A Fundamental Connection: Exchange Rates and Macroeconomic Expectations

Vania Stavrakeva
London Business School

Jenny Tang
Federal Reserve Bank of Boston

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Abstract

This paper presents new stylized facts about exchange rates and their relationship with macroeconomic fundamentals. We show that macroeconomic surprises explain a large majority of the variation in nominal exchange rate changes at a quarterly frequency. Using a novel present value decomposition of exchange rate changes that is disciplined with survey forecast data, we show that macroeconomic surprises are also a very important driver of the currency risk premium component and explain about half of its variation. These surprises have even greater explanatory power during economic downturns and periods of financial uncertainty.

Emails: vstavrakeva@london.edu, jenny.tang@bos.frb.org. The views expressed in this paper are those of the authors and do not necessarily represent the views of the Federal Reserve Bank of Boston or the Federal Reserve System. Nikhil Rao provided invaluable research assistance on this project. We thank Pierre-Olivier Gourinchas, Hélène Rey, Kenneth Rogoff and the participants at various seminars and conferences for their useful comments.

1 Introduction

The debate in international economics as to whether exchange rates are disconnected from macroeconomic fundamentals has permeated the field over the last two decades or so.[1] The current consensus is that, even contemporaneously, macroeconomic fundamentals and exchange rates are still rather disconnected.[2] The empirical exchange rate literature has moved, instead, toward documenting contemporaneous relationships between exchange rates and financial variables.[3] Overall, a perception has emerged that exchange rates are much closer to asset prices than to macroeconomic fundamentals.

Using novel econometric techniques, we revisit the debate and argue that the notion of such a contemporaneous disconnect between exchange rates and macroeconomic fundamentals is incorrect. While quarterly exchange rate changes are tightly linked to movements in currency risk premia, macroeconomic news explains much of the variation in these risk premia (about 50 percent). This same macroeconomic news also explains the vast majority of variation in exchange rate changes at a quarterly frequency (about 70 percent). The explanatory power is even higher during US recessions and periods of high financial uncertainty. The evidence in this paper calls for theories that connect not only exchange rate changes but also currency risk premia (or expected excess returns more broadly) to macroeconomic fundamentals.[4]

Macroeconomic news is closely monitored by foreign exchange rate investors (see the survey of foreign exchange rate investors by Cheung and Chinn 2001, for example). Not surprisingly, papers that study the high-frequency movements of exchange rates find that macro surprises, defined as announcements on macro variables minus forecasts of those variables, cause immediate statistically significant reactions in exchange rates in the hours following those announcements (Andersen et al. 2003; Faust et al. 2007). This paper first contributes to the literature by linking this event study literature with the debate on the exchange rate

[1]See the influential paper by Meese and Rogoff (1983) and papers by Frankel and Rose (1995), Engel and West (2005), and Engel, Mark, and West (2008) that followed.

[2]A recent exception is the paper by Koijen and Yogo (2020), who find that macroeconomic and policy variables explain 55 percent of exchange rate variation. Evans (2010) also finds that 30 percent of the variation in realized currency returns at a two-month horizon can be traced back to macroeconomic news through its impact on order flows.

[3]Valchev (2016), Engel and Wu (2018), and Jiang, Krishnamurthy, and Lustig (Forthcoming) document a link between exchange rates and convenience yields; Avdjiev et al. (2019) between exchange rates and deviations from covered interest parity; and Lilley et al. (2019), Adrian and Xie (2020), and Stavrakeva and Tang (2020a) between exchange rates and derivatives positions or cross-border asset holdings.

[4]More recent examples of such theories include those by Gourinchas, Rey, and Govillot (2018) and Stavrakeva and Tang (2020c), who present empirical and theoretical evidence regarding the link between currency risk premia and revisions in expectations of future GDP growth as a crucial driver of flight-to-safety episodes.

disconnect at lower frequencies. We do so by constructing quarterly macro news indices from macroeconomic surprises using a method that expands upon the work of Altavilla, Giannone, and Modugno (2017) and captures a multidimensional response to macro news that has rich dynamics. Given that these surprises measure the unforecasted component of announcements about macroeconomic outcomes that occurred in the past, we can interpret the explanatory power of the macroeconomic news indices for exchange rates as coming from a causal relationship. We find that in the sample starting in 2001, when our data on macroeconomic surprises begin, these macroeconomic news indices can explain the vast majority of variation in exchange rate changes for nine advanced economy currencies against the USD (70 percent in a panel regression). The explanatory power is even larger for the major financial center currency crosses against the USD—73, 83, 83, and 71 percent for the CHF, EUR, GBP and JPY, respectively.

This paper next contributes by delving deeper into determining the channel through which macroeconomic news drives exchange rate changes. To do so, we apply a novel econometric procedure for estimating a well-known exchange rate change decomposition. Using a simple accounting identity as a starting point, we provide a breakdown of 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.[5] We also estimate a similar decomposition for real exchange rate changes decomposed into a lagged real interest rate differential, a lagged currency expected excess return, and changes in expectations over the paths of relative short-term real interest rates and excess returns.[6]

Based on this decomposition, we investigate whether macroeconomic surprises matter for exchange rate movements via their link to changes in expectations over relative inflation and interest rate paths, the macroeconomic fundamental components of the exchange rate change decomposition, or via the revisions in expectations over the currency risk premium path, which is often perceived as a financial variable. What is important to emphasize is that all of the exchange rate change components are endogenous and can move as a result of macroeconomic surprises.

The estimation technique that we use has been applied in previous work to decompose

[5]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 will be rates on three-month government debt, which we will often refer to as policy rates.

[6]This paper is closely related 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 they usually focus on decomposing the real exchange rate level.

government bond yields.[7] More specifically, we estimate a VAR (vector autoregression) augmented with additional constraints that ensure that the VAR-based expectations closely match survey forecasts of professional forecasters. The VAR serves as a structured way to interpolate and extrapolate the expectations for exchange rates, three-month bill rates, and inflation for horizons that are not reported in survey responses. We consider 10 advanced economies and use quarterly data over the 1990–2015 period. The survey data we use are the consensus (average) of professional forecasters for several macroeconomic and financial variables at both short and long horizons.

Calculating the various exchange rate components by generating expectations that closely match the survey 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 created by using small samples to estimate 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 literature argues 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.[8]

Once we calculate the various exchange rate change components, we perform a variance-covariance decomposition of the exchange rate change at a quarterly frequency. Our estimates indicate that, on average, across currency bases, the unconditional variances of the relative short-term policy rates and inflation components are, respectively, approximately 0.4 and 0.1 times as volatile as the nominal exchange rate change itself, while the currency risk premium component has about the same degree of volatility. Considering the real exchange rate change decomposition, the real interest rate components are about one-third as volatile as the real exchange rate change. Even though the currency risk premium component is the most volatile of all, we show that 51 percent of the variation in the currency risk premium component can be explained by macroeconomic news in the panel regressions. The macroeconomic surprises also explain 42 percent of the variation in the interest rate component and 31 percent of the variation in the inflation component.

The paper proceeds as follows. Section 2 presents evidence on the importance of macroeconomic news for explaining the variation in the exchange rate changes at a quarterly frequency.

[7] See Kim and Wright (2005), Wright (2011), Kim and Orphanides (2012), Piazzesi, Salomao, and Schneider (2015), and Crump, Eusepi, and Moench (2018).

[8] See Stavrakeva and Tang (2020b) for exchange rates; De Marco, Macchiavelli, and Valchev (2020) for interest rates; and Greenwood and Shleifer (2014) and Giglio et al. (2020) for equity returns. For details see Section 5.1.

Section 3 outlines a decomposition of exchange rate changes that relies only on a definition of the expected excess one-period currency return. Section 4 describes our survey-augmented VAR methodology, and Section 5 discusses the survey data that we use and documents the benefits of using survey-data-augmented VAR. Section 6 presents our baseline variance-covariance decomposition and the results regarding the link between macroeconomic surprises and the exchange rate change components. Section 7 concludes.

2 Exchange Rate News from Macroeconomic Fundamentals

In this section, we present our main exercise, which confirms the link between exchange rate changes and macroeconomic fundamentals.

The exchange rate literature has long discussed macroeconomic news as a driver of exchange rate fluctuations, but evidence of this link at quarterly or lower frequencies has been mixed at best (see Engel, Mark, and West 2008, for example). There is, however, ample evidence of a high-frequency response of exchange rates to more direct measures of macroeconomic news that do not require assumptions about the structure of the economy or the belief formation process (Andersen et al. 2003; Faust et al. 2007). In this section, we adapt these direct measures of macroeconomic news to lower frequencies and show that exchange rate changes at even quarterly frequencies are largely explained by macroeconomic news.

More specifically, we use news about macroeconomic fundamentals measured with surprises generated by releases of data on macroeconomic variables. These surprises are the differences between actual releases and median forecasts obtained in surveys conducted by Bloomberg and Informa Global Markets (IGM; formerly known as Money Market Services).

In our analysis, we include surprises for a variety of indices for each country chosen based on sample length as well as the popularity of each indicator as measured by Bloomberg's relevance value. The set of indicators includes measures of activity, inflation, trade, and the labor market.[9] The median forecasts for these indicators are generally measured at most a few days before the data release. In the case of IGM, a survey is conducted each Friday regarding the following week's data releases. For each currency pair, we include the indicators of the two countries.[10] Due to the more limited availability of expectations data

[9]See the Appendix for the full list.

[10]For the euro, we include euro-area indicators as well as those for the three largest European economies: Germany, France, and Italy.

for many of our indicators, the exercises in this section start in 2001:Q4.[11]

Our main innovation is to map these high-frequency surprises into a lower frequency in order to estimate the amount of variation in the quarterly exchange rate changes explained by these measures of macro news. We do so by constructing a quarterly exchange rate macro news index using high-frequency responses to these surprises. More precisely, we regress daily changes in the exchange rate on surprises that occurred in the most recent four trading days as well as sums of surprises over each of the preceding six months. In interpreting these sums of surprises, we note that the vast majority of indicators are released once per month (or less frequently), so these sums of surprises are generally going to be individual past surprises released within the past six months. The sums aggregate multiple past surprises only in cases of indicators that are released at a higher frequency, for example weekly unemployment insurance claims in the United States. We specify the regression in this way rather than in terms of past surprises to ensure that we include six months' worth of past surprises regardless of how often an indicator is announced.

The quarterly exchange rate macro news index is then constructed as sums over each quarter of the fitted values from these daily regressions. We then regress the exchange rate change on this macro news index. This construction of a news index can be thought of as a form of dimension reduction of a large number of macro surprises. Since macro surprises are not highly correlated with each other by nature of being surprises, typical dimension reduction techniques such as principal components or factor analysis are not suitable.

To summarize, we estimate:

$$y_t = \alpha + \beta \hat{x}_t^{QtrSum} + error_t, \tag{1}$$

where y_t is a quarterly exchange rate change, and $\hat{x}_t^{QtrSum}$ is a quarterly exchange rate macro news index. This index is constructed from sums over each quarter of fitted values from the following daily regression:

$$\begin{aligned} x_\tau = \alpha + \sum_{j=0}^{3} \beta_j Surp_{\tau-j} + \delta_1 \sum_{j=4}^{21} Surp_{\tau-j} + \delta_2 \sum_{j=22}^{42} Surp_{\tau-j} + \delta_3 \sum_{j=43}^{63} Surp_{\tau-j} \\ + \delta_4 \sum_{j=64}^{84} Surp_{\tau-j} + \delta_5 \sum_{j=85}^{105} Surp_{\tau-j} + \delta_6 \sum_{j=106}^{126} Surp_{\tau-j} + error_\tau, \end{aligned} \tag{2}$$

[11]Data for some of the indicators actually start later than 2001:Q4. In such cases, we use zeros where we do not observe surprises in the early part of our sample for this subset of indicators and recognize that the explanatory power of macro announcements may be understated due to mismeasurement caused by lack of data in the early part of the sample. We could instead start the analysis later but choose not to do so, as this would result in too few observations of quarterly data.

where τ indexes trading days, and $Surp_\tau$ are vectors of macro surprises, while the βs and δs are all vectors of coefficients, one for each macro surprise. Therefore, we capture a dynamic effect of each macro surprise on exchange rates that is summarized by 10 coefficients, four for the effect on the day of the announcement and the next three days and six that capture the response over the next six months. To include all macro surprises in one daily regression, we follow the literature in setting the surprise measure for an indicator to zero on days with no announcements for that indicator.

Using high-frequency surprises calculated as the realized macroeconomic variables minus the expected value of these variables, as of a few days prior to the announcement, alleviates concerns regarding reverse causality from exchange rates to macroeconomic fundamentals that are present in contemporaneous regressions of exchange rates on macroeconomic fundamentals used in other papers. This is because any effect of exchange rates on macro variables should be taken into account when analysts form their expectations of the macroeconomic variable prior to the announcement. It is important to note that the realization of the macroeconomic variable that is being announced takes place *before* the forecaster reports her forecast.[12] This supports a causal interpretation of the results from regression (1) as the effect of macroeconomic news on exchange rates.

This approach is akin to the analysis of the effects of macro news on low-frequency variation in bond yields in Altavilla, Giannone, and Modugno (2017). However, we expand on this method in the following important dimensions.

First, we include macroeconomic news not only for the United States but also for the other country in the currency pair. Second, we find that it's particularly important to estimate a richer high-frequency exchange rate and bond yield response to news that includes lagged surprises. One practical reason to allow flexibility in the reaction to news within the first few days of an announcement is that in some parts of the world, due to differences in time zones and holiday schedules, news often is released after end-of-day exchange rates are recorded in our daily exchange rate data.

