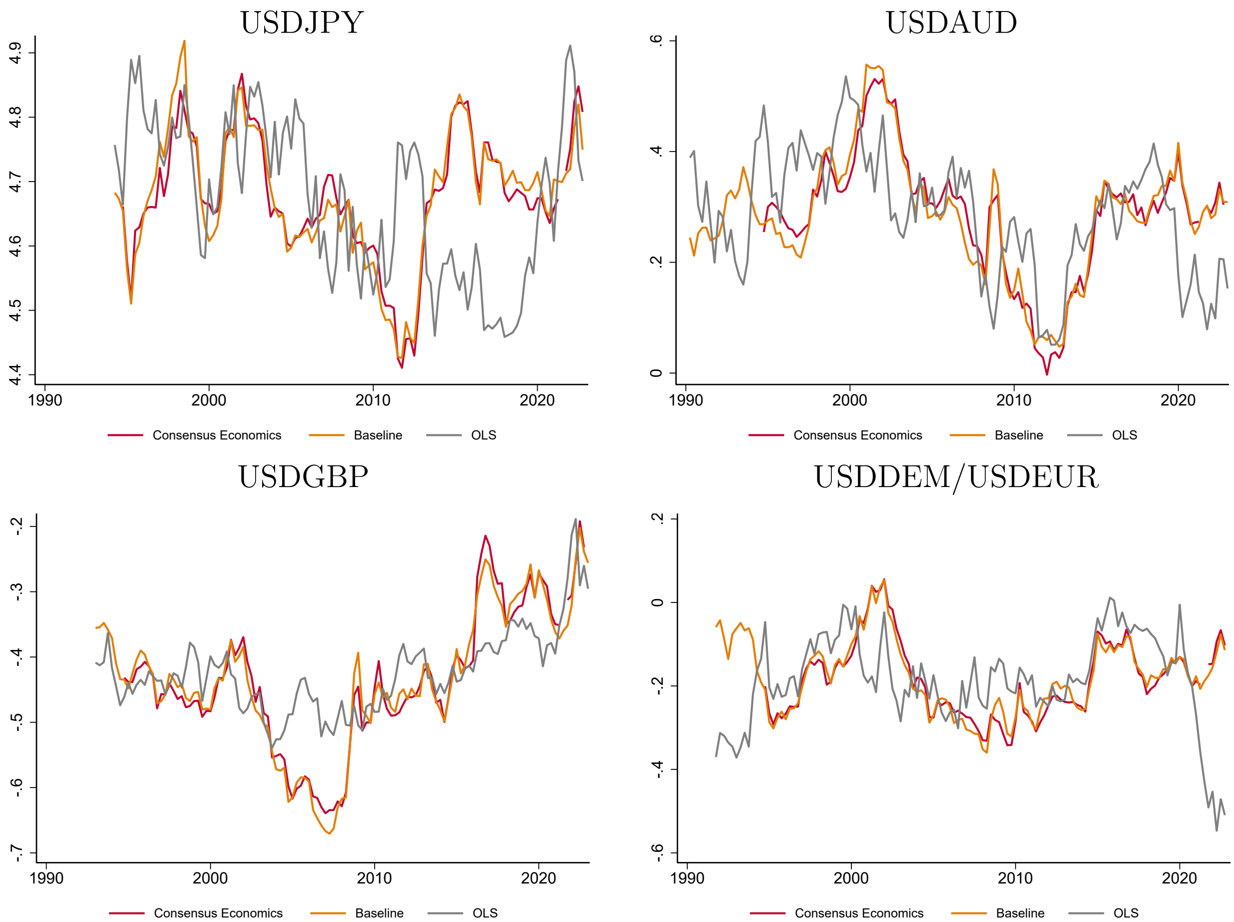
Source: Consensus Economics, Blue Chip Economic Indicators, and authors' calculations.

Figure 9: Model-implied and Survey Forecasts: Inflation (6–10 Years Ahead)



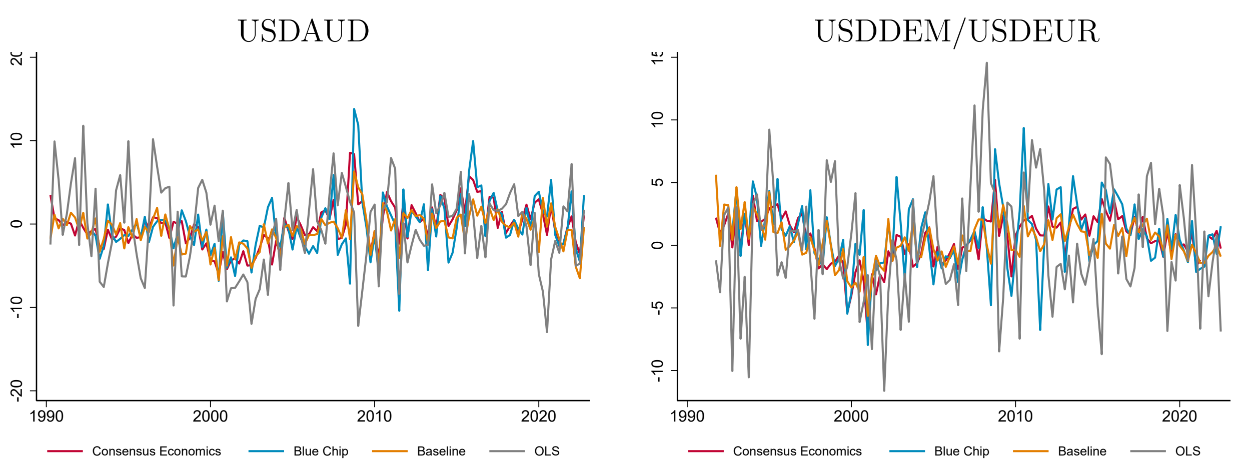
Source: Consensus Economics and authors' calculations.

Figure 10: Model-implied and Survey Forecasts: Exchange Rates (24 Months Ahead)



Source: Consensus Economics and authors' calculations.

Figure 11: Model-implied and Survey Currency Premia (3-month Horizon)



Source: Consensus Economics, Blue Chip Economic Indicators, and authors' calculations.

Table 2: Component Variances and Covariances US; Full Sample

USD Base	Financial Centers				Commodity Producers		
	CHF	DEM/EUR	GBP	JPY	AUD	CAD	NZD
$Var(\Delta s_t)$	27.48	25.88	18.61	34.56	32.57	13.93	31.71
$Var(\varphi_t^{EH})$	4.05	4.38	8.45	6.51	8.35	2.05	17.45
$Var(\varphi_t^{LR})$	2.29	1.64	8.28	5.43	1.89	3.30	5.54
$Var(\varphi_t^{\lambda})$	27.49	29.89	19.52	36.60	31.89	15.79	37.40
$2Cov(\varphi_t^{EH}, \varphi_t^{LR})$	−2.47	−1.57	−9.10	−2.73	−5.20	−1.06	−9.79
$2Cov(\varphi_t^{EH}, \varphi_t^{\lambda})$	2.21	−6.82	−6.51	0.95	−7.08	−5.40	−18.49
$2Cov(\varphi_t^{LR}, \varphi_t^{\lambda})$	−6.09	−1.64	−2.03	−12.20	2.74	−0.76	−0.39
$Var(-\varphi_t^{EH,F} - \varphi_t^{\lambda,F} + \varphi_t^{LR})$	27.94	27.54	18.54	35.38	34.26	13.66	29.88

Note: Variance-covariance decomposition of the exchange rate change components based on the survey-data augmented VAR. Rows 2 through 7 sum up to the total variance of the one-quarter exchange rate change in row 1.
Source: Global Financial Data and authors' calculations.

Table 3: Decomposing Trends in Exchange Rate Volatility

	Financial Centers				Commodity Producers		
	CHF	DEM/EUR	GBP	JPY	AUD	CAD	NZD
$Var(\Delta s_t)$	-13.00^{***}	-4.06^{***}	3.88^{***}	-11.16^{***}	4.49^{***}	3.59^{***}	5.69^{***}
	(1.14)	(0.86)	(0.90)	(1.46)	(1.44)	(0.82)	(1.44)
$Var(\varphi_t^{\lambda})$	-10.77^{***}	-4.25^{***}	1.15	-11.80^{***}	1.27	3.04^{***}	-1.99
	(0.92)	(1.01)	(0.96)	(1.35)	(0.96)	(0.59)	(1.34)
$Var(\varphi_t^{EH})$	-1.66^{***}	0.43^{**}	-2.11^{***}	0.09	-3.35^{***}	-0.85^{***}	-8.67^{***}
	(0.29)	(0.21)	(0.45)	(0.33)	(0.37)	(0.13)	(0.92)
$Var(\varphi_t^{LR})$	0.42^{***}	0.34^{***}	1.13^{**}	1.49^{***}	-0.49^{***}	0.60^{***}	0.07
	(0.11)	(0.07)	(0.43)	(0.22)	(0.08)	(0.13)	(0.16)
$2Cov(\varphi_t^{EH}, \varphi_t^{LR})$	1.07^{***}	0.48^{***}	0.79	-0.55^{**}	3.28^{***}	0.39^{**}	5.53^{***}
	(0.22)	(0.10)	(0.56)	(0.26)	(0.32)	(0.17)	(0.48)
$2Cov(\varphi_t^{EH}, \varphi_t^{\lambda})$	-3.54^{***}	-2.66^{***}	0.72	0.70	4.05^{***}	1.21^{**}	16.93^{***}
	(0.42)	(0.60)	(0.98)	(0.78)	(0.89)	(0.49)	(1.58)
$2Cov(\varphi_t^{LR}, \varphi_t^{\lambda})$	1.48^{***}	1.60^{***}	2.20^{**}	-1.09	-0.27	-0.80	-6.18^{***}
	(0.26)	(0.47)	(0.85)	(1.07)	(0.47)	(0.62)	(0.59)

Note: Each cell in this table reports the estimated coefficient from univariate regressions of each term in the exchange rate change variance decomposition on a time trend. The time trend is scaled such that the coefficient represents the average change in the term over a 10-year period. Note that the terms are scaled such that the coefficients in rows 2 through 7 sum up to the trend coefficient in the exchange rate change variance. Heteroskedasticity-robust standard errors are in parentheses.
Source: Authors' calculations.

Table 4: Decomposing Trends in Exchange Rate Volatility (Excluding Crises)

	Financial Centers				Commodity Producers		
	CHF	DEM/EUR	GBP	JPY	AUD	CAD	NZD
$Var(\Delta s_t)$	-14.04^{***}	-2.39^{***}	2.80^{***}	-10.67^{***}	2.90^{**}	4.79^{***}	5.03^{***}
	(1.40)	(0.79)	(0.26)	(1.75)	(1.27)	(0.41)	(1.40)
$Var(\varphi_t^{\lambda})$	-10.99^{***}	-4.43^{***}	-2.04^{***}	-15.92^{***}	-1.64	3.19^{***}	-3.02^{**}
	(1.06)	(1.02)	(0.65)	(1.41)	(1.08)	(0.50)	(1.39)
$Var(\varphi_t^{EH})$	-2.76^{***}	-0.47^{***}	-3.76^{***}	-1.44^{***}	-4.78^{***}	-1.01^{***}	-11.41^{***}
	(0.26)	(0.13)	(0.40)	(0.20)	(0.42)	(0.16)	(1.08)
$Var(\varphi_t^{LR})$	0.06	0.18^{***}	-0.45^{***}	1.17^{***}	-0.75^{***}	0.16^{**}	-0.79^{***}
	(0.06)	(0.03)	(0.16)	(0.08)	(0.09)	(0.06)	(0.09)
$2Cov(\varphi_t^{EH}, \varphi_t^{LR})$	1.97^{***}	0.80^{***}	4.03^{***}	-0.22	4.18^{***}	0.18	7.82^{***}
	(0.16)	(0.09)	(0.41)	(0.26)	(0.37)	(0.11)	(0.40)
$2Cov(\varphi_t^{EH}, \varphi_t^{\lambda})$	-4.33^{***}	-1.17^{*}	4.05^{***}	3.07^{***}	6.42^{***}	1.81^{***}	20.61^{***}
	(0.51)	(0.69)	(0.55)	(0.56)	(1.00)	(0.63)	(1.40)
$2Cov(\varphi_t^{LR}, \varphi_t^{\lambda})$	2.01^{***}	2.70^{***}	0.97	2.66^{***}	-0.54	0.47	-8.18^{***}
	(0.26)	(0.57)	(0.98)	(0.39)	(0.62)	(0.33)	(0.50)

Note: Each cell in this table reports the estimated coefficient from univariate regressions of each term in the exchange rate change variance decomposition on a time trend excluding any observations where the five-year rolling window includes a quarter during either the Great Financial Crises (2007:Q4 through 2009:Q2) or the acute phase of the COVID-19 pandemic (2020:Q1 and 2020:Q2). The time trend is scaled such that the coefficient represents the average change in the term over a 10-year period. Note that the terms are scaled such that the coefficients in rows 2 through 7 sum up to the trend coefficient in the exchange rate change variance. Heteroskedasticity-robust standard errors are in parentheses.
Source: Authors' calculations.

Table 5: Decomposing Trends in Exchange Rate Volatility (Excluding Tail Events)

	Financial Centers				Commodity Producers		
	CHF	DEM/EUR	GBP	JPY	AUD	CAD	NZD
$Var(\Delta s_t)$	-10.54^{***}	-3.45^{**}	3.08^{***}	-3.55^{*}	3.72^{***}	2.98^{***}	6.60^{***}
	(0.94)	(1.52)	(0.39)	(1.80)	(0.45)	(0.24)	(0.68)
$Var(\varphi_t^{\lambda})$	-11.09^{***}	-1.45	-0.45	-2.85	0.90	2.59^{***}	1.22
	(1.38)	(1.80)	(1.29)	(2.71)	(0.62)	(0.49)	(0.84)
$Var(\varphi_t^{EH})$	-0.69^{***}	0.71^{*}	-0.80^{*}	2.11^{***}	-4.63^{***}	-1.11^{***}	-10.72^{***}
	(0.24)	(0.39)	(0.45)	(0.56)	(0.32)	(0.13)	(0.99)
$Var(\varphi_t^{LR})$	0.40^{***}	0.25	0.64^{*}	2.51^{***}	-0.75^{***}	0.79^{***}	-0.26^{*}
	(0.14)	(0.18)	(0.32)	(0.30)	(0.08)	(0.15)	(0.16)
$2Cov(\varphi_t^{EH}, \varphi_t^{LR})$	0.47^{**}	0.03	0.08	0.13	4.13^{***}	0.70^{***}	6.42^{***}
	(0.22)	(0.14)	(0.66)	(0.54)	(0.29)	(0.12)	(0.50)
$2Cov(\varphi_t^{EH}, \varphi_t^{\lambda})$	-2.16^{***}	-4.63^{***}	-1.99^{*}	1.19	6.34^{***}	2.63^{***}	16.69^{***}
	(0.45)	(1.18)	(1.14)	(1.28)	(0.65)	(0.41)	(1.57)
$2Cov(\varphi_t^{LR}, \varphi_t^{\lambda})$	2.54^{***}	1.63^{**}	5.60^{***}	-6.63^{***}	-2.26^{***}	-2.61^{***}	-6.75^{***}
	(0.39)	(0.64)	(0.41)	(2.02)	(0.23)	(0.47)	(0.63)

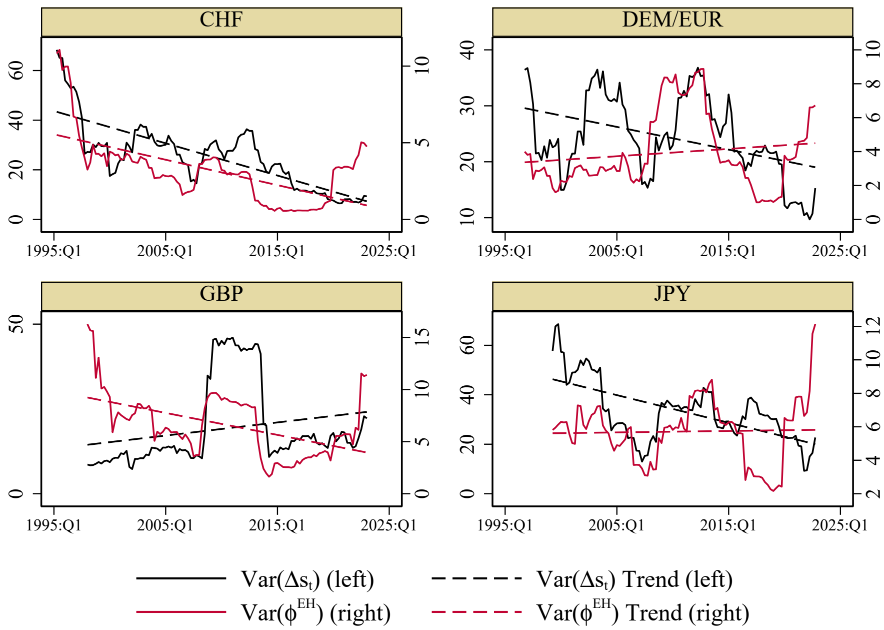
Note: Each cell in this table reports the estimated coefficient from univariate regressions of each term in the exchange rate change variance decomposition on a time trend excluding any observations where the five-year rolling window includes a quarter during which, for each currency, the exchange rate change was in the top or bottom 1 percent of the full sample. The time trend is scaled such that the coefficient represents the average change in the term over a 10-year period. Note that the terms are scaled such that the coefficients in rows 2 through 7 sum up to the trend coefficient in the exchange rate change variance. Heteroskedasticity-robust standard errors are in parentheses.
Source: Authors' calculations.

Table 6: Decomposing Trends in Volatility of φ_t^{EH}

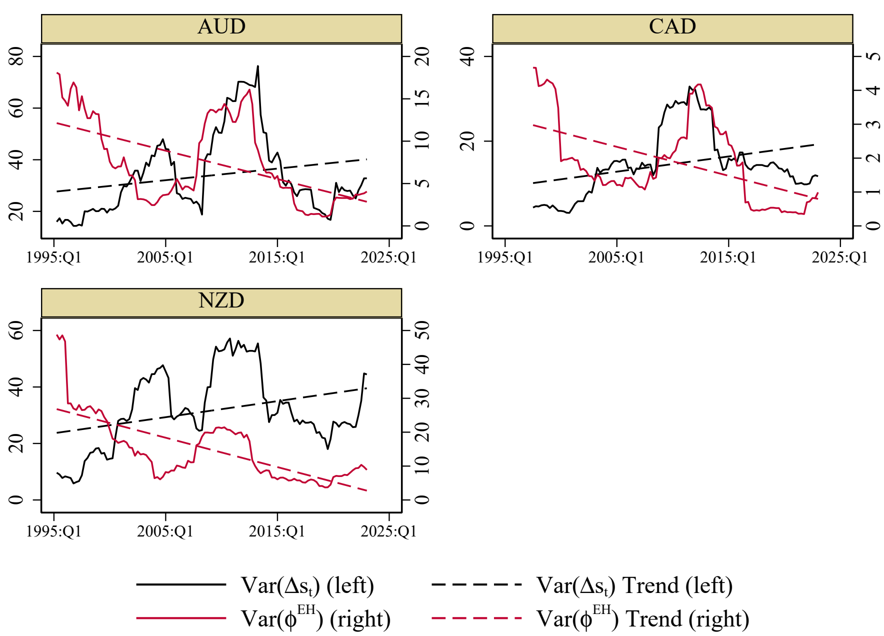
	Financial Centers				Commodity Producers		
	CHF	DEM/EUR	GBP	JPY	AUD	CAD	NZD
	$Var(\varphi_t^{EH}) = Var(\varphi_t^{EH,i}) + Var(\varphi_t^{EH,US}) - 2Cov(\varphi_t^{EH,i}, \varphi_t^{EH,US})$						
$Var(\varphi_t^{EH,i})$	0.88^{*}	2.02^{***}	0.28	-2.31^{***}	-5.15^{***}	1.64^{**}	-3.30^{***}
	(0.45)	(0.38)	(1.22)	(0.22)	(1.01)	(0.80)	(1.15)
$Var(\varphi_t^{EH,US})$	2.85^{***}	3.17^{***}	3.69^{***}	3.55^{***}	2.85^{***}	3.60^{***}	2.85^{***}
	(0.57)	(0.55)	(0.63)	(0.64)	(0.57)	(0.61)	(0.57)
$2Cov(\varphi_t^{EH,i}, \varphi_t^{EH,US})$	5.39^{***}	4.76^{***}	6.08^{***}	1.15^{**}	1.05	6.10^{***}	8.22^{***}
	(0.84)	(0.67)	(1.45)	(0.48)	(1.16)	(1.27)	(1.08)
	$Var(\varphi_t^{EH,i}) = Var(i_{t-1}^{i}) + Var(\varphi_t^{EH,F,i}) - 2Cov(i_{t-1}^{i}, \varphi_t^{EH,F,i})$						
$Var(i_{t-1}^{i})$	-0.07^{***}	-0.04^{***}	-0.01^{**}	-0.00^{***}	-0.04^{***}	-0.04^{***}	-0.05^{***}
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
$Var(\varphi_t^{EH,F,i})$	0.90^{*}	2.05^{***}	0.50	-2.27^{***}	-4.94^{***}	1.49^{*}	-3.08^{***}
	(0.46)	(0.36)	(1.24)	(0.21)	(0.96)	(0.80)	(1.12)
$2Cov(i_{t-1}^{i}, \varphi_t^{EH,F,i})$	-0.05	-0.01	0.21^{***}	0.04^{***}	0.18^{*}	-0.19^{***}	0.17^{*}
	(0.03)	(0.03)	(0.04)	(0.01)	(0.09)	(0.04)	(0.09)
	$Var(\varphi_t^{EH,US}) = Var(i_{t-1}^{US}) + Var(\varphi_t^{EH,F,US}) - 2Cov(i_{t-1}^{US}, \varphi_t^{EH,F,US})$						
$Var(i_{t-1}^{US})$	-0.02^{***}	-0.02^{***}	-0.03^{***}	-0.04^{***}	-0.02^{***}	-0.03^{***}	-0.02^{***}
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$Var(\varphi_t^{EH,F,US})$	2.87^{***}	3.14^{***}	3.66^{***}	3.44^{***}	2.87^{***}	3.58^{***}	2.87^{***}
	(0.56)	(0.55)	(0.63)	(0.64)	(0.56)	(0.61)	(0.56)
$2Cov(i_{t-1}^{US}, \varphi_t^{EH,F,US})$	-0.00	-0.06	-0.06	-0.16^{***}	-0.00	-0.05	-0.00
	(0.04)	(0.05)	(0.06)	(0.06)	(0.04)	(0.05)	(0.04)

Note: Each cell in this table reports the estimated coefficient from univariate regressions of each term in the φ_t^{EH} variance decomposition on a time trend. The time trend is scaled such that the coefficient represents the average change in the term over a 10-year period. Heteroskedasticity-robust standard errors are in parentheses.
Source: Authors' calculations.