There are also several economic reasons to allow for an effect of macro surprises that is longer-lived than the immediate aftermath of an announcement. At a micro level in terms of market reactions, the interpretation of a particular announcement may differ depending on the context from recent past announcements. Cheung and Chinn (2001) conduct a survey of forex traders and find that market reactions to macro announcements can be quite nuanced

[12]The only variable for which this is not true is monetary policy rates. Replacing the US policy rate surprises based on these surveys with policy rate surprises calculated within an hour of the announcements using derivatives data and the daily version of such for non-US economies does not change the results substantially.

and can depend on the context of the news.[13,14] We aim to capture this context by controlling for past news.[15] This idea of a contextual interpretation of news is also related to the "scapegoat" effect that was developed by Bacchetta and van Wincoop (2013) and strongly supported by the data (see Fratzscher et al. 2015). The scapegoat effect is one where macro fundamentals matter more the more they deviate from some fundamental value. At a more macro level, the slow response to news announcements is consistent with the literature on "slow-moving" capital, where infrequent portfolio adjustment leads asset prices to respond slowly to new information (see Duffie 2010 for a review of the literature). Bacchetta, Tièche, and van Wincoop (2020) provide evidence for this slow adjustment in international equity portfolios of mutual funds, while Bacchetta and van Wincoop (2019) show that delayed portfolio adjustment is consistent with a number of exchange rate empirical facts.[16]

Table 1 presents the unadjusted R^2s from the first-stage daily estimation of regression (2). These unadjusted R^2s show that the macro surprises do explain some exchange rate variation at the daily frequency, but they are far from explaining the majority of the variation. For example, the maximum unadjusted R^2 from regressing the daily exchange rate changes on the surprises is 11 percent, and the macro news index, calculated as the fitted values from this regression, is what explains almost all of the quarterly exchange rate change variation. Therefore, it's clear that we are not getting a high adjusted R^2 in regression (1) mechanically by over-fitting the daily data.

Table 2 shows the adjusted R^2s from the second-stage quarterly regressions in equation (1). We present both the bilateral regressions against the USD and the panel version (last column). These results show that news about macroeconomic fundamentals can consistently explain the majority of the quarterly exchange rate change variation, with an adjusted R^2 of 70 percent in the panel regression, and even up to 83 percent for the USDEUR and USDGBP currency crosses. The fact that the explanatory power of macroeconomic surprises is significantly higher at a lower frequency than at a daily frequency can be attributed

[13] "[S]ome traders have pointed out that there are some ambiguities in the interpretation of GDP announcements. GDP is the sum of many components, so the growth rate of aggregate output may not be a sufficient statistic, and in fact may require more analysis in order to determine the true impact of the economic release. One concrete example of this factor is the distinction between growth arising from an export surge, versus that arising from inventory accumulation. The former has a positive implication for future output growth, while the latter has the converse and hence the two have different implications on exchange rate movements." (p.457, Cheung and Chinn 2001)

[14] See also Evans and Lyons (2008) and Evans and Rime (2012) for discussion of the market mechanics of how macro news affects exchange rates through trading behavior.

[15] Note that we cannot include interaction terms between the various macroeconomic surprises due to the large number of macro surprises and in order to avoid over-fitting in the daily regression.

[16] Hanson, Lucca, and Wright (2017) and Brooks, Katz, and Lustig (2018) present evidence consistent with slow portfolio adjustment in bond markets.

to macroeconomic news having persistent effects on exchange rates while other sources of exchange rate movements have more short-lived effects.

Table 3 shows the adjusted R^2s from the second-stage quarterly regressions when the sample is split into time periods that are US recessions or not or when the VIX is higher or lower than its median value. It becomes clear that exchange rates are more strongly connected to macroeconomic fundamentals during times of economic or financial turmoil, with our macro news indices explaining 84 percent of the variation in quarterly exchange rate changes during US recessions compared with 65 percent during normal times. Furthermore, this pattern is consistent in time-series regressions of each bilateral exchange rate as well, with the exception of the adjusted R^2s for the USDCHF being slightly higher during periods of low VIX. This result is consistent with beliefs being more sensitive to news (public signals) when there is greater uncertainty about the economy, as discussed in Stavrakeva and Tang (2020c).

To summarize, while the previous literature finds a tenuous link between exchange rates and macroeconomic observables at a quarterly frequency, we show that, at a policy-relevant frequency, exchange rate changes are indeed predominantly driven by high-frequency news about macroeconomic fundamentals.

2.1 Importance of Different Types of Macro News

To further understand the importance of different types of macro news in explaining exchange rate changes, we construct news subindices as fitted values of different groups of the explanatory variables in regression (2).

First, we seek to understand the importance of including lagged macro surprises in constructing the exchange rate macro news indices. To do so, we construct a subindex using only the contemporaneous information captured by the part of the fitted value associated with the current and up to three daily lags of macro announcement surprises and another subindex that is the part of the fitted value belonging to the remaining six trading-month lags.

Second, we construct subindices using the parts of fitted values associated with surprises from data releases on inflation, activity, the external sector, and monetary variables.

Lastly, we analogously construct subindices for US and foreign data releases.

Table 4 presents an analysis of the contributions of different subindices in explaning quarterly exchange rate change variation. For reference, the first row presents the adjusted R^2s from the regressions on a single exchange rate news index in Table 2. Then, for each set of subindices, we first present the adjusted R^2s from quarterly regressions on the entire set. The subsequent rows in each block then give the contribution of each subindex to this adjusted R^2 defined as the decrease in the adjusted R^2 that would result from removing each individual subindex from the regression.

Several insights emerge from these results. First, it's clear that the rich dynamics that we allow in the daily-frequency regressions are indeed quite important for explaining variation in quarterly exchange rate changes, as nearly all of the explanatory power of the exchange rate news index comes from the longer lags of surprises. In terms of indicators of different economic concepts, information related to activity (production, employment, etc.) is most important, though news about inflation and monetary news are also quite important for some currencies. Lastly, US news and foreign news are about equally as important in explaining exchange rate variation.[17]

Second, note that these contributions do not sum to the adjusted R^2s from regressions on entire sets of subindices. This indicates that there are some nonzero correlations between subindices, which reflects nonzero correlations in surprises across different indicators and, to a lesser degree, across time. There are two sources for these nonzero correlations. One is that some of these surprises occur over overlapping time frames because the forecasts are measured up to a week before the data release, and there may also be concurrent data releases.[18] Another reason for these correlations is that these professional forecasts may not be consistent with full information rational expectations, in which case forecast errors may be correlated across variables and across time.

3 Exchange Rate Decomposition

In this section we introduce the exchange rate decomposition used to determine the channel through which macroeconomic news affects exchange rates. We start by presenting an exchange rate change decomposition based on an accounting identity. The foundation of this decomposition is a definition of the expected excess return from taking a long position in one-period, risk-free bonds of currency j and a simultaneous short position in one-period, risk-free bonds of currency i. We define the expected excess return from this trade in terms of the natural log of returns as:

$$\sigma_t \equiv \tilde{E}_t \Delta s_{t+1} - \tilde{\imath}_t, \tag{3}$$

[17]Caruso (2016) finds that since 2008, euro-area news has become more important than US news for high-frequency movements in the USDEUR exchange rate.

[18]For example, the US unemployment rate and change in nonfarm payrolls are announced in the same data release.

where s_t denotes the exchange rate in terms of the number of units of currency i per currency j, and $\tilde{\imath}_t$ represents the relative one-period interest rate differential calculated as country i minus j. We use the tilde in the same way with respect to other variables.

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

$$\Delta s_{t+1} = \tilde{\imath}_t + \sigma_t + \Delta s_{t+1} - \tilde{E}_t \Delta s_{t+1}. \quad (4)$$

Expressing equation (3) in terms of exchange rate levels and iterating forward gives:

$$s_t = -\tilde{E}_t \sum_{k=0}^{\infty} [\tilde{\imath}_{t+k} + \sigma_{t+k}] + \lim_{k \to \infty} \tilde{E}_t s_{t+k}. \quad (5)$$

Note that here we use a generic expectations operator $\tilde{E}_t$, and the only assumption we make about it is that the law of iterated expectations holds. First-differencing equation (5) and combining the resulting expression with equation (3) implies that the forecast error can be expressed as:

$$\begin{aligned} \Delta s_{t+1} - \tilde{E}_t \Delta s_{t+1} = & -\underbrace{\sum_{k=0}^{\infty} \left(\tilde{E}_{t+1} \tilde{\imath}_{t+k+1} - \tilde{E}_t \tilde{\imath}_{t+k+1} \right)}_{\varphi_{t+1}^{EH}} \\ & - \underbrace{\sum_{k=0}^{\infty} \left(\tilde{E}_{t+1} \sigma_{t+k+1} - E_t \sigma_{t+k+1} \right)}_{\sigma_{t+1}^{F}} + \underbrace{E_{t+1} \lim_{K \to \infty} s_{t+K} - E_t \lim_{K \to \infty} s_{t+K}}_{s_{t+1,\infty}^{\Delta E}}. \quad (6) \end{aligned}$$

Equation (6) allows us to express the realized exchange rate changes in terms of lagged interest rate differentials and expected excess returns in addition to changes in expectations in (i) contemporaneous ($t+1$) and future relative short-term rates, φ_{t+1}^{EH}; (ii) contemporaneous and future excess returns, σ_{t+1}^{F}; and (iii) long-run nominal exchange rate levels, $s_{t+1,\infty}^{\Delta E}$. If the real exchange rate, defined as $\Delta q_{t+k+1} = \Delta s_{t+k+1} - \tilde{\pi}_{t+k+1}$, is stationary or trend-stationary, the change in expectations over long-run real exchange rate levels will be zero, and $s_{t+1,\infty}^{\Delta E}$ 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,

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

where $\tilde{\pi}$ is the inflation rate in country i minus the inflation rate in country j. Notice that the assumption needed for the derivation above is that the real exchange rate is expected to revert to some known mean in the long run where this mean can be time varying as long as it is deterministic. Combining equations (3) and (6) implies that:

$$
\Delta s_{t+1} = \tilde{\imath}_t - \varphi^{EH}_{t+1} + \sigma_t - \sigma^F_{t+1} + s^{\Delta E}_{t+1,\infty}. \tag{7}
$$

The existing literature focuses primarily on decomposing the real exchange rate change into changes in expectations over the relative real rate paths and the currency risk premium path. The decomposition above can be rewritten as:

$$
\begin{aligned}
\Delta q_{t+1} &= \Delta s_{t+1} - \tilde{\pi}_{t+1} = \tilde{r}_t - \varphi^{r,EH}_{t+1} + \sigma_t - \sigma^F_{t+1}. \qquad (8) \\
\text{where } \varphi^{r,EH}_{t+1} &= \varphi^{EH}_{t+1} - s^{\Delta E}_{t+1,\infty} + \left(\tilde{\pi}_{t+1} - E_t\tilde{\pi}_{t+1}\right) = \sum_{k=0}^{\infty}\left(\tilde{E}_{t+1}\tilde{r}_{t+k+1} - \tilde{E}_t\tilde{r}_{t+k+1}\right) \\
\text{and } \tilde{r}_t &= \tilde{\imath}_t - E_t\tilde{\pi}_{t+1}.
\end{aligned}
$$

While the decompositions of the real and nominal exchange rate changes are similar, it is useful to examine both, as they allow us to jointly disentangle the extent to which nominal exchange rate movements are due to nominal versus real phenomena. Moreover, the real exchange rate decomposition cannot be used to study questions such as those concerning the extent to which monetary policy and inflation contribute separately to exchange rate movements and how their interaction affects exchange rate volatility. Therefore, we present the results of both decompositions.

4 VAR with Survey Data

To compute the terms in our decomposition, we need interest rate expectations at all horizons greater than zero as well as long-run exchange rate expectations. To obtain estimates of these expectations, we model exchange rates and short-term interest rates using the following reduced-form quarterly VAR(p) process:

$$\begin{aligned} F_{t+1} &= \bar{F} + \gamma(L) F_t + \varepsilon_{F,t+1} & (9) \\ \text{where } \gamma(L) &\equiv \gamma_1 + \gamma_2 L + ... + \gamma_p L^{p-1} \\ \text{and } F_{t+1} &\equiv [q_{t+1}^{i,US}, x_{t+1}^i, z_{t+1}^i, x_{t+1}^{US}, z_{t+1}^{US}]'. & (10) \end{aligned}$$

Here, q_{t+1} is the level of the real exchange rate defined as units of currency i per US dollar. 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 VAR-based expectations of the long-run real exchange rate are constant. The vector x_{t+1} is a set of yield curve variables that includes the three-month bill rate as well as the empirical term structure slope and curvature factors defined as:

$$\begin{aligned} sl_t^i &= y_t^{40,i} - i_t^i & (11) \\ c_t^i &= 2y_t^{8,i} - \left(y_t^{40,i} + i_t^i\right). & (12) \end{aligned}$$

The country-specific vector z_{t+1}^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+1}^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+1}^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+1}^{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. Second, to improve our fit of long-horizon inflation forecasts, we include an exponentially weighted average of lagged US inflation, which is constructed as:

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

where we choose $\rho = 0.95$. When we include $\{\pi_t^{avg,US}, ..., \pi_{t-p+1}^{avg,US}\}$ in the VAR in equation (9), it 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 further 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 a 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 exponentially weighted average of US 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 a sufficiently good proxy for the common declining trend in inflation across all the countries in our study.

This reduced-form VAR(p) in equation (9) can be written in a VAR(1) companion form:

$$\underbrace{\begin{bmatrix} F_{t+1} \\ \vdots \\ F_{t-p+2} \end{bmatrix}}_{\mathbf{X}_{t+1}} = \underbrace{\begin{bmatrix} \bar{F} \\ 0 \\ 0 \end{bmatrix}}_{\bar{\mathbf{X}}} + \underbrace{\begin{bmatrix} \gamma_1 & \gamma_2 & \cdots & \gamma_p \\ & \mathbf{I} & & \mathbf{0} \end{bmatrix}}_{\mathbf{\Gamma}} \underbrace{\begin{bmatrix} F_t \\ \vdots \\ F_{t-p+1} \end{bmatrix}}_{\mathbf{X}_t} + \underbrace{\begin{bmatrix} \varepsilon_{F,t+1} \\ 0 \\ \vdots \end{bmatrix}}_{\mathbf{\Xi}_{t+1}}. \qquad (13)$$

To ameliorate 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 do not further impose no-arbitrage restrictions. One advantage of this specification versus 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 allows 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 zero lower bound (ZLB) episodes.

Our next set of restrictions concerns the macroeconomic variables. We assume that

[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 only for countries where and time periods when actual short-term interest rates were negative.

changing economic conditions in the United States affect expectations over macro variables in other countries through spillovers into their macroeconomies. See Miranda-Agrippino and Rey (2015) for VAR-based evidence of such spillovers. At the same time, we restrict US macroeconomic variables to depend only on 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 exchange rate changes. As will be seen below, the model is still able to produce forecasts that closely mimic survey forecasts even with this restriction.

To summarize, if we partition each matrix $\{\gamma_1, ..., \gamma_p\}$ into five blocks corresponding to the partitioning of F_{t+1} given in equation (10), then the above restrictions imply the following zero restrictions on the matrix of VAR coefficients:

$$\gamma_l = \begin{bmatrix} \bullet & \bullet & \bullet & \bullet & \bullet \\ 0 & \bullet & 0 & 0 & 0 \\ 0 & \bullet & \bullet & \bullet & \bullet \\ 0 & 0 & 0 & \bullet & 0 \\ 0 & 0 & 0 & \bullet & \bullet \end{bmatrix} \quad \text{for } l = 1, ..., p. \tag{14}$$

Our main innovation to the literature on exchange rate decompositions is that we estimate not only (13) subject to (14), but that we further discipline the estimation using survey forecasts of exchange rates, interest rates, and inflation to ensure that our model-implied estimates closely capture private sector expectations.

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

$$\mathbf{Y}_t^S = H_t \left(\bar{\mathbf{X}}, \mathbf{\Gamma} \right) \mathbf{X}_t + H_t^Z \mathbf{Z}_t + \mathbf{\Xi}_{h,t}^S, \tag{15}$$

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 matrix of variables $\mathbf{X}_t$, which contains up to p lags of VAR variables. It's a function of the coefficient matrices in (13) as well as t through the quarter of the year in which that 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 further lags of the VAR variables and data on price levels, which are included in the matrix $\mathbf{Z}_t$. The error $\mathbf{\Xi}_{h,t}^S$ can be interpreted as capturing measurement error due to the discrepancy between forecasters' observations of real-time macroeconomic data versus our use of current vintage data as well as small differences between the timing of the surveys and our data observations. See the Appendix for further details on this mapping.

Taken together, the system of equations given by (13) and (15) can be interpreted as a way to interpolate and extrapolate the survey data available in $\mathbf{Y}_t^S$ to other horizons in a way that's consistent with the data-generating process in (13) and the behavior of actual realized one-period-ahead data. Without making any further assumptions regarding the errors, we can consistently estimate the coefficients $\bar{\mathbf{X}}$ and $\mathbf{\Gamma}$ subject to the restrictions in (14) by minimizing the sum of squared errors from all equations in (13) and (15).[20] Since the decomposition given in equations (4) and (6) 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/euro area, Japan, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom. For all financial variables, we use end-of-quarter values when possible. The sample time period is 1990 through 2016.

4.1 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 (7). First, to represent the expected excess return, σ_t, in terms of VAR variables, the exchange rate change and lagged short-term interest rates can be expressed as:

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

where e_q is a row vector that selects q_{t+1} from $\mathbf{X}_{t+1}$. That is, it has the same number of elements as $\mathbf{X}_{t+1}$, with an entry of 1 corresponding to the position of q_{t+1} in $\mathbf{X}_{t+1}$ and zeros elsewhere. Likewise, e_i^i and e_i^j are selection vectors corresponding to the short-term interest rates of countries i and the United States, respectively, and e_π^i and e_π^j are the same for

[20] This can be alternatively interpreted as estimating the regressions implied by (13) and (15) with cross-equation coefficient restrictions generated by the fact that $\bar{\mathbf{X}}$ and $\mathbf{\Gamma}$ show up in both sets of equations. Under this interpretation, equation (15) represents an estimation of data-generating processes for survey expectations as a function of observable variables in our VAR.

[21] The errors in matching forecast revisions are a function of current and lagged errors in matching forecast levels.

inflation. Thus, denoting VAR-implied expectations at time t by $\hat{E}_t$, we have the following:[22]

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

The final three terms in equation (7) are infinite sums of changes in expectations. Note that the VAR-implied change in expectations over future $\mathbf{X}_{t+k+1}$ can be written simply as a linear combination of the time $t+1$ reduced-form residuals:

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

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 our currency pairs:[23]

$$\begin{aligned} \varphi_{t+1}^{EH} &= \left(e_i^i - e_i^j\right)\left(\mathbf{I} - \mathbf{\Gamma}\right)^{-1}\mathbf{\Xi}_{t+1} \\ \sigma_{t+1}^F &= \left[\left(e_q + e_\pi^i - e_\pi^j\right)\mathbf{\Gamma} - \left(e_q + e_i^i - e_i^j\right)\right]\left(\mathbf{I} - \mathbf{\Gamma}\right)^{-1}\mathbf{\Xi}_{t+1} \\ s_{t+1,\infty}^{\Delta E} &= \left(e_\pi^i - e_\pi^j\right)\left(\mathbf{I} - \mathbf{\Gamma}\right)^{-1}\mathbf{\Xi}_{t+1}. \end{aligned} \tag{16}$$

The additional components used in the real exchange rate change decomposition can be obtained as:

$$\begin{aligned} \varphi_{t+1}^{r,EH} &= \varphi_{t+1}^{EH} - s_{t+1,\infty}^{\Delta E} + \left(\tilde{\pi}_{t+1} - E_t\tilde{\pi}_{t+1}\right) \\ &= \left(e_i^i - e_i^j - \left(e_\pi^i - e_\pi^j\right)\right)\left(\mathbf{I} - \mathbf{\Gamma}\right)^{-1}\mathbf{\Xi}_{t+1} + \left(e_\pi^i - e_\pi^j\right)\mathbf{\Xi}_{t+1}, \\ \text{and } \tilde{r}_t &= \tilde{\imath}_t + \left(\tilde{\pi}_{t+1} - E_t\tilde{\pi}_{t+1}\right) - \tilde{\pi}_{t+1} \\ &= \left(e_i^i - e_i^j\right)\mathbf{X}_t - \left(e_\pi^i - e_\pi^j\right)\left(\mathbf{X}_{t+1} - \mathbf{\Xi}_{t+1}\right). \end{aligned}$$

Note that none of the terms in this decomposition is a residual in the traditional sense, since each 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

[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 presented above, this means that the relevant information set differs across variables.

[23]While no restrictions were imposed on the residuals when estimating the VAR, in order to derive the analytical results in (16) and also to define the VAR-based expectations in equation (15) we assume that $E_t\mathbf{\Xi}_{t+k} = 0$. 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.

expected excess return that holds exactly by assumption.

5 Survey Data

In the estimation, we include data on consensus (that is, average) professional forecasts for exchange rates, three-month interest rates, 10-year yields, and inflation at various horizons obtained from Blue Chip and Consensus Economics.

The Blue Chip publications contain forecasts from about 50 survey respondents, and Consensus Economics polls approximately 200 forecasters; each publication contains responses from about 10 to 30 participants for any given variable.

For most variables, we have data for forecast horizons up to two years ahead. We also use data on long-horizon forecasts for 6- to 10-year-ahead averages of inflation rates. For interest rates, we have similar long-horizon forecasts for the United States (7- to 11-year-ahead averages). However, we do not directly observe long-horizon nominal interest rate forecasts for 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, as we find that doing so greatly improves our fit of US long-horizon interest rate forecasts. Table 5 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 73 percent to 84 percent over our sample.

5.1 Benefits of Using Survey Data

In this subsection, we discuss the advantages of employing survey data to discipline the VAR used to obtain expectations of future inflation, interest rates, and exchange rates. While survey data on inflation and interest rate expectations have been used widely in decomposing yields into term premia and expectations hypothesis components, this is the first paper that applies the method to the estimation of the exchange rate change components.[24]

[24]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)

Using survey data on expectations is desirable for several reasons.

First, it can alleviate a well-known empirical bias, namely that the estimated autoregressive VAR coefficients tend to be biased downward due to the use of small samples. This bias leads to flat medium- to long-run forecasts (see Jarocinski and Marcet 2011 and the references within the paper).[25] The bias is particularly problematic when using the VAR-based expectations to calculate the components of the exchange rate change decomposition, as they are functions of *undiscounted* infinite sums of expectations. Alternative ways used in the more recent literature to alleviate this bias include long-run priors (see Giannone, Lenza, and Primiceri 2019) and informative priors on the observables (see Jarocinski and Marcet 2011), among others.

Second, Stavrakeva and Tang (2020b) 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.[26] De Marco, Macchiavelli, and Valchev (2020) also use Consensus Economics survey data to proxy bankers' beliefs when they show that during the European sovereign debt crisis, European banks' sovereign debt positions were higher when the banks expected the sovereign bond to have lower yields (higher prices) in the future. These papers argue that the Consensus Economics survey data are consistent with market participants' positions and, hence, support their use as a proxy for the beliefs of the marginal trader, whose expectations are represented in the exchange rate decomposition in equation (7).

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. The survey-data augmented VAR described in Section 4 can be interpreted as a way to interpolate and extrapolate the average professional forecaster's expectations to horizons for which survey-based forecasts are not available.

Finally, we could have chosen to minimize only the sum of squared differences between the survey data expectations and the VAR-implied expectations. However, minimizing also the sum of squared residuals from the VAR ensures that if there is any measurement error (for example, it is feasible that the survey data are just a proxy for the beliefs of the marginal

uses survey data to estimate term premia for a set of developed countries that largely overlap with the ones considered in this study.

[25]For a discussion on the presence of such bias in the context of this paper, see Section 5.2.

[26]Stavrakeva and Tang (2020b) also show that the main drivers of both the average and the individual-level Consensus Economics expected exchange rate changes are the theory of PPP and lagged exchange rate movements. Additionally, in the Online Appendix of this paper we present regressions and graphs that show that both the random walk and the UIRP models are not the main models used by professional forecasters to form their beliefs. Moreover, we show the presence of in-sample predictive power of the survey-based exchange rate change forecasts.

trader rather than the actual beliefs), it will be minimized.

5.2 Fit of the Estimated VAR-Based Expectations

To assess the model's ability to fit the survey forecasts, panel A of Tables 6 through 11 presents correlations as well as root-mean-square deviations between model-implied forecasts and the survey measure for three-month interest rates, nominal exchange rates, and inflation. Panel B of these tables presents the same statistics using OLS estimation of only equation (13) with the restrictions in (14). Of course, the model augmented with survey data should, by definition, produce a better fit of survey data. The measures of fit in these tables serve to illustrate that the improvement is sometimes quite substantial.

In general, the results in these tables show that a standard estimate of the VAR that optimizes only the one-period-ahead fit of each variable, by only including equation (13) subject to the restrictions in (14), does a poor job of mimicking the behavior of private sector forecasts, particularly for horizons longer than one quarter or the current year. However, panel A of these tables shows that a very good fit of the private sector forecasts can be obtained with the data-generating process assumed in (13) given appropriate VAR coefficients.[27]

Turning first to the fit of three-month interest rate forecasts presented in Tables 6 and 7, correlations between the benchmark model-implied and survey forecasts are 95 percent or higher across all countries for horizons up to two years ahead. For our long-horizon forecasts, the correlations range from 42 percent to 97 percent, with the majority being 93 percent or higher. These fits are a marked improvement over the case without forecast data, where the correlations are even negative for Switzerland and the United Kingdom. The root-mean-square deviation (RMSD) reveals a similar pattern with the VAR with survey data, achieving values that are smaller by a factor of close to four for many countries and horizons beyond three months. For the long-horizon forecasts, the RMSD is reduced by a factor of close to 10 in some cases compared with the VAR without survey data. The results for the fit of 10-year yield survey forecasts, not shown here, are very similar to those for three-month interest rates.

For nominal exchange rate level forecasts, Tables 8 and 9 show that the benchmark model performs similarly, with correlations of 93 percent or better across all horizons and currency pairs in our baseline estimation. Relative to a model without forecast data, the RMSD

[27] When evaluating these fits, it's important to keep in mind that the number of observations decreases with the forecast horizon, with the longest forecast horizons suffering the most. For example, due to the timing of the survey, data for the 2Y horizon are generally available only annually and can have as few as 10 to 20 observations, depending on the country.

between model-implied and survey forecasts is often smaller by a factor of more than three at longer horizons. These tables also include measures of fit between survey and VAR-implied measures of currency premia for a three-month investment horizon as defined in equation (3). While the estimation that does not include survey data produces estimated currency premia that have correlations with the survey-based measures that are often negative and at most only 29 percent, our estimates produce correlations ranging from 41 percent to 77 percent.

Lastly, Tables 10 and 11 show that our benchmark model achieves a similarly large improvement in fit of inflation survey forecasts relative to an estimation that does not use this data.

Figures 1 through 6 plot survey forecasts against model-implied fits both with and without the additional forecast data equations for a few select countries. These figures illustrate the potential reasons behind some of the differences in results obtained in our exchange rate change decomposition compared with those based on estimation methods that do not use survey data. Here, one can also see how augmenting the model with survey data improves several qualitative aspects of the model-implied forecasts. One notable feature seen in Figure 1 is that including survey forecasts in the estimation results in no violations of the ZLB in 12-month-ahead three-month bill rate forecasts, unlike the estimation without forecast data. Figure 2 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/euro area. In contrast, by using survey data in the estimation, our model better mimics the variation in long-horizon survey forecasts.

The one-year-ahead inflation forecasts seen in Figure 3 are realistically less volatile when we add survey data to the estimation, particularly for the United Kingdom and Germany/euro area. Figure 4 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 actually trend up for Germany/euro area over time.