Figure 12: $Var(\varphi_t^{EH})$



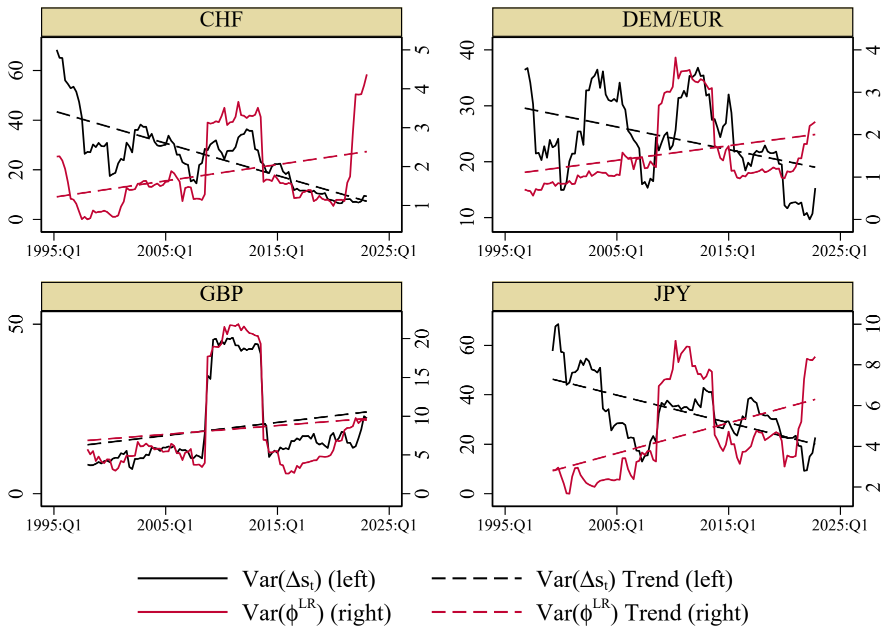
(a) Financial Centers



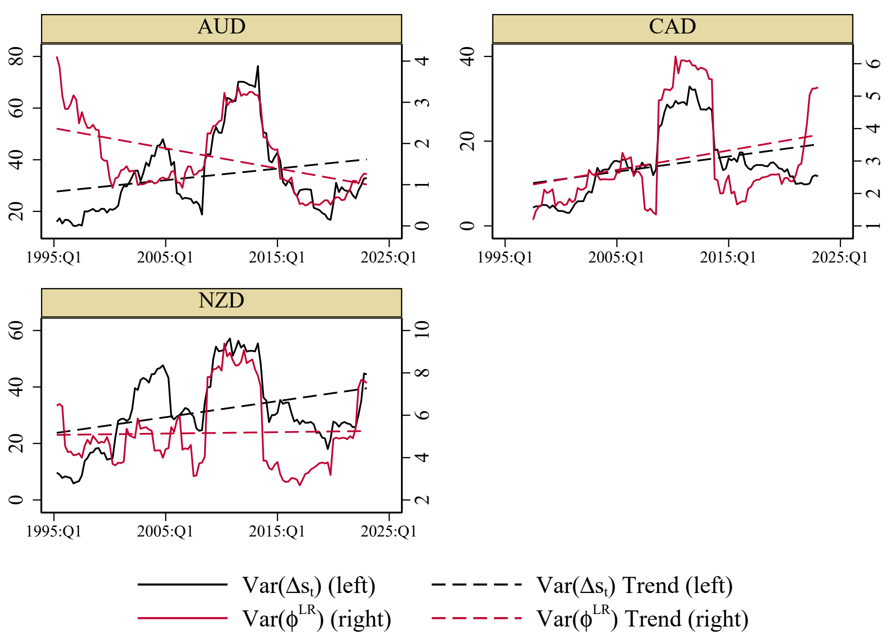
(b) Commodity Producers

Source: Global Financial Data and authors' calculations.

Figure 13: $Var(\varphi_t^{LR})$



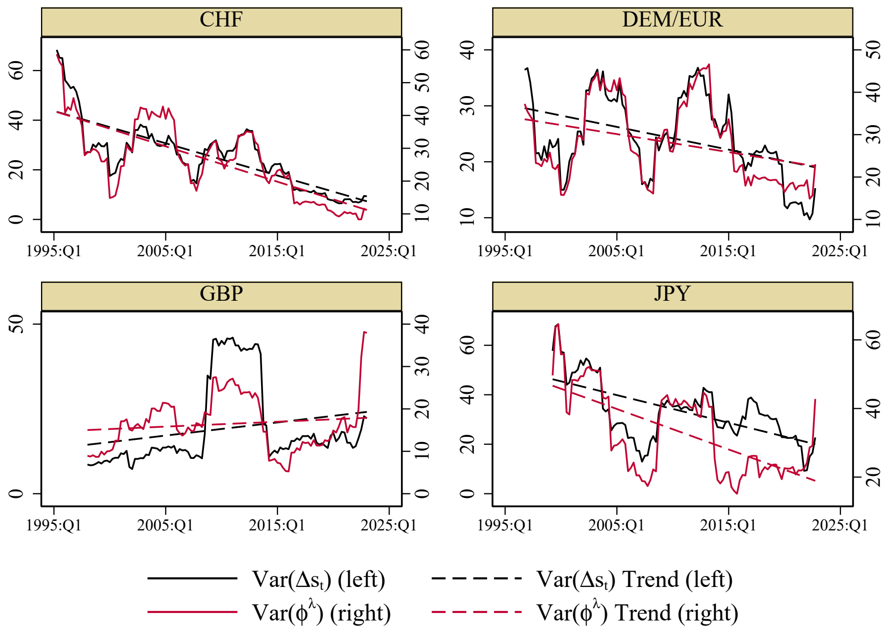
(a) Financial Centers



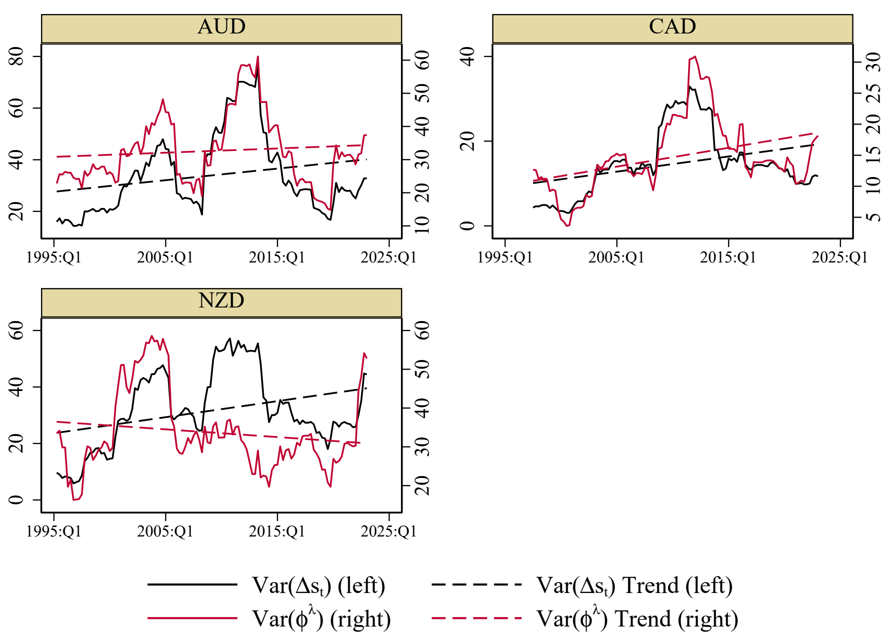
(b) Commodity Producers

Source: Global Financial Data and authors' calculations.

Figure 14: $Var(\varphi_t^{\lambda})$



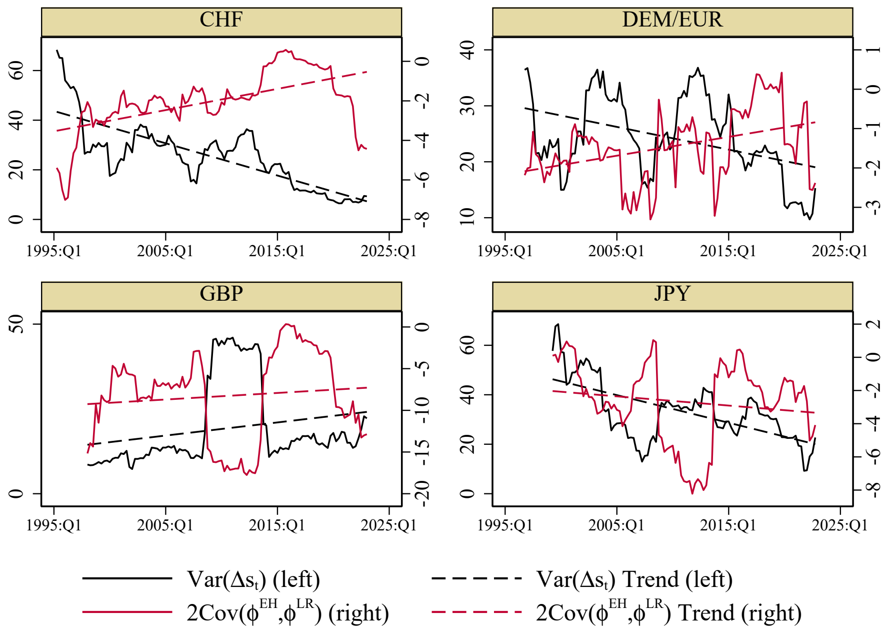
(a) Financial Centers



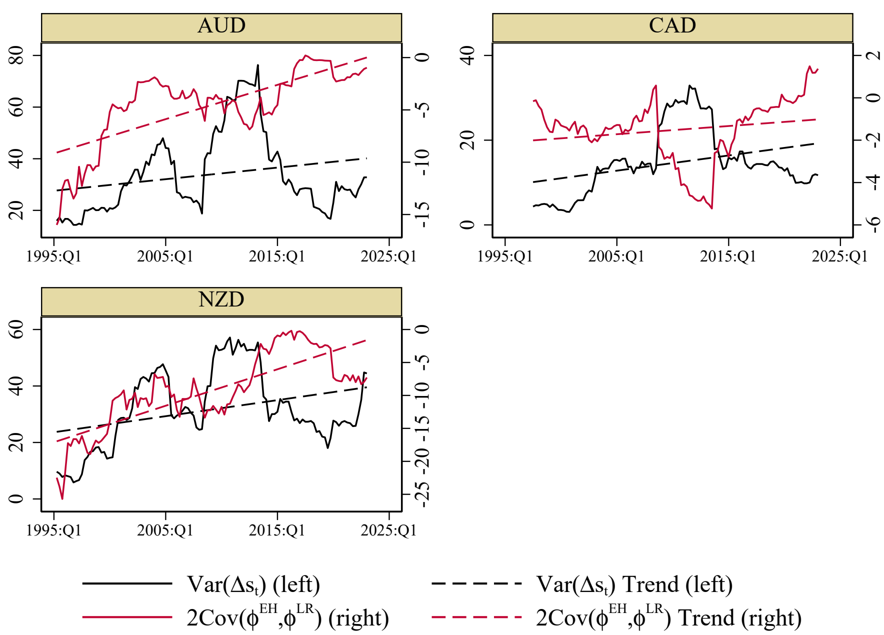
(b) Commodity Producers

Source: Global Financial Data and authors' calculations.