Lastly, Figures 5 and 6 shows that our VAR specification is capable of producing a very close fit of exchange rate forecasts, even at a 24-month horizon, and currency premia based on survey data for a variety of currencies.

As an additional check of external validity, we compare our model-implied interest rate expectations with market-based measures of short-term interest rate surprises computed using futures prices by adapting the method used by Bernanke and Kuttner (2005) to a quarterly frequency. Note that these data are *not* used in the estimation. We find that the model-implied quarterly US short-term interest rate surprise, $i^{US}_{t+1} - \hat{E}_t\left[i^{US}_{t+1}\right]$, has a correlation of 76 percent with the market-based federal funds rate surprise measure over the full sample. Table 12 shows these correlations for several additional countries. With the exception of Norway, for which we have data on only less liquid forward rate contracts rather than interest rate futures, the correlations are all 63 percent or higher and above 79 percent for a majority of the countries that we consider. These high correlations are evidence that the short-term interest rate expectations based on our survey-data-augmented VAR are also consistent with expectations of financial market participants that can be inferred from asset prices.[28]

6 Variance-Covariance Decomposition and the Effect of Macro News on the Exchange Rate Components

In this section, we first present variance-covariance decompositions of the quarterly exchange rate change based on our estimated components in equations (7) and (8). The purpose of the decomposition is to assess how much the different components of the real and nominal exchange rates change and how much the interactions (covariances) between them contribute to overall variation in exchange rates. Second, we estimate the extent to which the various exchange rate change components are driven by macroeconomic surprises.

Note that we can use our decomposition to express the variance of the exchange rate change as a sum of variances and the covariances of all the exchange rate change components:

$$\begin{aligned} Var\left(\Delta s_{t+1}\right) = {} & Var\left(\tilde{\imath}_t - \varphi^{EH}_{t+1}\right) + Var\left(\sigma_t - \sigma^F_{t+1}\right) + Var\left(s^{\Delta E}_{t+1,\infty}\right) \\ & + 2Cov\left(\tilde{\imath}_t - \varphi^{EH}_{t+1}, \sigma_t - \sigma^F_{t+1}\right) + 2Cov\left(\tilde{\imath}_t - \varphi^{EH}_{t+1}, s^{\Delta E}_{t+1,\infty}\right) \\ & + 2Cov\left(s^{\Delta E}_{t+1,\infty}, \sigma_t - \sigma^F_{t+1}\right). \end{aligned} \tag{17}$$

The equivalent decomposition of the real exchange rate change is given by:

$$\begin{aligned} Var\left(\Delta q_{t+1}\right) = {} & Var\left(\tilde{r}_t - \varphi^{r,EH}_{t+1}\right) + Var\left(\sigma_t - \sigma^F_{t+1}\right) \\ & + 2Cov\left(\tilde{r}_t - \varphi^{r,EH}_{t+1}, \sigma_t - \sigma^F_{t+1}\right). \end{aligned} \tag{18}$$

[28]Note that the futures contracts we use are typically written on interbank interest rates, while our VAR produces expectations of three-month T-bill rates. By basing our comparisons on expected interest rate surprises, we are able to abstract from differences in the rates that do not vary at a quarterly frequency. Nonetheless, the differences in financial instruments might make it harder to detect a high correlation between our model-implied expectations and the ones implied by futures prices, even if our model accords well with financial market participants' expectations-formation processes.

The estimates of these unconditional moments, averaged across pairs for each base currency, are reported in Table 13, while Table 14 reports the moments for each currency against the USD base.

First, we consider decomposition (17). Over the entire sample, the ratios of variances, averaged across all currency bases—$\frac{Var\left(\tilde{\imath}_t-\varphi_{t+1}^{EH}\right)}{Var(\Delta s_{t+1})}$, $\frac{Var\left(s_{t+1,\infty}^{\Delta E}\right)}{Var(\Delta s_{t+1})}$, and $\frac{Var\left(\sigma_t-\sigma_{t+1}^{F}\right)}{Var(\Delta s_{t+1})}$—are 0.4, 0.1, and 1.0, respectively, while the average numbers for the USD base are 0.48, 0.17, and 0.93, respectively. While the currency risk premium is indeed the most volatile component, the monetary policy and inflation components are jointly at least half as volatile as the nominal exchange rate change itself.

Importantly we note that the contemporaneous and forward-looking components that reflect new information received in period $t+1$ ($-\varphi_{t+1}^{EH} - \sigma_{t+1}^{F} + s_{t+1,\infty}^{\Delta E}$) are generally as volatile as the exchange rate change itself. This is another manifestation of the difficulty in forecasting exchange rates using past information.

We observe the following patterns regarding the covariance terms in equation (17). The term $Cov\left(\tilde{\imath}_t - \varphi_{t+1}^{EH}, \sigma_t - \sigma_{t+1}^{F}\right)$ is negative, on average, over our sample and contributes to a lower exchange rate variance. A negative value of $Cov\left(\tilde{\imath}_t - \varphi_{t+1}^{EH}, \sigma_t - \sigma_{t+1}^{F}\right)$ means that higher expected future interest rates in country i relative to country j (higher φ_{t+1}^{EH}) are associated with higher expected future excess returns from investing in the three-month government bond of country i and shorting the three-month government bond of country j (lower σ_{t+1}^{F}). This result is consistent with the Fama puzzle (see Fama 1984), namely that a higher realized excess return from investing in currency i is associated with a higher interest rate differential in country i relative to country j. 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 $Cov\left(\tilde{\imath}_t - \varphi_{t+1}^{EH}, s_{t+1,\infty}^{\Delta E}\right)$ term also contributes to lower exchange rate change volatility and implies that higher expected future interest rates in country i relative to country j (higher φ_{t+1}^{EH}) are associated with expected future inflation that is higher in country i than in country j (higher $s_{t+1,\infty}^{\Delta E}$). This is consistent with short-term rates being predominantly driven by monetary policy that raises rates when inflation is high.

Finally, $Cov\left(s_{t+1,\infty}^{\Delta E}, \sigma_t - \sigma_{t+1}^{F}\right)$ varies in sign across currency pairs and is quite small. A negative (positive) value implies that a higher expected inflation path in country i relative to country j is associated with higher (lower) expected excess returns from being long currency j and short currency i going forward (σ_{t+1}^{F}).

Next, consider the decomposition of the real exchange rate change in equation (18).

Across all currency pairs, the average volatility of the real interest rate component is 31 percent of the average volatility of the real exchange rate where the corresponding value for the USD base is 34 percent. $Cov\left(\tilde{r}_t - \varphi^{r,EH}_{t+1}, \sigma_t - \sigma^F_{t+1}\right)$ is negative and very similar to $Cov\left(\tilde{\imath}_t - \varphi^{EH}_{t+1}, \sigma_t - \sigma^F_{t+1}\right)$, which is not surprising given the fairly small covariance between the inflation and currency risk premium components. This implies that models that attempt to explain the Fama puzzle must do so not only with respect to the nominal interest rate differential but also the real interest rate differential.

To summarize, we confirm the finding in the previous literature that the most volatile component of exchange rate changes is indeed the component related to expected future excess returns. Next we show that all components, including the expected excess return, are to a large extent driven by macroeconomic news.

To do so, we further augment the method in Section 2 with a third innovation that we make on the method by Altavilla, Giannone, and Modugno (2017). More specifically, in addition to the exchange rate macro news index, we also construct news indices based on the three-month bill rates and the slope and curvature of the yield curve, constructed separately for each one of the two countries and defined as in equations (11) and (12). Those are constructed in the exact same way as the exchange rate change news index. The reason for adding these news indices is that, as suggested by the imperfect correlation between our exchange rate change components, it is unlikely that a single macro news index adequately captures the response of each of the components to news. Given that one of the exchange rate change components is the changes in expectations over the relative policy rate path, we choose to construct news indices based on the standard three factors shown to explain most of the yield curve variation. In principle, we could also include a news index created using break-even inflation rates that would be related to inflation expectations, another important component of exchange rate changes, but real bonds are not available for many of the countries in our analysis.

Tables 16 and 17 show the results for bilateral and fixed-effect panel regressions of exchange rate changes and their subcomponents on this expanded set of macro news indices. The adjusted R^2s for the exchange rate change are almost the same as in Table 2, showing that a single exchange rate news index is sufficient for summarizing the effect of macro announcements on exchange rates. The most interesting result from this exercise is that macroeconomic fundamentals can explain 51 percent of the variation of the expected excess return component in the panel regression and the number is as high as 71 percent for the USDEUR cross. The macro news indices also explain 42 percent and 31 percent of the variation of the policy rate and inflation components, respectively. The unconstrained bilateral regressions show that the explanatory power of macro news with respect to the inflation component is as high as 57 percent for the USDGBP cross, and for the policy rate component it is as high as 66 percent for the USDCHF cross.

Table 18 shows the adjusted R^2s from the second-stage quarterly regressions, with the sample split into time periods when the United States is in a recession or not or time periods when the value of the VIX is below or above its median value over our sample. The previously seen pattern of a stronger explanatory power of macroeconomic surprises during times of economic or financial turmoil is also evident for each of the underlying exchange rate change components.

7 Conclusion

This paper provides evidence that challenges the widely accepted disconnect between exchange rates and macroeconomic fundamentals. Using data on macroeconomic surprises, we show that the new information revealed by announcements about macroeconomic indicators can explain about 70 percent of the variation in exchange rate changes.

We trace the channels through which exchange rates respond to this macro news using a novel decomposition of the exchange rate change based on estimated expectations that closely match survey forecast data. Most interestingly, these macroeconomic surprises explain a large fraction—51 percent—of the variation in the currency risk premium component, which is generally thought to be driven by financial factors. This empirical evidence calls for theories that feature a connection between macro fundamentals and exchange rates through currency risk premia.

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Tables and Figures

Table 1: R^2s from Daily Regressions of the Exchange Rate Change on Macroeconomic Surprises

		AUD	CAD	CHF	DEM/EUR	GBP	JPY	NOK	NZD	SEK	USD
	# of Surprises	23	24	20	34	23	22	21	21	24	13
Exchange Rate	# of Obs.	3716	3716	2541	3717	3716	3716	3717	3716	3717	
	R^2	0.08	0.08	0.11	0.11	0.09	0.09	0.07	0.08	0.10	

Note: Each row presents R^2s from daily regressions with different dependent variables on macroeconomic surprises. The regressors include current and up to a three-day lag of macro surprises as well as the sums of past macro surprises over each of the previous six months, with months being approximated using blocks of 21 trading days.

Table 2: Adjusted R^2s from Quarterly Regressions of the Exchange Rate Change on a Macroeconomic News Index (USD Base)

	AUD	CAD	CHF	DEM/EUR	GBP	JPY	NOK	NZD	SEK	Panel
Exch Rate News Index	0.94***	0.96***	1.07***	0.99***	1.11***	0.99***	0.96***	0.98***	1.02***	0.99***
	(0.08)	(0.15)	(0.11)	(0.07)	(0.07)	(0.07)	(0.07)	(0.10)	(0.08)	(0.02)
Constant	-0.04	-0.01	0.12	-0.00	-0.00	0.00	-0.00	-0.02	0.01	-0.00
	(0.52)	(0.45)	(0.42)	(0.28)	(0.27)	(0.38)	(0.42)	(0.55)	(0.43)	(0.01)
# of Obs.	57	57	39	57	57	57	57	57	57	495
Adjusted R^2	0.64	0.49	0.73	0.83	0.83	0.71	0.76	0.60	0.70	0.70

Note: Each row presents adjusted R^2s from quarterly regressions with different dependent variables on macroeconomic news indices constructed as quarterly sums of the fitted values from daily regressions of exchange rates on the current and up to a three-day lag of macro surprises as well as the sums of past macro surprises over each of the past six months, with months being approximated using blocks of 21 trading days.

Table 3: Adjusted R^2s from Quarterly Regressions of the Exchange Rate Change and Its Components on a Macroeconomic News Index with the Sample Split by Recessions and High Financial Volatility Periods

	AUD	CAD	CHF	DEM/EUR	GBP	JPY	NOK	NZD	SEK	Panel
US Recessions	0.76	0.59	0.96	0.98	0.98	0.91	0.80	0.62	0.87	0.84
Not US Recessions	0.58	0.45	0.70	0.82	0.68	0.63	0.73	0.59	0.65	0.65
VIX High	0.72	0.60	0.70	0.85	0.89	0.73	0.79	0.63	0.79	0.75
VIX Low	0.45	0.28	0.76	0.80	0.72	0.68	0.63	0.54	0.52	0.59

Note: Each row presents the adjusted R^2s from a quarterly regression on a particular subsample of the exchange rate change or a subcomponent on macroeconomic news indices, constructed as quarterly sums of the fitted values from daily regressions of exchange rates on the current and up to a three-day lag of macro surprises as well as the sums of past macro surprises over each of the past six months, with months being approximated using blocks of 21 trading days. We use NBER recession dates, and the VIX is split by the median value in the 2001q4–2015q4 sample.

Table 4: Adjusted R^2s from Quarterly Regressions of the Exchange Rate Change on Macro News Subindices

	AUD	CAD	CHF	DEM/EUR	GBP	JPY	NOK	NZD	SEK	Panel
Single exch rate news index	0.64	0.49	0.73	0.83	0.83	0.71	0.76	0.60	0.70	0.70
Both timing-based subindices	0.64	0.48	0.73	0.83	0.83	0.71	0.75	0.60	0.70	0.70
Contemporaneous contribution	0.01	0.04	0.13	0.09	0.05	0.08	0.06	0.02	0.02	0.05
Lags contribution	0.64	0.49	0.67	0.84	0.82	0.53	0.77	0.62	0.71	0.69
All concept subindices	0.64	0.47	0.71	0.83	0.83	0.70	0.76	0.58	0.69	0.70
Inflation contribution	0.30	0.16	0.37	0.47	0.26	0.17	0.50	0.03	0.26	0.30
Activity contribution	0.58	0.40	0.61	0.66	0.51	0.71	0.49	0.41	0.49	0.30
External contribution	0.13	0.14	0.15	0.43	0.01	0.13	0.05	0.28	0.07	0.18
Monetary contribution	0.15	0.27	0.05	0.31	0.40	0.01	0.28	0.11	0.16	0.22
Both country subindices	0.64	0.48	0.73	0.83	0.83	0.71	0.75	0.59	0.69	0.69
US contribution	0.34	0.30	0.71	0.83	0.52	0.54	0.54	0.37	0.50	0.54
Foreign contribution	0.62	0.49	0.37	0.65	0.63	0.45	0.55	0.37	0.59	0.56

Note: The first row in each block contains adjusted R^2s from quarterly regressions on sets of macroeconomic news subindices. The subsequent rows give the contribution of individual subindices to the adjusted R^2 after controlling for all the other subindices. That is, it's the difference between the adjusted R^2 with all subindices and the one in a regression that omits the relevant subindex. These subindices are constructed as quarterly sums of the fitted values given by subsets of regressors from daily regressions of exchange rates on the current and up to a three-day lag of macro surprises as well as the sums of past macro surprises over each of the past six months with months being approximated using blocks of 21 trading days.

Table 5: Relationship between US Long-Horizon Interest Rate Forecasts, Macroeconomic Forecasts, and Forward Rates

	Baseline	Wright (2011)
6Y-10Y Ahead Inflation Forecast	0.93***	1.60***
	(0.23)	(0.22)
6Y-10Y Ahead GDP Growth Forecast	0.42***	0.86***
	(0.13)	(0.13)
5Y Ahead 5Y Forward Rate	0.23***	
	(0.04)	
Constant	−0.17	−1.86***
	(0.57)	(0.60)
Adj. R^2	0.84	0.73
# of Observations	41	41

Note: The dependent variable is the 6Y–10Y-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 Economics. The sample is semiannual observations over 1997:Q3 through 2013:Q4 and quarterly observations thereafter until 2015:Q4. Heteroskedasticity-robust standard errors are reported in parentheses.

Table 6: Correlations between Survey and Model-Implied Forecasts: 3-Month Bill Rates

Panel A: With Forecast Data

Horizon	Source	AU	CA	CH	DE	JP	NO	NZ	SE	UK	US
3M	BC	0.990	0.990	0.972	0.992	0.991				0.994	0.991
3M	CF	0.996	0.992	0.990	0.995	0.997	0.991	0.994	0.995	0.996	0.998
6M	BC	0.987	0.990	0.963	0.993	0.990				0.995	0.993
12M	BC	0.981	0.984	0.966	0.989	0.987				0.995	0.988
12M	CF	0.992	0.978	0.989	0.993	0.996	0.970	0.975	0.989	0.993	0.991
0Y	BC	0.985	0.987		0.994	0.980				0.997	
1Y	BC	0.963	0.979		0.982	0.960				0.992	
2Y	BC	0.972	0.977		0.971	0.945				0.987	
LR	BC/Imp.	0.956	0.928	0.586	0.939	0.948	0.835	0.525	0.969	0.423	0.926

Panel B: Without Forecast Data

Horizon	Source	AU	CA	CH	DE	JP	NO	NZ	SE	UK	US
3M	BC	0.974	0.983	0.955	0.984	0.990				0.988	0.989
3M	CF	0.994	0.991	0.989	0.993	0.998	0.988	0.991	0.986	0.994	0.997
6M	BC	0.948	0.982	0.940	0.982	0.983				0.988	0.985
12M	BC	0.901	0.975	0.918	0.974	0.952				0.987	0.969
12M	CF	0.952	0.973	0.975	0.985	0.990	0.958	0.933	0.978	0.990	0.974
0Y	BC	0.934	0.973		0.981	0.945				0.988	
1Y	BC	0.819	0.961		0.955	0.808				0.980	
2Y	BC	0.899	0.976		0.955	0.628				0.987	
LR	BC/Imp.	0.946	0.924	-0.031	0.903	0.326	0.802	0.323	0.945	-0.101	0.851

Note: The horizons 0Y through 2Y in this table represent current year up to two years ahead. The "LR" horizon represents the average over years 7 through 11 ahead for the United States. For other countries, this horizon represents imputed forecasts for the average of years 6 through 10 ahead. See the main text for details on the imputation method.

Table 7: RMSD between Survey and Model-Implied Forecasts: 3-Month Bill Rates

Panel A: With Forecast Data

Horizon	Source	AU	CA	CH	DE	JP	NO	NZ	SE	UK	US
3M	BC	0.054	0.068	0.085	0.061	0.026				0.067	0.074
3M	CF	0.048	0.062	0.086	0.053	0.035	0.068	0.065	0.091	0.052	0.039
6M	BC	0.064	0.066	0.094	0.053	0.027				0.058	0.066
12M	BC	0.076	0.078	0.083	0.062	0.033				0.060	0.081
12M	CF	0.077	0.094	0.081	0.059	0.038	0.114	0.103	0.114	0.065	0.070
0Y	BC	0.064	0.075		0.047	0.035				0.048	
1Y	BC	0.094	0.086		0.077	0.058				0.069	
2Y	BC	0.089	0.082		0.105	0.070				0.086	
LR	BC/Imp.	0.075	0.064	0.062	0.069	0.088	0.071	0.071	0.054	0.072	0.072

Panel B: Without Forecast Data

Horizon	Source	AU	CA	CH	DE	JP	NO	NZ	SE	UK	US
3M	BC	0.087	0.124	0.133	0.102	0.049				0.134	0.150
3M	CF	0.078	0.073	0.136	0.090	0.063	0.132	0.081	0.169	0.114	0.077
6M	BC	0.130	0.152	0.164	0.113	0.070				0.143	0.177
12M	BC	0.194	0.224	0.216	0.162	0.128				0.187	0.249
12M	CF	0.288	0.196	0.255	0.173	0.152	0.232	0.181	0.260	0.194	0.230
0Y	BC	0.129	0.155		0.120	0.087				0.134	
1Y	BC	0.212	0.275		0.240	0.192				0.231	
2Y	BC	0.229	0.360		0.327	0.250				0.310	
LR	BC/Imp.	0.290	0.569	0.456	0.614	0.654	0.477	0.236	0.562	0.678	0.663

Note: The horizons 0Y through 2Y in this table represent current year up to two years ahead. The "LR" horizon represents the average over years 7 through 11 ahead for the United States. For other countries, this horizon represents imputed forecasts for the average of years 6 through 10 ahead. See the main text for details on the imputation method.

Table 8: Correlations between Survey and Model-Implied Forecasts: Nominal Exchange Rate

Panel A: With Forecast Data

Horizon	Source	AUD	CAD	CHF	DEM	JPY	NOK	NZD	SEK	GBP
3M	BC	0.993	0.994	0.988	0.988	0.985				0.982
3M	CF	0.993	0.998	0.993	0.993	0.992	0.988	0.993	0.989	0.991
6M	BC	0.985	0.993	0.986	0.985	0.985				0.983
12M	BC	0.982	0.985	0.984	0.977	0.973				0.971
12M	CF	0.987	0.996	0.986	0.989	0.984	0.974	0.985	0.974	0.986
24M	CF	0.977	0.995	0.981	0.981	0.963	0.969	0.980	0.966	0.977
0Y	BC	0.966	0.978		0.973	0.980				0.974
1Y	BC	0.962	0.977		0.958	0.960				0.957
2Y	BC	0.967	0.982		0.928	0.956				0.964
3M CP	BC	0.770	0.410	0.746	0.722	0.539				0.505
3M CP	CF	0.636	0.648	0.748	0.741	0.597	0.478	0.670	0.595	0.561

Panel B: Without Forecast Data

Horizon	Source	AUD	CAD	CHF	DEM	JPY	NOK	NZD	SEK	GBP
3M	BC	0.956	0.970	0.950	0.936	0.928				0.904
3M	CF	0.968	0.982	0.949	0.950	0.950	0.950	0.973	0.938	0.936
6M	BC	0.884	0.935	0.901	0.857	0.841				0.820
12M	BC	0.808	0.851	0.804	0.706	0.577				0.764
12M	CF	0.841	0.884	0.811	0.706	0.648	0.707	0.845	0.656	0.775
24M	CF	0.670	0.707	0.838	0.466	0.242	0.585	0.581	0.465	0.637
0Y	BC	0.913	0.928		0.869	0.836				0.820
1Y	BC	0.804	0.768		0.605	0.513				0.720
2Y	BC	0.611	0.691		0.383	0.327				0.718
3M CP	BC	-0.010	-0.133	0.095	-0.056	0.005				-0.163
3M CP	CF	0.204	0.293	0.027	0.035	0.155	-0.003	0.148	0.072	0.187

Note: The horizons 0Y, 1Y, and 2Y in this table represent current year, next year, and two years ahead, respectively. The remaining horizons are months out from the forecast month. Exchange rate forecasts are for end-of-period values. The “3M CP” rows correspond to fits of survey-implied three-month currency premia, for both sources of survey data, computed using the three-month bill rate data used in our VAR. The units for currency premia are in unannualized percentages.

Table 9: RMSD between Survey and Model-Implied Forecasts: Nominal Exchange Rate

Panel A: With Forecast Data

Horizon	Source	AUD	CAD	CHF	DEM	JPY	NOK	NZD	SEK	GBP
3M	BC	0.023	0.017	0.025	0.022	0.024				0.019
3M	CF	0.021	0.010	0.018	0.015	0.018	0.021	0.021	0.020	0.012
6M	BC	0.030	0.018	0.027	0.023	0.024				0.020
12M	BC	0.033	0.024	0.029	0.026	0.031				0.023
12M	CF	0.024	0.013	0.023	0.017	0.024	0.028	0.026	0.025	0.014
24M	CF	0.030	0.013	0.023	0.019	0.028	0.028	0.025	0.023	0.016
0Y	BC	0.048	0.032		0.030	0.026				0.021
1Y	BC	0.048	0.030		0.033	0.032				0.024
2Y	BC	0.049	0.025		0.040	0.035				0.023
3M CP	BC	2.258	1.720	2.453	2.161	2.417				1.915
3M CP	CF	2.095	1.021	1.780	1.483	1.791	2.059	2.134	2.029	1.224

Panel B: Without Forecast Data

Horizon	Source	AUD	CAD	CHF	DEM	JPY	NOK	NZD	SEK	GBP
3M	BC	0.055	0.037	0.054	0.048	0.052				0.041
3M	CF	0.044	0.028	0.051	0.041	0.046	0.043	0.044	0.050	0.032
6M	BC	0.087	0.054	0.077	0.069	0.075				0.055
12M	BC	0.110	0.087	0.117	0.092	0.113				0.060
12M	CF	0.093	0.078	0.111	0.088	0.107	0.103	0.101	0.116	0.055
24M	CF	0.133	0.157	0.125	0.115	0.131	0.144	0.178	0.162	0.067
0Y	BC	0.079	0.057		0.067	0.075				0.052
1Y	BC	0.110	0.115		0.104	0.111				0.060
2Y	BC	0.150	0.176		0.127	0.126				0.063
3M CP	BC	5.495	3.665	5.404	4.836	5.186				4.085
3M CP	CF	4.420	2.827	5.133	4.137	4.584	4.283	4.381	4.973	3.170

Note: The horizons 0Y, 1Y, and 2Y in this table represent current year, next year, and two years ahead, respectively. The remaining horizons are months out from the forecast month. Exchange rate forecasts are for end-of-period values. The "3M CP" rows correspond to fits of survey-implied three-month currency premia, for both sources of survey data, computed using the three-month bill rate data used in our VAR. The units for currency premia are in unannualized percentages.

Table 10: Correlations between Survey and Model-Implied Forecasts: Inflation

Panel A: With Forecast Data

Horizon	Source	AU	CA	CH	DE	JP	NO	NZ	SE	UK	US
0Y	BC	0.908	0.905		0.965	0.962				0.972	
0Y	CF	0.940	0.973	0.991	0.971	0.985	0.973	0.909	0.992	0.993	0.990
1Y	BC	0.795	0.788		0.917	0.921				0.893	
1Y	CF	0.896	0.738	0.979	0.950	0.949	0.921	0.779	0.979	0.927	0.971
2Y	BC	0.905	0.807		0.918	0.821				0.613	
2Y	CF	0.907	0.655	0.975	0.959	0.916	0.902	0.851	0.978	0.618	0.965
LR	CF	0.895	0.577	0.214	0.794	0.773	-0.226	0.728	0.689	0.877	0.942

Panel B: Without Forecast Data

Horizon	Source	AU	CA	CH	DE	JP	NO	NZ	SE	UK	US
0Y	BC	0.862	0.841		0.933	0.935				0.925	
0Y	CF	0.865	0.947	0.974	0.949	0.977	0.944	0.863	0.983	0.966	0.978
1Y	BC	0.177	0.233		0.505	0.712				0.510	
1Y	CF	0.203	0.294	0.728	0.624	0.868	0.537	0.457	0.879	0.578	0.772
2Y	BC	-0.506	-0.103		0.294	0.357				0.008	
2Y	CF	-0.523	0.063	0.284	0.392	0.640	0.283	0.246	0.737	-0.141	0.650
LR	CF	-0.708	0.505	0.112	-0.375	0.158	0.464	0.506	0.051	0.028	0.137

Note: The horizons 0Y, 1Y, and 2Y in this table represent current year, next year, and two years ahead, respectively. Inflation forecasts are on an annual-average-over-annual-average basis. The "LR" horizon represents the average over years 6 through 10 ahead.