Figure 15: $2Cov(\varphi_t^{EH}, \varphi_t^{LR})$



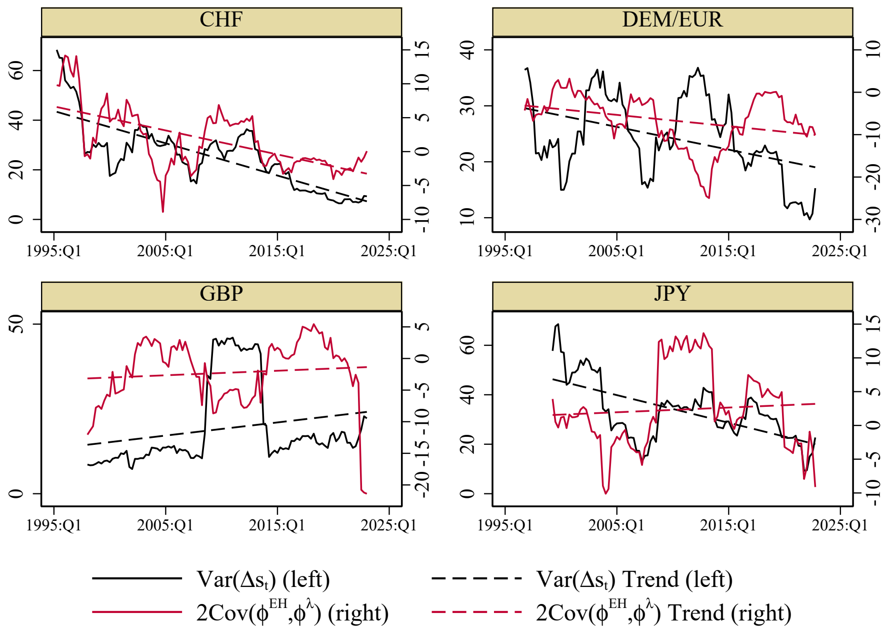
(a) Financial Centers



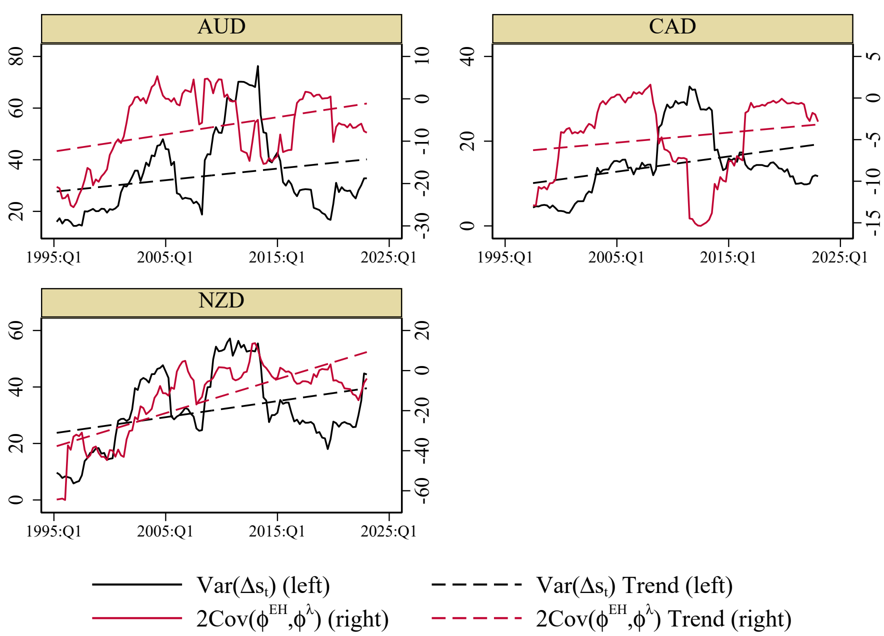
(b) Commodity Producers

Source: Global Financial Data and authors' calculations.

Figure 16: $2Cov(\varphi_t^{EH}, \varphi_t^{\lambda})$



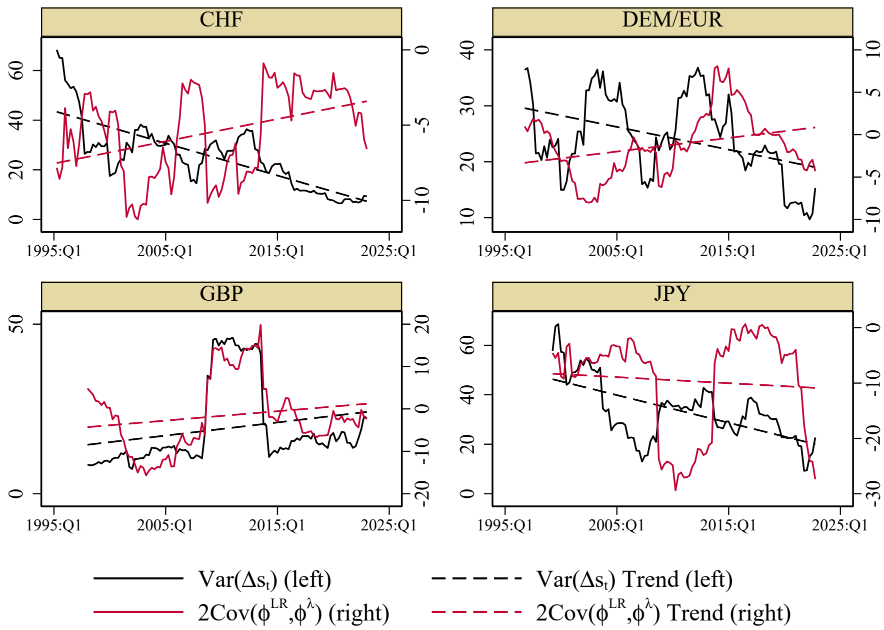
(a) Financial Centers



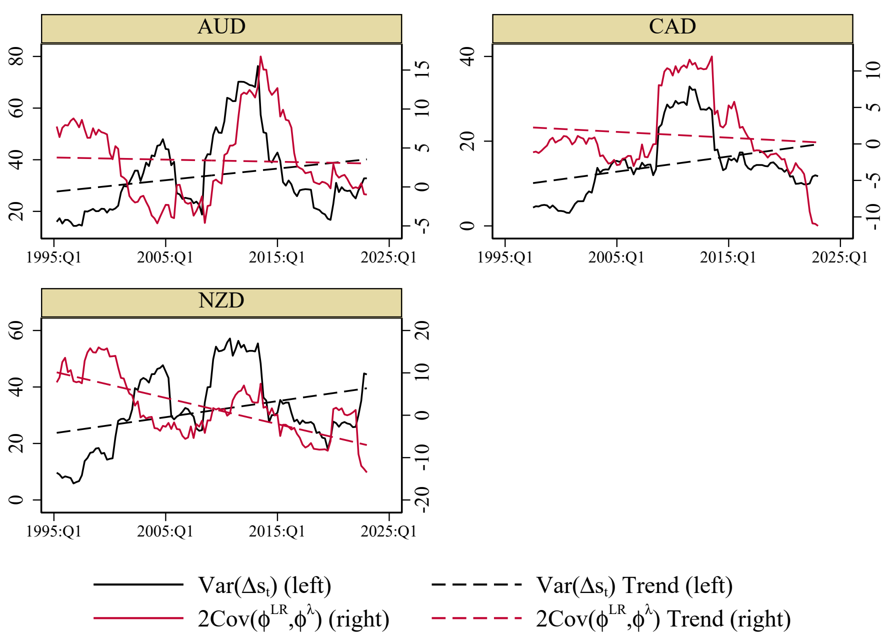
(b) Commodity Producers

Source: Global Financial Data and authors' calculations.

Figure 17: $2Cov(\varphi_t^{LR}, \varphi_t^{\lambda})$



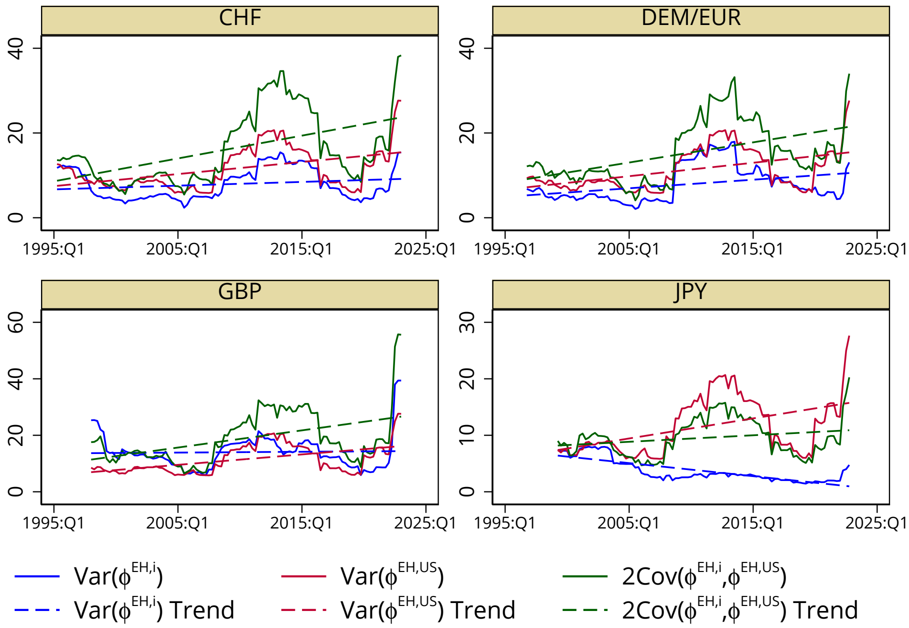
(a) Financial Centers



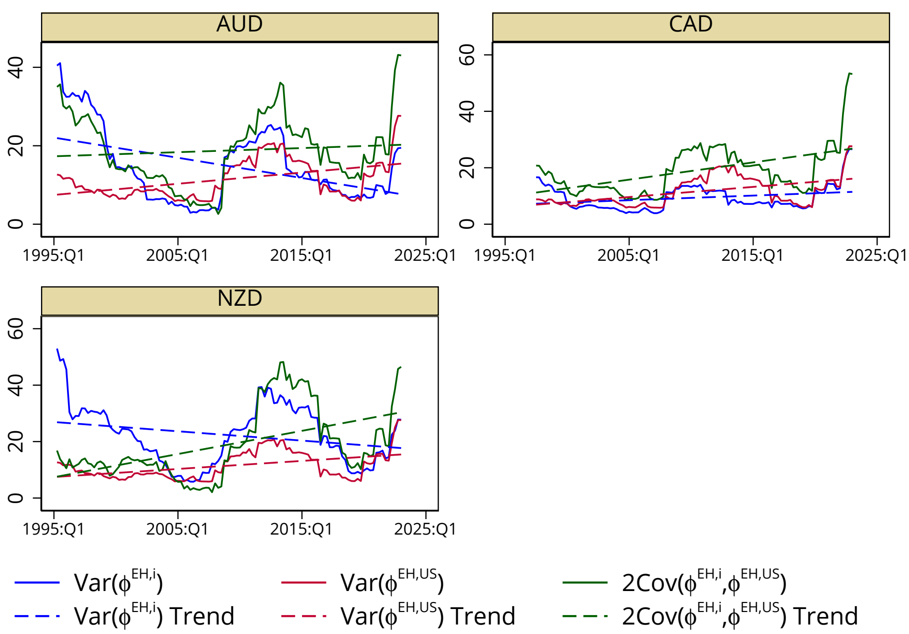
(b) Commodity Producers

Source: Global Financial Data and authors' calculations.

Figure 18: Further Decomposition of $Var(\varphi_t^{EH})$



(a) Financial Centers



(b) Commodity Producers

Note: The components displayed here are those in the decomposition: $Var(\varphi_t^{EH}) = Var(\varphi_t^{EH,i}) + Var(\varphi_t^{EH,US}) - 2Cov(\varphi_t^{EH,i}, \varphi_t^{EH,US})$.
Source: Authors' calculations.

Appendix

A Forecast-augmented VAR

We model exchange rates and short-term interest rates for each country i using the following reduced-form quarterly VAR(p) process:

$$\begin{aligned} F_t &= \bar{F} + \gamma(L) F_{t-1} + \varepsilon_{F,t} \quad (8) \\ \text{where } \gamma(L) &\equiv \gamma_1 + \gamma_2 L + ... + \gamma_p L^{p-1} \\ \text{and } F_t &\equiv [q_t^{i,US}, \tilde{x}_t^i, z_t^i, x_t^{US}, z_t^{US}]'. \quad (9) \end{aligned}$$

Here, q_t is the level of the real exchange rate defined as units of currency i per USD. By including the real exchange rate in levels, we estimate a specification where a stable estimate of the VAR implies that long-run purchasing power parity (PPP) holds and that VAR-based expectations of the long-run real exchange rate are constant. The vector x_t^{US} is a set of variables describing the US yield curve, including the three-month bill rate as well as the empirical term structure slope and curvature factors defined as:

$$\begin{aligned} sl_t^{US} &= y_t^{40,US} - i_t^{US} \\ c_t^{US} &= 2y_t^{8,US} - \left(y_t^{40,US} + i_t^{US}\right). \end{aligned}$$

The vector $\tilde{x}_{t+1}^i$ is a set of variables describing the yield curve *differentials* between country i and the United States. More specifically, it includes the relative three-month bill rate as well as the relative slope and curvature factors defined as $\tilde{sl}_t^i = sl_t^i - sl_t^{US}$ and $\tilde{c}_t^i = c_t^i - c_t^{US}$. The country-specific vector z_t^j for $j \in \{i, US\}$ represents other variables that may be useful for forecasting either short-term interest rates or changes in the exchange rate. Importantly, we always include a quarterly inflation rate (measured using CPI inflation) in z_t^j. This allows us to compute VAR-based expectations of nominal exchange rate changes from our estimates of the real exchange rate and inflation equations. The other variables in z_t^j include the GDP gap and the current-account-to-GDP ratio.

In addition to these variables, we include several other US macroeconomic variables in z_t^{US}. First, we capture global financial conditions using the US VIX index and the spread between the three-month US LIBOR and Treasury bill rates (the TED spread). While the yield curve variables do capture aspects of financial conditions that affect markets for sovereign debt, the VIX and TED spread can reflect financial conditions in other markets, such as equity and interbank lending markets, which may be relevant to financial market participants for forecasting interest rates, inflation, or exchange rates. Secondly, to improve our fit of long-horizon inflation forecasts, we include an exponentially weighted average of lagged US inflation, which is constructed as:

$$\pi_t^{avg,US} = \rho\pi_{t-1}^{avg,US} + (1-\rho)\pi_{t-p}^{US},$$

where we choose $\rho = 0.95$. When we include $\{\pi_{t-1}^{avg,US}, ..., \pi_{t-p}^{avg,US}\}$ in the VAR in equation (8), this contains information on US inflation for lags beyond p. Note also that the coefficients in the VAR equation for this variable can be fixed at their known values, allowing us to include information in the VAR from longer lags of US inflation in a way that minimizes the number of additional coefficients to be estimated.

This variable improves our fit of long-horizon inflation forecasts by capturing the declining trend in inflation expectations as most central banks in our countries of interest began targeting inflation during our sample. Since this decline is common to most countries in our sample, an alternative would have been to use an average or principal component of country-specific exponentially weighted averages rather than only the one for the United States. The issue with such a measure is that the true data-generating process for this variable would be a function of all our countries' inflation rates. To avoid estimating a misspecified equation for this variable, we would have to estimate a large VAR with all countries' variables simultaneously, which is infeasible. Since the US exponentially weighted average inflation has a correlation of 0.95 with the first principal component estimated from the set of analogous measures for each country, we believe that it is an adequate proxy for the common declining trend in inflation across all the countries in our study.

This reduced-form VAR(p) in equation (8) can be written in a VAR(1) companion form:

$$\underbrace{\begin{bmatrix} F_t \\ \vdots \\ F_{t-p+1} \end{bmatrix}}_{\mathbf{X}_t} = \underbrace{\begin{bmatrix} \bar{F} \\ 0 \\ 0 \end{bmatrix}}_{\bar{\mathbf{X}}} + \underbrace{\begin{bmatrix} \gamma_1 & \gamma_2 & \cdots & \gamma_p \\ & \mathbf{I} & & \mathbf{0} \end{bmatrix}}_{\mathbf{\Gamma}} \underbrace{\begin{bmatrix} F_{t-1} \\ \vdots \\ F_{t-p} \end{bmatrix}}_{\mathbf{X}_{t-1}} + \underbrace{\begin{bmatrix} \varepsilon_{F,t} \\ 0 \\ \vdots \end{bmatrix}}_{\mathbf{\Xi}_t}. \tag{10}$$

To address the problem of overparameterization in unrestricted VARs, we follow Cushman and Zha (1997) in restricting both the contemporaneous and the lagged relationships between the variables in the VAR; that is, we impose zero restrictions on the elements of $\{\gamma_1, ..., \gamma_p\}$. More specifically, we consider a specification in which each country's financial variables follow a smaller three-variable VAR.[19] This can be interpreted as a version of a three-factor affine term structure model in which we directly measure, rather than estimate, the factors and

[19] One caveat is that we do not impose a zero lower bound (ZLB) in the VAR. However, once the estimation is disciplined by survey data, we estimate negative three-month bill rate forecasts mainly just for countries and time periods for which actual short-term interest rates were negative.

do not further impose no-arbitrage restrictions. One advantage of this specification over one that models the short-term interest rate as a function of macroeconomic variables (such as a Taylor rule) is that it uses information from long-term yields in a parsimonious way. This enables the estimates to better capture the effects of forward guidance, among other factors, on expectations and is therefore more appropriate for a sample that includes ZLB episodes.

Our next set of restrictions concerns the macroeconomic variables. We assume that changing economic conditions in the United States affect expectations for macro variables in other countries through spillovers from the United States into the macroeconomy of these other countries (see Miranda-Agrippino and Rey (2020) for VAR-based evidence of such spillovers). At the same time, we restrict US macroeconomic variables to depend on only lags of themselves and US financial variables. Lastly, we allow the real exchange rate to enter as a lag only in its own equation. We impose this restriction so that information from lagged exchange rates themselves will not enter the nominal interest rate or long-term exchange rate terms. This distinction becomes relevant when we consider the importance of movements in these terms in driving variation in exchange rate changes. As we show below, even with this restriction, the model is still able to produce forecasts that closely mimic survey forecasts.

To summarize, if we partition each matrix $\{\gamma_1, ..., \gamma_p\}$ into five blocks corresponding to the partitioning of F_t given in (9), then the above restrictions imply the following zero restrictions on the matrix of VAR coefficients:

$$\gamma_l = \begin{bmatrix} \bullet & \bullet & \bullet & \bullet & \bullet \\ 0 & \bullet & 0 & 0 & 0 \\ 0 & \bullet & \bullet & \bullet & \bullet \\ 0 & 0 & 0 & \bullet & 0 \\ 0 & 0 & 0 & \bullet & \bullet \end{bmatrix} \quad \text{for } l = 1, ..., p. \tag{11}$$

Our main innovation to the existing literature on exchange rate decompositions is that we not only estimate (10) subject to (11), but also further discipline the estimation using survey forecasts of exchange rates, interest rates, and inflation to ensure that our model-implied estimates accurately capture private-sector expectations.

More specifically, we add the following set of equations relating survey forecasts to VAR-implied forecasts:

$$\mathbf{Y}_t^S = H_t\left(\bar{\mathbf{X}}, \mathbf{\Gamma}\right)\mathbf{X}_t + H_t^Z \mathbf{Z}_t + \mathbf{\Xi}_{h,t}^S \tag{12}$$

where $\mathbf{Y}_t^S$ is a vector of survey forecasts. The right-hand side of the above equation maps current and lagged data $\{F_{t-l}\}_{l=0}^{P}$ into model-implied forecasts that correspond to this vector of survey forecasts. $H_t\left(\bar{\mathbf{X}}, \mathbf{\Gamma}\right)$ is the matrix of coefficients on the VAR variables $\mathbf{X}_t$, which contain up to p lags of VAR variables. It is a function of the coefficient matrices in (10) as well as t through the quarter of the year in which period t falls. The dependence on the quarter is a result of the forecast horizons and variable definitions in our survey data. For the same reason, the mapping is also a function of additional variables $\mathbf{Z}_t$, which contain further lags of the VAR variables and data on price levels. The error $\mathbf{\Xi}^S_{h,t}$ can be interpreted as capturing measurement error due to the discrepancy related to forecasters' observations of real-time macroeconomic data and our use of current vintage data as well as small differences between the timing of the surveys and our data observations. See Section A.2 below for further details on this mapping.

Considered collectively, the system of equations given by (10) and (12) can be interpreted as a way to interpolate and extrapolate the survey data available in $\mathbf{Y}^S_t$ to other horizons in a way that is consistent with the data-generating process in (10) and the behavior of realized one-period-ahead data. Without making any further assumptions about the errors, we can consistently estimate the coefficients $\bar{\mathbf{X}}$ and $\mathbf{\Gamma}$ subject to the restrictions in (11) by minimizing the sum of squared errors from all equations in (10) and (12).[20] Because the decomposition given in equations (3) and (5) relies heavily on forecast revisions, we also include differences between model-implied and survey forecast revisions as additional errors in this estimation.[21] We estimate this system using quarterly data with a lag length of two quarters for the following nine economies against the United States: Australia, Canada, Germany/the eurozone, Japan, New Zealand, Switzerland, and the United Kingdom. For all financial variables, we use end-of-quarter values when possible. The overall sample time period is 1990 through 2023, but we exclude periods of currency pegging prior to 1992:Q4 for the GBP and from 2011:Q3 through 2015:Q1 for the CHF; samples for individual countries may also differ slightly due to data unavailability.

To ensure consistency of the coefficients in the data-generating process of the US variables, we estimate the equations for US variables separately over the full sample of data available for the United States and then hold these coefficients fixed when estimating country i equations for each country in our sample.

[20]This can be alternatively interpreted as estimating the regressions implied by (10) and (12) with cross-equation coefficient restrictions generated by the fact that $\bar{\mathbf{X}}$ and $\mathbf{\Gamma}$ appear in both sets of equations. Under this interpretation, the equations in (12) represent an estimation of data-generating processes for survey expectations as a function of observable variables in our VAR.

[21]For cases where the available forecast horizons do not allow us to construct revisions, we use changes in forecasts.

A.1 Calculating the Components of the Exchange Rate Decomposition

Using the estimated VARs, we can easily obtain the five components of exchange rate changes listed in equation (6). First, to represent the expected excess return, λ_t, in terms of VAR variables, the exchange rate change and lagged short-term interest rate differential can be expressed as:

$$\begin{aligned}\Delta s_t &\equiv \Delta q_t + \tilde{\pi}_t = \left(e_q + e_\pi^i - e_\pi^j\right)\mathbf{X}_t - e_q\mathbf{X}_{t-1} \\ \tilde{\imath}_{t-1} &= e_{\tilde{\imath}}\mathbf{X}_{t-1},\end{aligned}$$

where e_q is a row vector that selects q_t from $\mathbf{X}_t$; that is, it has the same number of elements as $\mathbf{X}_t$ with an entry of one corresponding to the position of q_t in $\mathbf{X}_t$ and zeros elsewhere. Likewise, $e_{\tilde{\imath}}$ is the selection vector corresponding to the short-term interest rate of countries i relative to the United States, and e_π^i and e_π^j are the selection vectors for inflation in country i and the United States, respectively. Thus, by denoting VAR-implied expectations at time t by $\hat{E}_t$, we have the following expression for the lagged currency premium:[22]

$$\lambda_{t-1} = \hat{E}_{t-1}[\Delta s_t] - \tilde{\imath}_{t-1} = \left(e_q + e_\pi^i - e_\pi^j\right)\left(\bar{\mathbf{X}} + \mathbf{\Gamma}\mathbf{X}_{t-1}\right) - \left(e_q + e_{\tilde{\imath}}\right)\mathbf{X}_{t-1}.$$

The final three terms in equation (6) are infinite sums of changes in expectations. Note that the VAR-implied change in expectations over future $\mathbf{X}_{t+k}$ can be written simply as a linear combination of the time t reduced-form residuals:

$$\hat{E}_t\mathbf{X}_{t+k} - \hat{E}_{t-1}\mathbf{X}_{t+k} = \mathbf{\Gamma}^k\mathbf{\Xi}_t.$$

Using this fact, we can construct the remaining three VAR-implied exchange rate change components as follows, as long as estimates of the VAR are stationary, which is true for all

[22] The $\hat{E}_t$ operator denotes expectations based on the linear projections performed in the VAR estimation. Although not explicitly delineated, the operator conditions only on the set of regressors included in the estimation of each equation. Due to the restrictions set out above, this means that the relevant information set differs across variables.

our currency pairs:[23]

$$\begin{aligned}
\varphi_t^{EH,F} &= e_{\tilde{i}} \left(\mathbf{I} - \mathbf{\Gamma} \right)^{-1} \mathbf{\Xi}_t \\
\varphi_t^{\lambda,F} &= \left[\left(e_q + e_\pi^i - e_\pi^j \right) \mathbf{\Gamma} - \left(e_q + e_{\tilde{i}} \right) \right] \left(\mathbf{I} - \mathbf{\Gamma} \right)^{-1} \mathbf{\Xi}_t \\
\varphi_t^{LR} &= \left(e_\pi^i - e_\pi^j \right) \left(\mathbf{I} - \mathbf{\Gamma} \right)^{-1} \mathbf{\Xi}_t.
\end{aligned} \tag{13}$$

Note that none of the terms in this decomposition is a residual in the traditional sense because each term can be directly computed from the variables and coefficient estimates in the reduced-form VAR model. These five terms sum to the exchange rate change without any other residual in the equation because the decomposition is based on a definition of the expected excess return that holds exactly by assumption.