Table 11: RMSD between Survey and Model-Implied Forecasts: Inflation

Panel A: With Forecast Data

Horizon	Source	AU	CA	CH	DE	JP	NO	NZ	SE	UK	US
0Y	BC	0.399	0.286		0.222	0.232				0.231	
0Y	CF	0.358	0.156	0.182	0.223	0.196	0.205	0.450	0.287	0.120	0.148
1Y	BC	0.280	0.184		0.210	0.304				0.181	
1Y	CF	0.414	0.209	0.194	0.212	0.322	0.301	0.487	0.304	0.189	0.190
2Y	BC	0.169	0.190		0.196	0.426				0.144	
2Y	CF	0.313	0.133	0.214	0.162	0.400	0.306	0.255	0.265	0.158	0.157
LR	CF	0.280	0.193	0.190	0.194	0.351	0.336	0.211	0.229	0.167	0.199

Panel B: Without Forecast Data

Horizon	Source	AU	CA	CH	DE	JP	NO	NZ	SE	UK	US
0Y	BC	0.530	0.400		0.329	0.320				0.410	
0Y	CF	0.575	0.228	0.339	0.306	0.236	0.316	0.591	0.449	0.282	0.226
1Y	BC	0.798	0.587		0.619	0.653				0.750	
1Y	CF	1.264	0.528	1.050	0.595	0.512	0.749	0.902	1.020	0.732	0.536
2Y	BC	0.941	0.688		0.703	0.969				0.755	
2Y	CF	1.409	0.590	1.685	0.679	0.840	0.816	0.832	1.352	0.791	0.597
LR	CF	1.140	0.498	6.927	0.636	1.179	0.579	0.380	0.873	0.381	0.872

Note: The horizons 0Y, 1Y, and 2Y in this table represent current year, next year, and two years ahead, respectively. Inflation forecasts are on an annual-average-over-annual-average basis. The "LR" horizon represents the average over years 6 through 10 ahead.

Figure 1: Model-Implied and Survey Forecasts: 3-Month Bill Rate (12 Months Ahead)

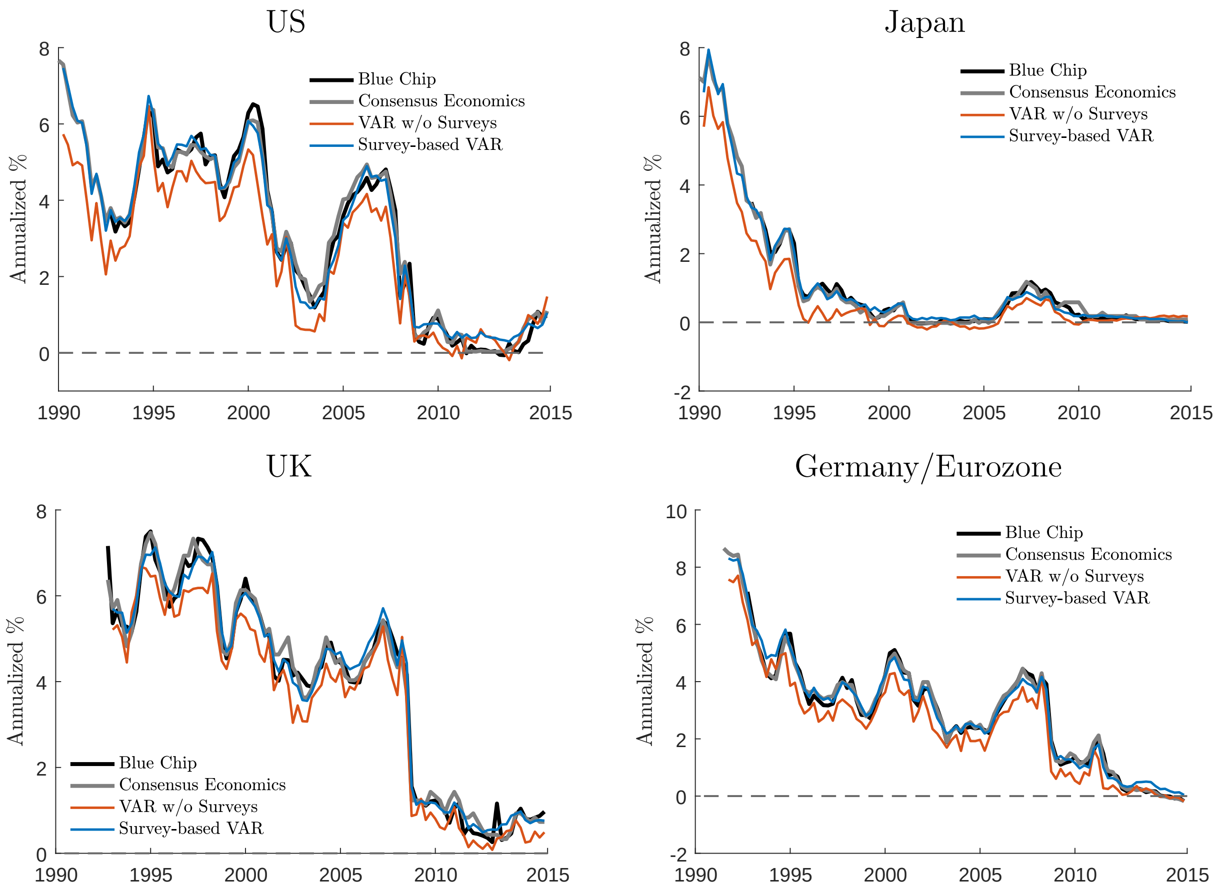
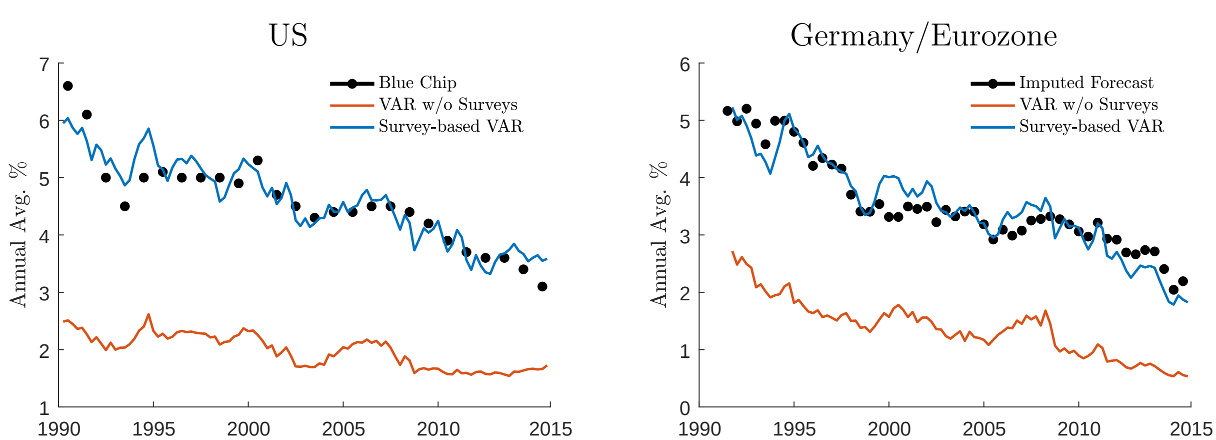


Figure 2: Model-Implied and Survey Forecasts: 3-Month Bill Rate (Long Horizon)



Note: The long horizon for the United States is the 7–11-year-ahead average, while it is the 6–10-year-ahead average for all other countries.

Figure 3: Model-Implied and Survey Forecasts: Inflation (1 Year Ahead)

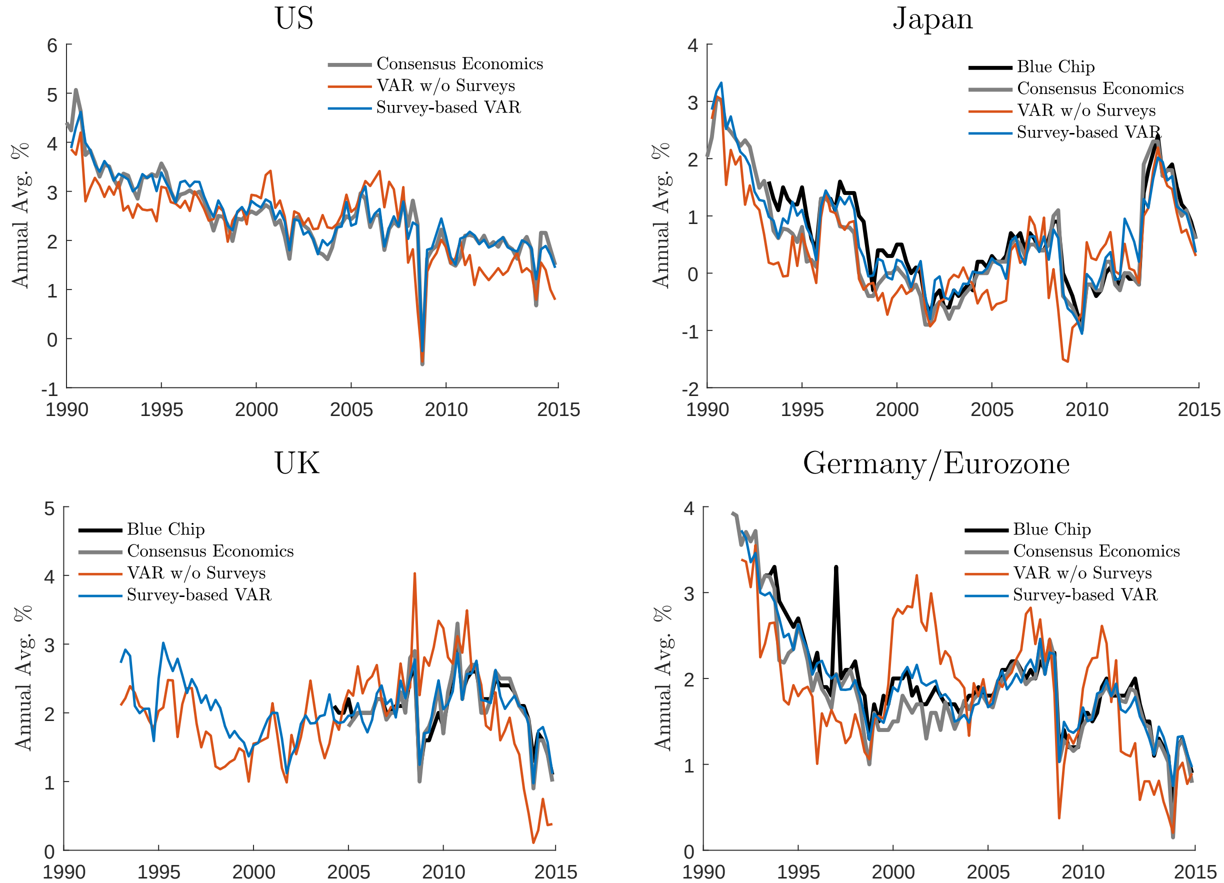


Figure 4: Model-Implied and Survey Forecasts: Inflation (6–10 Years Ahead)

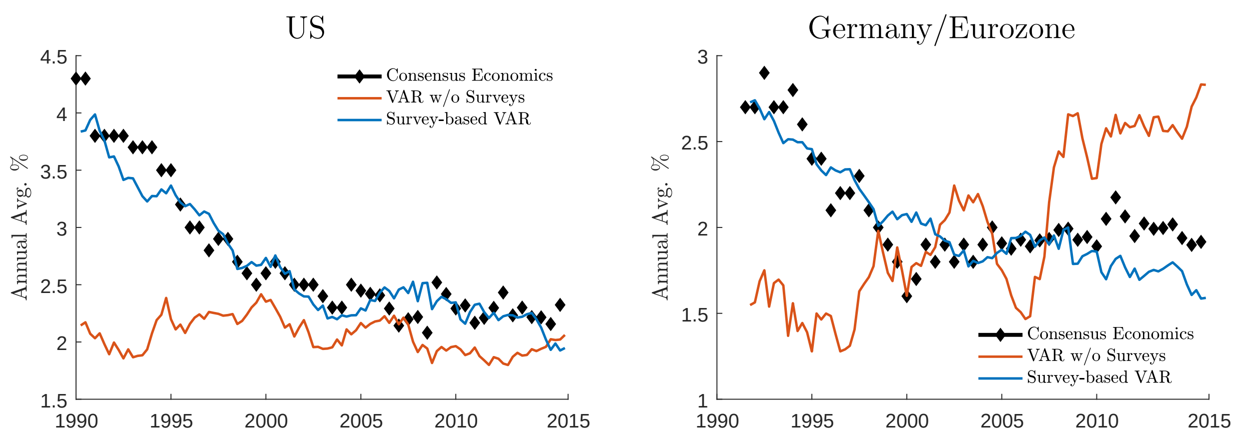


Figure 5: Model-Implied and Survey Forecasts: Exchange Rates (24 Months Ahead)