A.2 Details on Mapping VAR to Survey Forecasts

The VAR augmented with survey data given by equations (10) and (12) in the main text can be written in the following, more compact state-space form:

$$Z_t = \bar{\mathbf{\Gamma}} Z_{t-1} + \bar{\mathbf{\Xi}}_t$$
$$\begin{bmatrix} Y_t^A \\ Y_t^S \end{bmatrix} = \underbrace{\begin{bmatrix} E^A \\ E_t^S \end{bmatrix}}_{\mathbf{E}_t} Z_t + \begin{bmatrix} 0 \\ \Xi_t^s \end{bmatrix},$$

where Z includes a constant, the elements in X as described in Section 3.1, and the additional lags of X that appear in equation (12). $\bar{\mathbf{\Gamma}}$ thus includes the coefficients in $\bar{\mathbf{X}}$ and $\mathbf{\Gamma}$ as well as additional ones and zeros. $\bar{\mathbf{\Xi}}_t$ contains $\mathbf{\Xi}_t$ and zeros. Y_t^A contains observed actuals, which are mapped using a selection matrix E^A to the elements in the state vector Z_t. Y_t^S contains survey forecasts, which are a linear function of Z_t, where E_t^S is a product of selection matrices and powers of $\bar{\Gamma}$, as shown below. The time variation in E_{t+1}^S results from the nature of the survey forecasts, which are detailed below. Ξ_t^s are IID Gaussian errors whose variances are, for parsimony, parameterized by country-variable-horizon groups (following Crump, Eusepi, and Moench (2018)). Within each country and survey variable, forecasts for horizons as long as two quarters out form one group. Those for horizons three quarters to two years out form another and, those for long-run averages of the three-month interest rates form the

[23]While no restrictions were imposed on the residuals when estimating the VAR, to derive the analytical results in (13) and to define the VAR-based expectations in equation (12), we assume that $\check{E}_t \mathbf{\Xi}_{t+k} = 0$. Given that the approach we take here is similar to estimating the parameters of a pre-specified data-generating process for the consensus forecast data, as long as we are consistent and match the survey data well, it is inconsequential whether we allow for persistence in the VAR residuals. The VAR should be interpreted simply as a way to interpolate and extrapolate survey data for horizons for which they are unavailable.

final group.

The mapping between actual data and the survey forecasts is given by the matrix:

$$E_t^S = H_t^S \underbrace{\begin{bmatrix} I \\ \bar{\Gamma} \\ \vdots \\ \bar{\Gamma}^{h_{\max}} \end{bmatrix}}_{\tilde{\bar{\Gamma}}},$$

where $h_{\max}$ is the longest available horizon for our set of survey variables. Right-multiplying $\widetilde{\Gamma}$ by the state vector Z_t results in a large matrix containing model-implied forecasts for horizons 0 to $h_{\max}$. Each row of H_t^S corresponds to the mapping for a single survey forecast. Most rows of H_t^S are selection vectors selecting the relevant forecast horizon and variable. A few notable exceptions are discussed below:

1. Mapping annualized quarterly log growth rate actuals to annual average percentage growth rates (for example, zero- to two-years-ahead inflation forecasts):

   Let $z_{j,t}$ be an annualized quarterly log growth rate of some variable X_t so that we have:

$$\begin{aligned} z_{j,t} &\approx 400\Delta x_t \\ \text{where } x_t &\equiv \ln X_t. \end{aligned}$$

   Let $y_{i,t}^S$ be a forecast of the annual average percentage growth rate of X_t between years $h-1$ and h ahead of the current year. Then we have:

$$\begin{aligned} y_{i,t}^S &= 100E_t\left[\frac{X_{t-q}+X_{t-q+1}+X_{t-q+2}+X_{t-q+3}}{X_{t-q-1}+X_{t-q-2}+X_{t-q-3}+X_{t-q-4}}-1\right] \quad \text{where } q = Q(t)-4h-1 \\ &= 100E_t\left[\Delta x_{t-q+3}+2\Delta x_{t-q+2}+3\Delta x_{t-q+1}+4\Delta x_{t-q}+3\Delta x_{t-q-1}+2\Delta x_{t-q-2}+\Delta x_{t-q-3}\right] \\ &= \sum_{l=-3}^{3}\underbrace{\frac{4-|l|}{4}}_{w_l}E_t[z_{j,t-q+l}]. \end{aligned}$$

   In the above expression, $Q(t)$ gives the quarter of the year in which t falls. In the context of the framework above, the relevant row of H_{t+1}^S would contain a vector of zeros and the elements of $\{w_l\}$ in a way that results in the weighted average shown above.

2. Mapping real exchange rate forecasts to nominal exchange rate forecasts:

   Our model contains real exchange rates q_t, while the survey participants forecast the nominal exchange rate s_t. We use the relationship below to obtain model-implied forecasts of s_t, which we map to the survey data:

$$\hat{E}_t s_{t+h} = \hat{E}_t q_{t+h} + \sum_{i=1}^{h} \hat{E}_t \tilde{\pi}_{t+i} + \tilde{p}_t,$$

where $E_t^S s_{t+h}$ is the observed h-period ahead forecast, $E_t^M s_{t+h}$ is the model-implied forecast, and $\tilde{p}_t$ is the actual relative price level.

B Data Details

B.1 Macroeconomic Variables Used in Section 2

Section 2 uses a longer monthly data sample that starts in 1973. Variables that had only quarterly data are carried forward to monthly.

- 10 year yields – Global Financial Data
- Unemployment rate – Global Financial Data
- Total CPI – OECD (NZL quarterly only)
- Industrial Production (Total IP for all countries except Japan, Manufacturing IP for Japan, quarterly for NZL and part of the CHE sample)
- Exchange rates – Global Financial Data

	Start	End
AU	1973:M1	2023:M7
CA	1973:M1	2023:M7
CH	1973:M1	2023:M3
DE	1973:M1	2023:M7
JP	1973:M1	2023:M8
NZ	1973:M1	2023:M6
UK	1973:M1	2023:M7
US	1973:M1	2023:M8

B.2 Macroeconomic and Financial Variables Used for the Exchange Rate Change Decomposition

- *Exchange rates*: End-of-quarter exchange rates are computed using daily data from Global Financial Data.

- *Short-term rates*: End-of-quarter three-month bill rates are obtained from the following sources:
  - Australia, Canada, New Zealand, Switzerland, United Kingdom, and United States: Central bank data obtained through Haver Analytics.
  - Germany: Reuters data obtained through Haver Analytics. German three-month bill rates are replaced with three-month EONIA OIS swap rates starting in 1999:Q1.
  - Japan: Bloomberg
- *Zero-coupon yields:* End-of-quarter zero-coupon yields are obtained from the following sources:
  - Canada, Germany, Switzerland, and United Kingdom: Central banks. German zero-coupon bond yields are replaced with estimates of zero-coupon yields on AAA-rated euro-area sovereign debt provided by the European Central Bank (ECB).
  - Australia, New Zealand: Data from Wright (2011) extended with data from central banks
  - Japan: Bloomberg.
  - United States: Gürkaynak, Sack, and Wright (2007)
- *Output gap and current account-to-GDP ratio:* All macro data are from the OECD Main Economic Indicators and Economic Outlook databases. The GDP gap is computed using the OECD's annual estimates of potential GDP, which were log-linearly interpolated to the quarterly frequency. German data are replaced with euro-area data starting in 1999:Q1.
- *CPI inflation:* Government statistical agencies.
- *US VIX and TED spread:* Haver Analytics.
- *Market-based interest rate surprises and expected changes:* These are computed using prices of futures on three-month interest rates on the last trading day of each quarter. These expectations refer to the three-month rates on each contract's last trading day, which typically falls within the second-to-last week of each quarter. When we compute the surprises and expected changes in these interest rates, the actual rate we use is the underlying rate of each futures contract. The futures data are all obtained from Bloomberg and are based on the following underlying rates:
  - Australia: Australian 90-day bank accepted bills.
  - Canada: Canadian three-month bankers' acceptance.

- Switzerland: Three-month Euroswiss.
- Germany/EU: ICE three-month Euribor.
- New Zealand: New Zealand 90-day bank accepted bills.
- United Kingdom: Three-month Sterling LIBOR.
- United States: Three-month Eurodollar.

The following table shows the start and end of our data samples for each currency. For the CHF, we also exclude the period of fixed exchange rates (2011:Q3–2015:Q1) from the estimation of the VAR coefficients, though we still compute exchange rate change components over this period.

	Start	End
AU	1990:Q3	2023:Q1
CA	1992:Q4	2023:Q1
CH	1990:Q3	2023:Q1
DE	1992:Q1	2022:Q4
JP	1994:Q3	2022:Q4
NZ	1990:Q3	2023:Q1
UK	1993:Q2	2023:Q1
US	1990:Q3	2023:Q1

B.3 Survey Data Details

In the VAR, we include the following survey data for three-month interest rates, CPI inflation, and exchange rates:

Blue Chip Economic Indicators

- Countries: Australia, Canada, Germany/the eurozone, Japan, United Kingdom, United States
- Non-US variables: Current, one-, and two-year-ahead forecasts of three-month interest rates, CPI inflation, and exchange rates.
- US variables: Seven- to 11-year-ahead average three-month bill rate (starting in 1990:Q1).
- Other details: Forecasts for German three-month interest rates and CPI inflation are replaced with eurozone forecasts starting in January 2000, when they become available.

Blue Chip Financial Forecasts

- Countries: Australia, Canada, Germany/the eurozone, Japan, Switzerland, United Kingdom, United States
- Variables: three-, six- and 12-month-ahead three-month interest rate and exchange rate forecasts.
- Other details: Forecasts for German three-month interest rates and exchange rates are replaced with eurozone forecasts starting in January 1999.

Consensus Economics

- Country coverage: Australia, Canada, Germany/the eurozone, Japan, New Zealand, Switzerland, United Kingdom, United States
- Variables: Current, one- and two-year-ahead, and six- to 10-year-ahead average for CPI inflation; three-, 12-, and 24-month-ahead for exchange rates. six- to 10-year- ahead average GDP growth forecasts are used to impute long-horizon, non-US three-month bill rate forecasts, but they are not directly included in the VAR estimation.
- Other details: Forecasts for Germany are replaced with eurozone forecasts as they become available. Short-horizon CPI inflation and three-month interest rate forecasts switch from Germany to the eurozone in December 2002 and January 2005, respectively. Long-horizon CPI inflation and GDP growth forecasts switch from Germany to the eurozone in April 2003.

Other details:

- The Blue Chip publications contain forecasts from about 50 survey respondents, while Consensus Economics polls approximately 200 forecasters. Each publication contains responses from about 10 to 30 participants for any given variable.
- For interest rates, we have long-horizon forecasts for the United States (six- to 10-year-ahead or seven- to 11-year ahead averages), but not other countries. Instead, we impute long-horizon three-month interest rates using a procedure akin to the one employed in Wright (2011). More specifically, Wright (2011) fits US long-horizon three-month interest rate forecasts to US long-horizon inflation and GDP growth forecasts and then uses the estimated coefficients to impute long-horizon three-month interest rate forecasts for other countries. We adopt this method but also include five-year-ahead five-year forward rates in the regression because we found that this approach greatly improved our fit of US long-horizon interest rate forecasts. Table A1 below shows the regression of US long-horizon rates whose estimates are used to impute long-horizon interest rate forecasts for other countries. Compared with the original Wright (2011) specification, adding five-year-ahead five-year forward rates to the regression raises the adjusted R^2 from 81 to 88 percent over our sample.
- All inflation forecasts are for an annual-average (price index)-over- annual-average basis. Annual interest rate and exchange rate forecasts are for end-of-year values. Months-ahead forecasts are for end-of-month values.
- Surveys are usually published within the first two weeks of the month and contain responses from survey participants from the end of the prior month. To map the survey data to our model, we backdate the survey variables (for example, a January publication is mapped to model-implied forecasts as of the end of Q4)
- CPI forecasts for the United Kingdom begin in 2004:Q2 in all databases. Previous inflation forecasts for the United Kingdom were for the retail price index.
- Three-month interest rate forecasts for certain countries are explicitly for interbank rather than bill rates. There are also cases where the survey does not specify the particular rate that respondents forecast. To account for this, we allow data-source-specific constants in the rows of equation (12) that correspond to three-month interest rate forecast data. Though sometimes statistically significant, the estimated constants are small and consistent with average spreads between interbank and bill rates. When assessing model fit, we include this additional constant in the model-implied counterpart to forecasts of the *surveyed variable*. However, this additional constant is not considered to be part of the model-implied three-month *bill rate* forecasts.

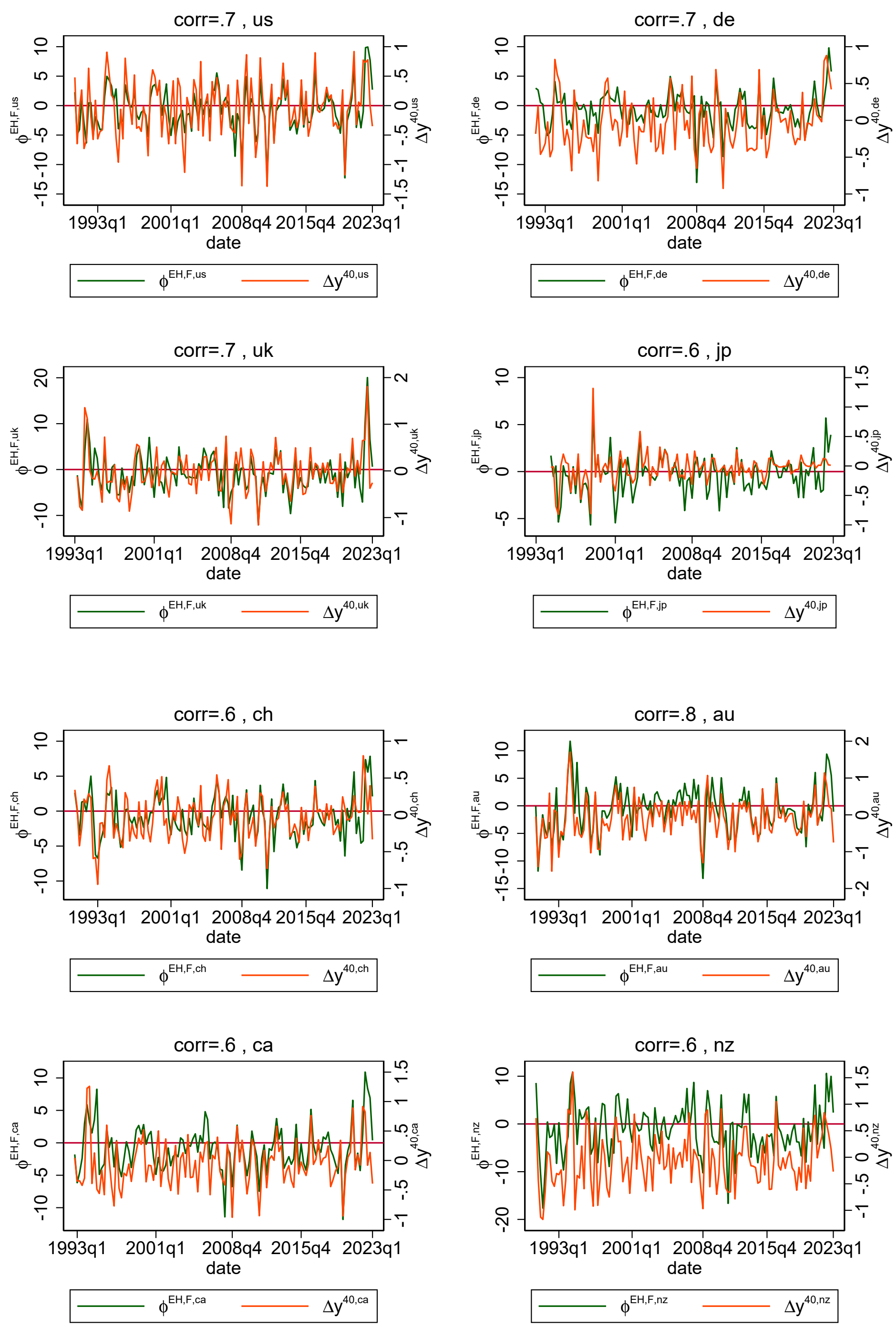
Table A1: Relationship between US Long-horizon Interest Rate Forecasts, Macroeconomic Forecasts, and Forward Rates

	Baseline	Wright(2011)
6Y-10Y Ahead Inflation Forecast	0.75**	1.76***
	(0.30)	(0.34)
6Y-10Y Ahead GDP Growth Forecast	0.86***	1.60***
	(0.16)	(0.15)
5Y Ahead 5Y Forward Rate	0.32***	
	(0.05)	
Constant	-1.45**	-4.40***
	(0.65)	(0.65)
Adj. R^2	0.88	0.81
# of Observations	69	69

Note: The dependent variable is the six- to 10-year-ahead three-month interest rate forecast. All dependent and independent variables in this regression are specific to the United States and are contemporaneous in timing. All forecast data used are from *Consensus Forecasts*. The sample is semi-annual observations over 1997:Q3 through 2013:Q4 and quarterly observations thereafter until 2022:Q4. Heteroskedasticity-robust standard errors are reported in parentheses.
Source: Authors' calculations.

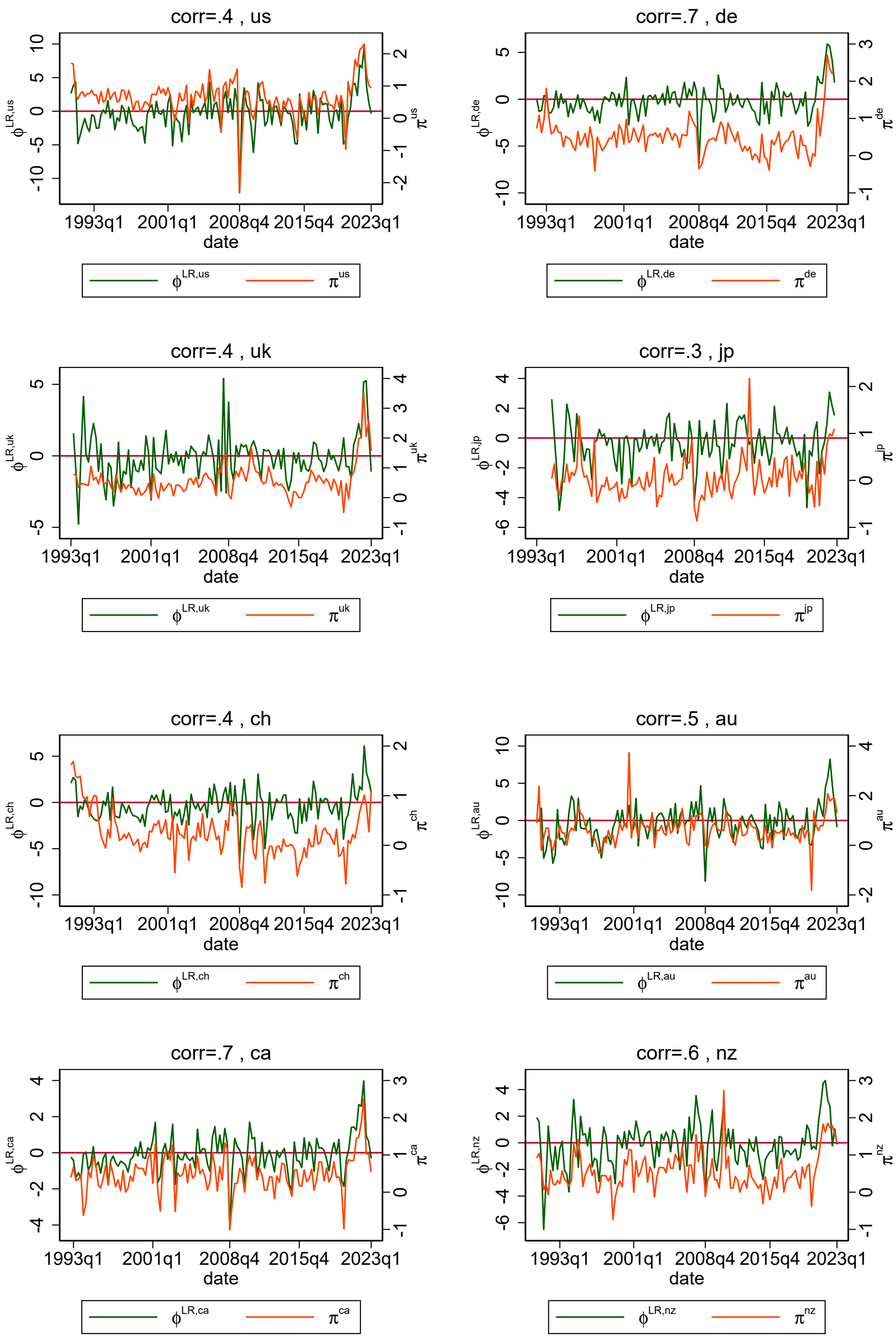
C Additional Figures

Figure A1: $\varphi_t^{EH,F,i}$ and Changes in 10-year Yields



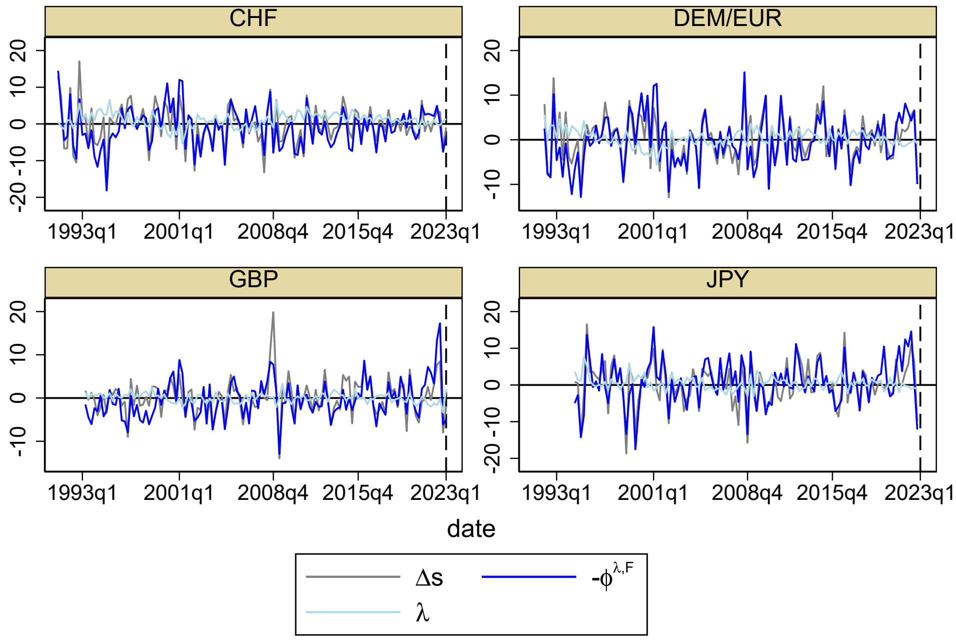
Source: Global Financial Data and authors' calculations.