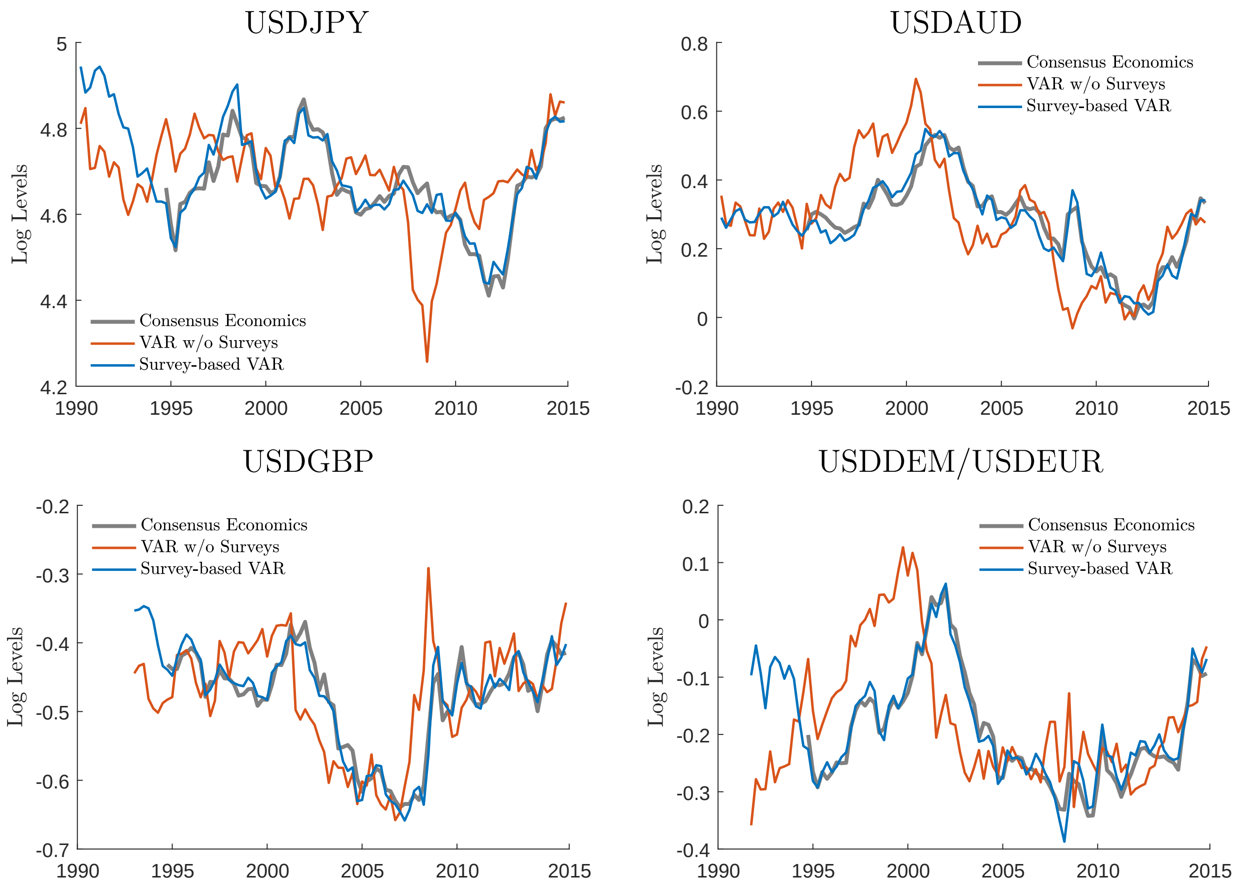


Figure 6: Model-Implied and Survey Currency Premia (3-Month Horizon)

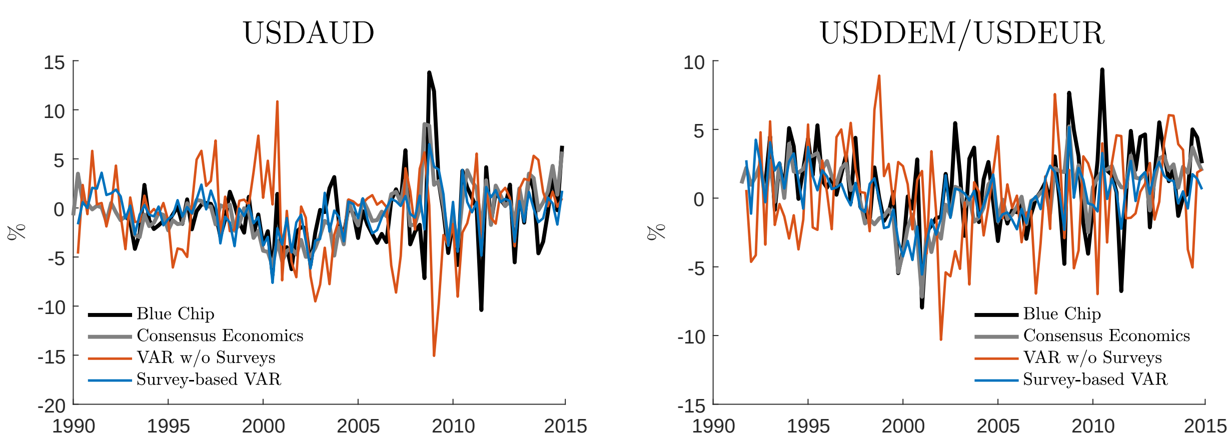


Table 12: Correlation between Model-Implied and Market-Based 3-Month Interest Rate Surprises

	AU	CA	CH	DE	NO	NZ	SE	UK	US
	0.83	0.68	0.63	0.84	0.12	0.86	0.79	0.81	0.76
# Observations	105	100	102	96	102	102	102	110	115

Note: These correlations are between errors in three-month-ahead forecasts, based on our VAR and futures/forwards prices, of three-month interest rates.

Table 13: Component Variances and Covariances

Bases (avg across pairs)	AUD	CAD	CHF	DEM/EUR	GBP	JPY	NOK	NZD	SEK	USD
$Var(\Delta s_{t+1})$	35.54	27.28	31.40	24.28	24.80	48.25	27.46	33.64	28.42	30.52
$Var(\tilde{i}_t - \varphi_{t+1}^{EH})$	13.94	8.88	12.05	9.56	7.87	14.27	16.50	10.48	16.15	14.80
$Var(s_{t+1,\infty}^{\Delta E})$	3.25	2.64	2.69	2.21	4.18	4.95	2.98	3.86	4.26	4.22
$Var(\sigma_t - \sigma_{t+1}^{F})$	32.73	28.32	32.09	26.90	25.37	48.39	35.53	30.83	28.32	28.29
$Var(-\varphi_{t+1}^{EH} - \sigma_{t+1}^{F} + s_{t+1,\infty}^{\Delta E})$	34.99	25.46	29.04	23.92	24.42	41.79	24.88	31.21	24.67	28.37
$Cov(\tilde{i}_t - \varphi_{t+1}^{EH}, s_{t+1,\infty}^{\Delta E})$	−4.71	−2.06	−2.49	−2.60	−1.33	−5.53	−1.66	−3.44	−5.70	−4.43
$Cov(\tilde{i}_t - \varphi_{t+1}^{EH}, \sigma_t - \sigma_{t+1}^{F})$	−2.34	−4.32	−5.74	−5.41	−3.65	−3.53	−10.65	−2.82	−6.26	−4.40
$Cov(s_{t+1,\infty}^{\Delta E}, \sigma_t - \sigma_{t+1}^{F})$	−0.14	0.10	0.51	0.82	−1.33	−0.62	−1.47	0.49	1.80	0.44
$Var(\tilde{r}_t - \varphi_{t+1}^{r,EH})$	7.92	7.51	10.01	6.60	9.27	8.24	16.54	7.48	9.22	9.76
$Cov(\tilde{r}_t - \varphi_{t+1}^{r,EH}, \sigma_t - \sigma_{t+1}^{F})$	−2.64	−4.07	−5.21	−4.58	−4.93	−3.61	−12.44	−2.08	−4.65	−3.92

Note: Variance-covariance decomposition of the exchange rate change components based on the survey-data-augmented VAR.

Table 14: Component Variances and Covariances

USD Base	AUD	CAD	CHF	DEM/EUR	JPY	NOK	NZD	SEK	GBP
$Var(\Delta s_{t+1})$	34.52	15.04	36.60	28.92	35.86	35.43	31.63	38.30	18.36
$Var(\tilde{i}_t - \varphi^{EH}_{t+1})$	11.42	7.93	16.42	9.53	15.78	27.52	11.37	25.05	8.19
$Var(s^{\Delta E}_{t+1,\infty})$	2.26	4.84	2.02	1.54	7.47	1.02	6.31	4.35	8.19
$Var(\sigma_t - \sigma^F_{t+1})$	35.14	16.60	31.53	25.09	37.89	32.80	32.58	28.49	14.49
$Var(-\varphi^{EH}_{t+1} - \sigma^F_{t+1} + s^{\Delta E}_{t+1,\infty})$	34.73	13.37	35.91	29.84	34.24	30.64	29.46	29.99	17.15
$Cov(\tilde{i}_t - \varphi^{EH}_{t+1}, s^{\Delta E}_{t+1,\infty})$	−3.45	−2.73	−3.40	−1.59	−6.78	−3.60	−6.33	−8.53	−3.46
$Cov(\tilde{i}_t - \varphi^{EH}_{t+1}, \sigma_t - \sigma^F_{t+1})$	−5.04	−6.19	−1.76	−1.12	−2.73	−12.39	−5.27	−3.78	−1.35
$Cov(s^{\Delta E}_{t+1,\infty}, \sigma_t - \sigma^F_{t+1})$	1.34	1.75	−1.52	−0.91	−3.13	3.03	2.28	2.52	−1.44
$Var(\tilde{r}_t - \varphi^{r,EH}_{t+1})$	6.67	6.76	11.62	7.26	8.79	21.83	4.58	12.45	7.89
$Cov(\tilde{r}_t - \varphi^{r,EH}_{t+1}, \sigma_t - \sigma^F_{t+1})$	−4.00	−4.40	−3.06	−1.71	−4.76	−10.58	−2.64	−1.65	−2.49

Note: Variance-covariance decomposition of the exchange rate change components based on the survey-data-augmented VAR.

Table 15: R^2s from Daily Regressions of the Exchange Rate Change and Yield Curve Factors on Macroeconomic News Indices

		AUD	CAD	CHF	DEM/EUR	GBP	JPY	NOK	NZD	SEK	USD
	# of Surprises	23	24	20	34	23	22	21	21	24	13
3-Month Bill Rate	# of Obs.	3597	3566	1396	3680	3686	3587	3583	3569	3588	3566
	R^2	0.18	0.17	0.35	0.20	0.09	0.06	0.15	0.15	0.40	0.04
Yield Curve Curvature	# of Obs.	3587	3542	1356	3636	3685	3575	3561	3567	3575	3566
	R^2	0.12	0.15	0.23	0.11	0.07	0.05	0.06	0.07	0.13	0.07
Yield Curve Slope	# of Obs.	3587	3542	1356	3636	3685	3575	3561	3567	3575	3566
	R^2	0.10	0.10	0.31	0.10	0.07	0.06	0.09	0.08	0.15	0.06

Note: Each row presents R^2s from daily regressions with different dependent variables on macroeconomic news surprises. The regressors include current and up to a three-day lag of macro surprises as well as the sums of past macro surprises over each of the previous six months, with months being approximated using blocks of 21 trading days.

Table 16: Adjusted R^2s from Quarterly Regressions of the Exchange Rate Change and Its Components on Macroeconomic News Indices (USD base)

	AUD	CAD	CHF	DEM/EUR	GBP	JPY	NOK	NZD	SEK
Δs_{t+1}	0.62	0.47	0.74	0.82	0.82	0.70	0.76	0.59	0.68
σ_{t+1}^{F}	0.49	0.31	0.40	0.71	0.52	0.47	0.64	0.34	0.52
φ_{t+1}^{EH}	0.53	0.56	0.66	0.35	0.49	0.45	0.41	0.57	0.31
$s_{t+1,\infty}^{\Delta E}$	0.36	0.34	0.16	0.24	0.57	0.26	0.47	0.48	0.32

Note: Each row presents adjusted R^2s from quarterly regressions with different dependent variables on macroeconomic news indices constructed as quarterly sums of the fitted values from daily regressions of exchange rates and yield curve factors on the current and up to a three-day lag of macro surprises as well as the sums of past macro surprises over each of the past six months, with months being approximated using blocks of 21 trading days.

Table 17: Quarterly Panel Regressions of the Exchange Rate Change and Its Components on Macroeconomic News Indices (USD base)

	Δs_{t+1}	σ^F_{t+1}	φ^{EH}_{t+1}	$s^{\Delta E}_{t+1,\infty}$
Exch Rate News Index	0.96***	-0.75***	-0.09***	0.01
	(0.02)	(0.02)	(0.01)	(0.01)
Foreign Bill Rate News Index	-0.01**	-0.02**	0.02***	-0.00
	(0.00)	(0.01)	(0.01)	(0.01)
Foreign Slope News Index	-0.01	0.00	0.01	0.01
	(0.00)	(0.01)	(0.01)	(0.00)
Foreign Curvature News Index	-0.00	0.00	-0.01	0.00
	(0.00)	(0.01)	(0.01)	(0.01)
US Bill Rate News Index	-0.01	0.02***	-0.06***	-0.03***
	(0.01)	(0.00)	(0.00)	(0.00)
US Slope News Index	-0.01	0.01**	-0.04***	-0.03***
	(0.01)	(0.00)	(0.00)	(0.00)
US Curvature News Index	0.01	0.03***	-0.04***	-0.01**
	(0.01)	(0.01)	(0.00)	(0.00)
# of Obs.	495	495	495	495
Adj. R^2	0.71	0.51	0.42	0.31

Note: Each column is a quarterly regression of the exchange rate change or a subcomponent on macroeconomic news indices constructed as quarterly sums of the fitted values from daily regressions of exchange rates and yield curve factors on the current and up to a three-day lag of macro surprises as well as the sums of past macro surprises over each of the past six months, with months being approximated using blocks of 21 trading days.

Table 18: Adjusted R^2s From Quarterly Panel Regressions of the Exchange Rate Change and Its Components on Macroeconomic News Indices with the Sample Split by Recessions and High Financial Volatility Periods

	Δs_{t+1}	σ^F_{t+1}	φ^{EH}_{t+1}	$s^{\Delta E}_{t+1,\infty}$
US Recessions	0.86	0.69	0.64	0.70
Not US Recessions	0.65	0.46	0.38	0.16
VIX High	0.77	0.58	0.47	0.44
VIX Low	0.59	0.41	0.34	0.21

Note: Each row presents adjusted R^2s from quarterly regression on a particular subsample of the exchange rate change or a subcomponent on macroeconomic news indices, constructed as quarterly sums of the fitted values from daily regressions of exchange rates and yield curve factors on the current and up to a three-day lag of macro surprises as well as the sums of past macro surprises over each of the past six months, with months being approximated using blocks of 21 trading days. We use NBER recession dates, and the VIX is split by the median value in the 2001q4–2015q4 sample.