Figure A2: $\varphi_t^{LR,i}$ and Inflation

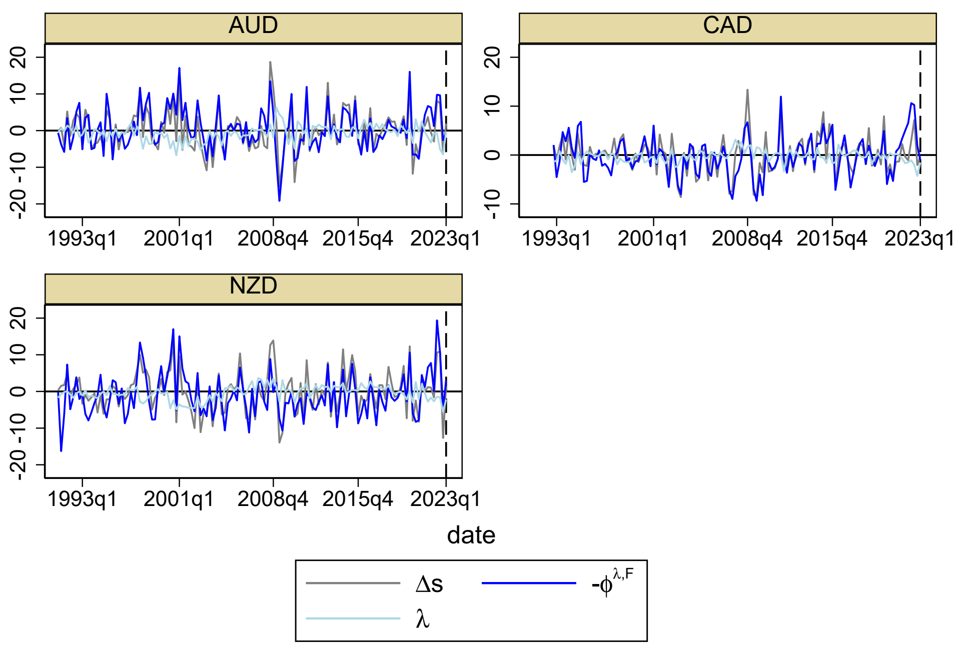


Source: Organisation for Economic Cooperation and Development and authors' calculations.

Figure A3: Lagged and Expected Future Currency Premia Components



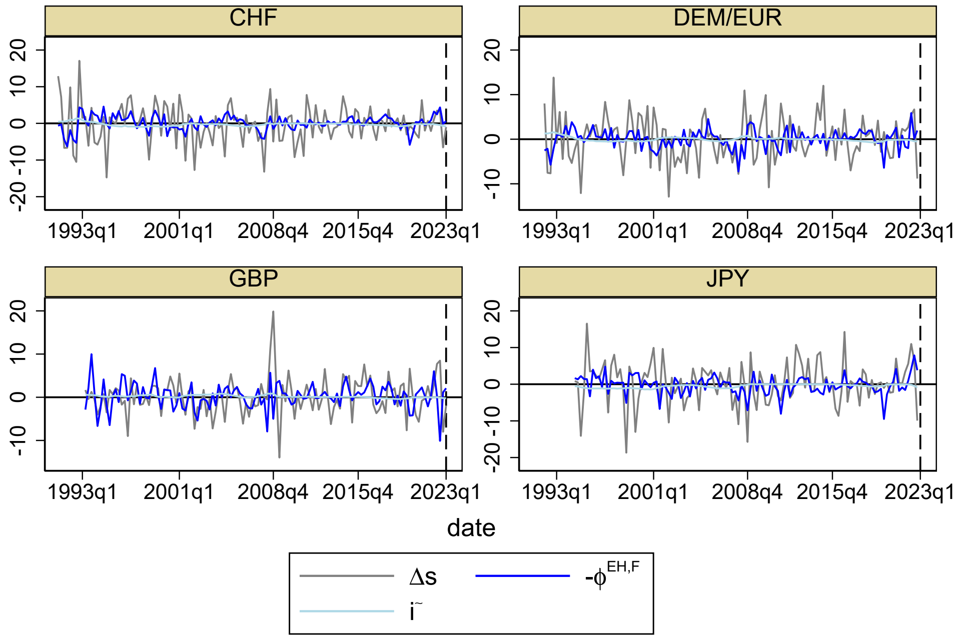
(a) Financial Centers



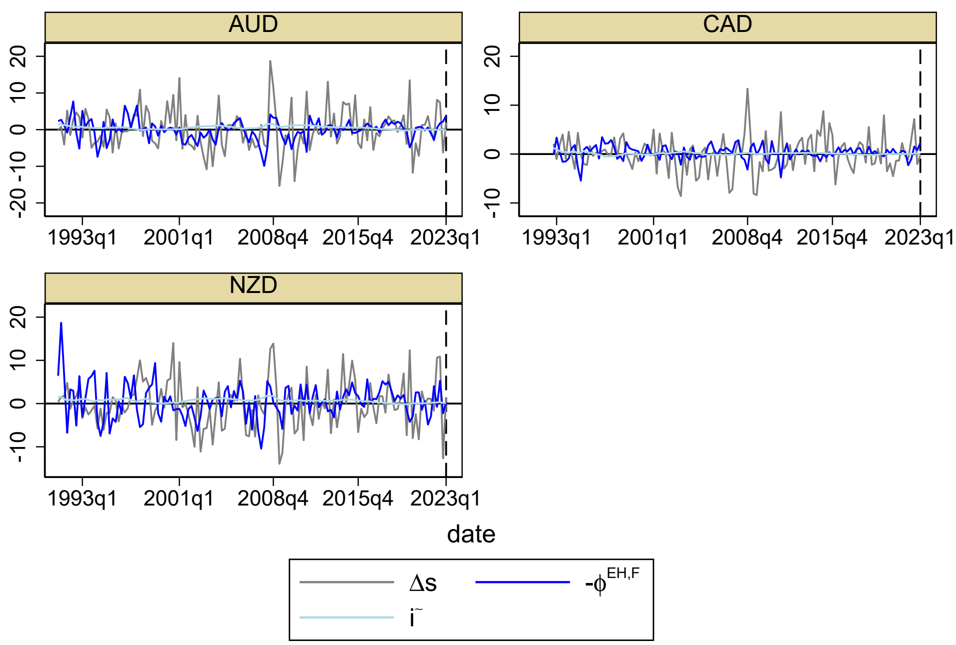
(b) Commodity Producers

Source: Global Financial Data and authors' calculations.

Figure A4: Lagged and Expected Future Interest Rate Differential Components



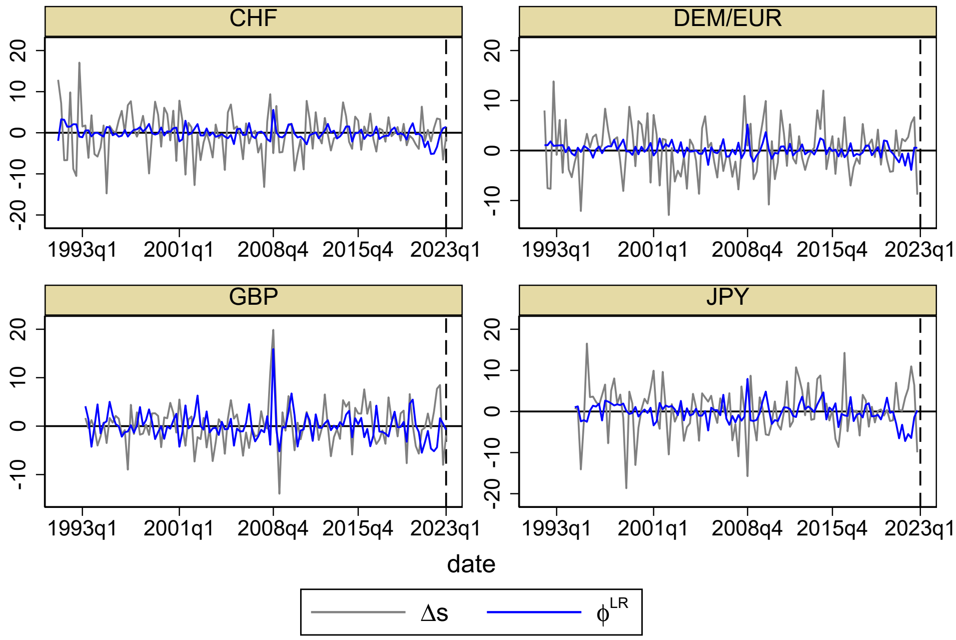
(a) Financial Centers



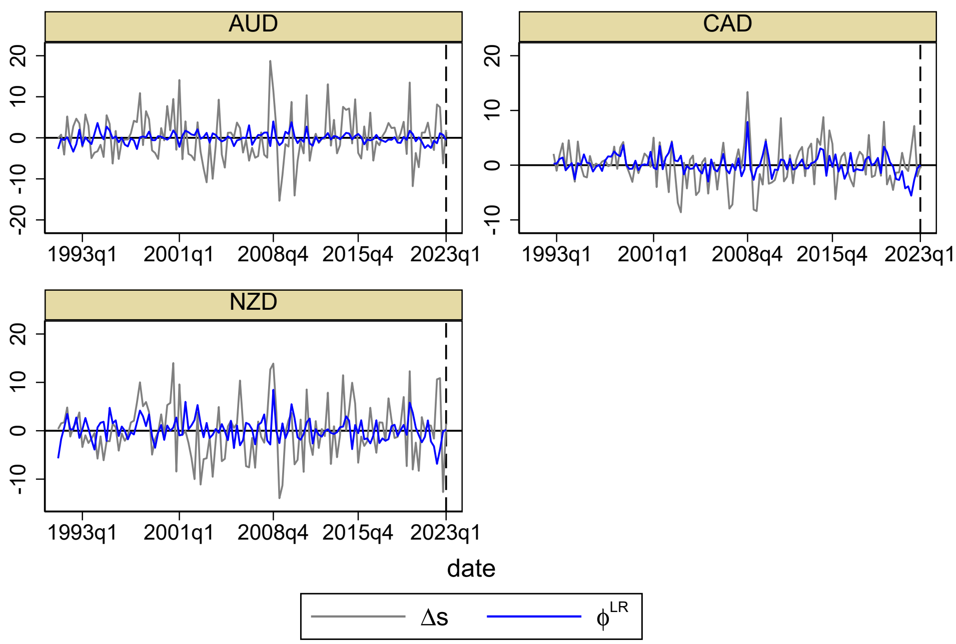
(b) Commodity Producers

Source: Global Financial Data and authors' calculations.

Figure A5: Expected Future Inflation Component



(a) Financial Centers



(b) Commodity Producers

Source: Global Financial Data and authors' calculations.