Appendix

A Details on Mapping VAR to Survey Forecasts

The VAR augmented with survey data given by equations (13) and (15) in the main text can be written in the following, more compact state-space form:

$$Z_{t+1} = \bar{\mathbf{\Gamma}} Z_t + \bar{\mathbf{\Xi}}_{t+1}$$
$$\begin{bmatrix} Y^A_{t+1} \\ Y^S_{t+1} \end{bmatrix} = \underbrace{\begin{bmatrix} E^A \\ E^S_{t+1} \end{bmatrix}}_{\mathbf{E}_{t+1}} Z_{t+1} + \begin{bmatrix} 0 \\ \Xi^s_{t+1} \end{bmatrix},$$

where Z includes a constant, the elements in X as described in Section 4, and the additional lags of X that appear in equation (15). $\bar{\mathbf{\Gamma}}$ thus includes the coefficients in $\bar{\mathbf{X}}$ and $\mathbf{\Gamma}$ as well as additional ones and zeros. $\bar{\mathbf{\Xi}}_{t+1}$ contains $\mathbf{\Xi}_{t+1}$ and zeros. Y^A_{t+1} contains observed actuals that are mapped using a selection matrix E^A to the elements in the state vector Z_{t+1}. Y^S_{t+1} contains survey forecasts that are a linear function of Z_{t+1}, where E^S_{t+1} is a product of selection matrices and powers of $\bar{\Gamma}$, as shown below. The time variation in E^S_{t+1} results from the nature of the survey forecasts, which will be detailed below. Ξ^s_{t+1} are i.i.d. 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 up to 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 final group.

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

$$E^S_{t+1} = H^S_{t+1} \underbrace{\begin{bmatrix} I \\ \bar{\Gamma} \\ \vdots \\ \bar{\Gamma}^{h_{\max}} \end{bmatrix}}_{\tilde{\bar{\Gamma}}},$$

where $h_{\max}$ is the longest available horizon for our set of survey variables. Right-multiplying $\widetilde{\bar{\Gamma}}$ by the state vector Z_{t+1} results in a large matrix containing model-implied forecasts for horizons 0 to $h_{\max}$. Each row of H^S_{t+1} corresponds to the mapping for a single survey forecast. Most rows of H^S_{t+1} are selection vectors selecting the relevant forecast horizon and variable. Two notable exceptions are discussed below.

1. Mapping annualized quarterly log growth rate actuals to annual average percent growth rates (for example, zero- through two-year-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

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

   In the above expression, $Q\left(t\right)$ 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 that 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 Note on the Estimation Procedure

The size of the VAR presents computational issues that prevent us from estimating the entire system of equations at once. Rather, we make use of the block-wise sequential nature of the VAR given by the restrictions in equation (14). Since the equations for the financial variables for a country are independent of the macroeconomic equations, we estimate them first. We then estimate a system that is expanded to include the macroeconomic equations, holding fixed the coefficients in the financial equations. Finally, we add the exchange rate equation to the model and estimate this system, holding fixed the previously estimated coefficients in the financial and macroeconomic blocks.

C Data Details

C.1 Macroeconomic and Financial Variables

- *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, Norway, Sweden, 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, Sweden, 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).
  - Norway: Data from Wright (2011) extended with data from the BIS
  - 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 final trading day of each quarter. These expectations refer to the three-month rates on each contract's final trading day, which typically falls within the second-to-last week of each quarter. When computing the surprises and expected changes in these interest rates, the actual rate used 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.
  - Norway: Three-month NIBOR.
  - New Zealand: New Zealand 90-day bank accepted bills.
  - Sweden: Three-month Swedish T-bill (1992:Q4 through 2007:Q4); three-month STIBOR (2008:Q1 through present).
  - United Kingdom: Three-month Sterling LIBOR.
  - United States: Three-month Eurodollar.

We exclude periods when the GBP and CHF had fixed exchange rates, as can be seen in the following table:

Data Sample Ranges

Australia	1989:Q4 – 2015:Q4
Canada	1992:Q2 – 2015:Q4
Germany	1991:Q2 – 2015:Q4
Japan	1992:Q3 – 2015:Q4
New Zealand	1990:Q1 – 2015:Q4
Norway	1989:Q4 – 2015:Q4
Sweden	1992:Q4 – 2015:Q4
Switzerland	1992:Q1 – 2011:Q2
United Kingdom	1992:Q4 – 2015:Q4
United States	1989:Q4 – 2015:Q4

C.2 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/euro area, Japan, United Kingdom, United States
- Date range: 1993:Q3 through 2015:Q4
- Non-US variables: Current, one-, and two-year-ahead forecasts of three-month interest rates, CPI inflation, and exchange rates.
- US variables: 7- through 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 euro-area forecasts starting in January 2000, when they become available.

Blue Chip Financial Forecasts

- Countries: Australia, Canada, Germany/euro area, Japan, Switzerland, United Kingdom, United States
- Date range: 1993:Q1 through 2015:Q4
- Variables: 3-, 6-, and 12-month-ahead three-month interest rate, 10-year yield, and exchange rate forecasts.
- Other details: Forecasts for German three-month interest rates and exchange rates are replaced with euro-area forecasts starting in January 1999. Forecasts for the German 10-year yield are used throughout the sample since forecasts for AAA-rated euro-area 10-year yields are not available.

Consensus Economics

- Country coverage: Australia, Canada, Germany/euro area, Japan, Norway, New Zealand, Sweden, Switzerland, United Kingdom, United States
- Date range: 1990:Q1 through 2015:Q4
- Variables: Current, one- and two-year-ahead and 6- through 10-year-ahead average for CPI inflation; 3- and 12-month-ahead for three-month interest rates and 10-year yields; 3-, 12-, and 24-month-ahead for exchange rates. Six- through ten-year-ahead average GDP growth forecasts are used to impute long-horizon non-US three-month bill rate forecasts, but are not directly included in the VAR estimation.

- Other details: Forecasts for Germany are replaced with euro-area forecasts as they become available. Short-horizon CPI inflation and three-month interest rate forecasts switch from Germany to euro area in December 2002 and January 2005, respectively. Long-horizon CPI inflation and GDP growth forecasts switch from Germany to euro area in April 2003.

Other details:

- 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 preceding 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 in which 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 (15) 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.

C.3 Macroeconomic Announcement Surprises

We use surprises for the following indicators for each country. When both Bloomberg and Informa Global Markets (IGM) publish expectations for the same indicator, we choose the source based on data availability. In a few rare cases in which indicators are discontinued, we splice the surprise series with a close substitute.

- Australia: GDP, CPI all groups goods component, employment change, unemployment rate, trade balance, current account balance, RBA cash rate target, building approvals, housing finance owner-occupied home number of loans, retail sales

- Canada: trade balance, Bank of Canada overnight lending rate, housing starts, employment change, Ivey Purchasing Managers Index (PMI), unemployment rate, current account balance, CPI, GDP, retail sales
- Euro area:
  - Germany: CPI, unemployment change, ifo Business Climate Index, industrial production, total manufacturing new orders, manufacturing PMI, ZEW Indicator of Economic Sentiment
  - Euro area: ECB main refinancing operations announcement rate, consumer confidence, CPI, unemployment rate, GDP, m3 money supply, manufacturing PMI, trade balance
  - France: CPI, industrial production excluding construction, manufacturing PMI
  - Italy: manufacturing business confidence, CPI, industrial production
- Japan: Tokyo core CPI, PPI, unemployment rate, jobs-to-applicants ratio, industrial production, trade balance, current account balance, GDP, core machinery orders, Tankan large enterprise manufacturing index
- New Zealand: GDP, CPI, unemployment rate, trade balance, current account balance, Reserve Bank of New Zealand official cash rate, employment changes, retail trade
- Norway: CPI, unemployment rate, Norges bank deposit rate, DNB Norway PMI, credit indicator, GDP, retail sales
- Sweden: industrial production, Sweden repo rate (decision rate), Swedbank Sweden PMI, retail sales, CPI, unemployment rate, GDP, trade balance
- Switzerland: GDP, industrial production, trade balance, procure.ch PMI, CPI, unemployment rate, retail sales
- United Kingdom: claimant count rate, unemployment rate, core CPI, Nationwide House Price Index, manufacturing production, PPI, Bank of England official bank rate, CPI, GDP, industrial production, trade balance
- United States: federal funds target rate, capacity utilization, new home sales, initial jobless claims, leading indicators index, nonfarm payrolls, ISM manufacturing index, trade balance, unemployment rate, core CPI, core PPI, GDP, retail sales

Online Appendix

A Additional Evidence on the Consensus Economics Exchange Rate Forecasts

First, we show that survey-based forecasted exchange rate changes 3, 12, and 24 months ahead, calculated using Consensus Economics data, predict the exchange rate change over the corresponding horizon in sample. Table A-1 presents a panel regression of the realized exchange rate change on the forecasted exchange rate change, calculated using the survey data. All the coefficients are statistically significant at the 10 percent level or lower.

The second exercise that we perform tests whether the in-sample predictive power of the survey exchange rate forecasts is above and beyond the predictive power of the interest rate differential. For this exercise, we separate the survey-based expected exchange rate change into a currency risk premium component and the interest rate differential. Denoting logarithms of variables with lowercase letters, we define the survey-based expected excess return as:

$$\sigma_t^S \equiv E_t^S \Delta s_{t+1} - \tilde{\imath}_t,$$

where E_t^S denotes the survey-based forecast at time t.

For this empirical exercise, we consider three commonly used measures of the interest rate differential: three-month government bond rates, three-month Libor rates, and the three-month forward premium (the three-month forward exchange rate minus the spot rate). The forward premium is often used as a measure of the interest rate differential relevant for financial markets, conditional on covered interest rate parity (CIP) holding. For each of these measures, we calculate a corresponding survey-implied currency risk premium. Table A-2 shows the regression results from a panel regression of the realized quarterly exchange rate change on σ_t^S and $\tilde{\imath}_t$. σ_t^S is highly statistically significant for all three measures, while the interest rate differential is not statistically significant.[29] Therefore, the survey data have predictive content of future exchange rate movements above and beyond the interest rate differential and is a better predictor of future exchange rate changes than the forward premium or lagged interest rate differentials.

In Figure A-1, we plot the expected exchange rate change using the survey data along

[29] Note that the coefficients on both $\tilde{\imath}_t$ and σ_t are well below one and the constants are sometimes statistically different from zero. This implies that the full-information rational expectations (FIRE) hypothesis does not hold in the data when one uses survey data—a result previously documented by Froot and Frankel (1989), among others, and more recently supported by Stavrakeva and Tang (2020b).

with the lagged interest rate differential measured using forward rates, government bond rates, or Libor rates. One can see that the behavior of survey-based expected exchange rate changes differ greatly from the rate differentials. In addition, the survey-based expected exchange rate change also differs substantially from zero, evidence that forecasters are also not simply relying on a random walk model of exchange rates.

The difference between the expected exchange rate change and a particular interest rate differential is the currency risk premium, σ_t^S, which is substantially more volatile than the relative interest rate differential. Table A-3 reports the bilateral regression of the survey-based expected exchange rate change on the forward rate minus the spot rate, and while the coefficient is statistically significant for some currency pairs, most of the variation of the survey-based expected exchange rate change (more than 80 percent) cannot be attributed to forward rates.

Together, all of the above results suggest that the surveyed practitioners do not simply use rules of thumb based on forward rates, a UIRP relationship, or a random walk model when providing an exchange rate forecast. Furthermore, using survey data delivers currency risk premia that have a significant in-sample predictive power of realized exchange rate changes that is independent of the lagged interest rate differential.

Table A-1: Predictive Power of Survey Forecasted Exchange Rate Changes

Months ahead:	3	12	24
$E_t^S[s_{t+h} - s_t]$	0.24^{***}	0.49^{*}	0.85^{**}
	(0.05)	(0.29)	(0.37)
Constant	-0.10^{***}	0.09	1.04
	(0.02)	(1.39)	(3.10)
Adj. R^2	0.01	0.05	0.13
# of Observations	954	927	729

Note: The dependent variable is the realized exchange rate change over the respective horizon. Standard errors are reported in parentheses. The three-month-ahead regression uses heteroskedasticity-robust standard errors clustered by currency pair. The 12- and 24-month-ahead regressions use Driscoll-Kraay standard errors with a lag length of three and seven quarters, respectively, to account for the overlapping observations at these horizons.

Table A-2: Predictive Power of Survey Forecasted Excess Returns vs Interest Rate Differentials

Rate differential Measure:	Bill rates	Libor rates	Forward premium
σ_t^S	0.25***	0.26***	0.23***
	(0.06)	(0.06)	(0.06)
$\tilde{i}_t$	0.22	0.15	0.41
	(0.43)	(0.45)	(0.29)
Constant	−0.09	−0.14**	−0.13**
	(0.11)	(0.06)	(0.05)
Adj. R^2	0.01	0.01	0.01
# of Observations	954	863	918

Note: The dependent variable is the realized exchange rate change. Heteroskedasticity-robust standard errors clustered by currency pair are reported in parentheses.

Table A-3: Relationship between Survey Forecasted Exchange Rate Changes and the Forward Premium

	AUD	CAD	CHF	DEM/EUR	JPY	NOK	NZD	SEK	GBP
Forward Premium	1.69***	0.48	1.35***	1.56*	0.70**	1.02***	1.19	1.47***	0.79*
	(0.63)	(0.31)	(0.49)	(0.84)	(0.31)	(0.30)	(0.87)	(0.33)	(0.46)
Constant	−0.59	−0.13	1.24***	0.37	0.68***	−0.55**	−0.07	−0.72***	0.68***
	(0.40)	(0.15)	(0.29)	(0.28)	(0.26)	(0.23)	(0.76)	(0.25)	(0.19)
Adj. R^2	0.07	0.02	0.07	0.04	0.03	0.15	0.02	0.17	0.05
# of Observations	107	107	107	71	107	107	107	107	107

Note: The dependent variable is the expected exchange rate change using the survey data. Heteroskedasticity-robust standard errors clustered by currency pair are reported in parentheses.

Figure A-1: Survey Forecasted Exchange Rate Changes vs Interest Rate Differentials

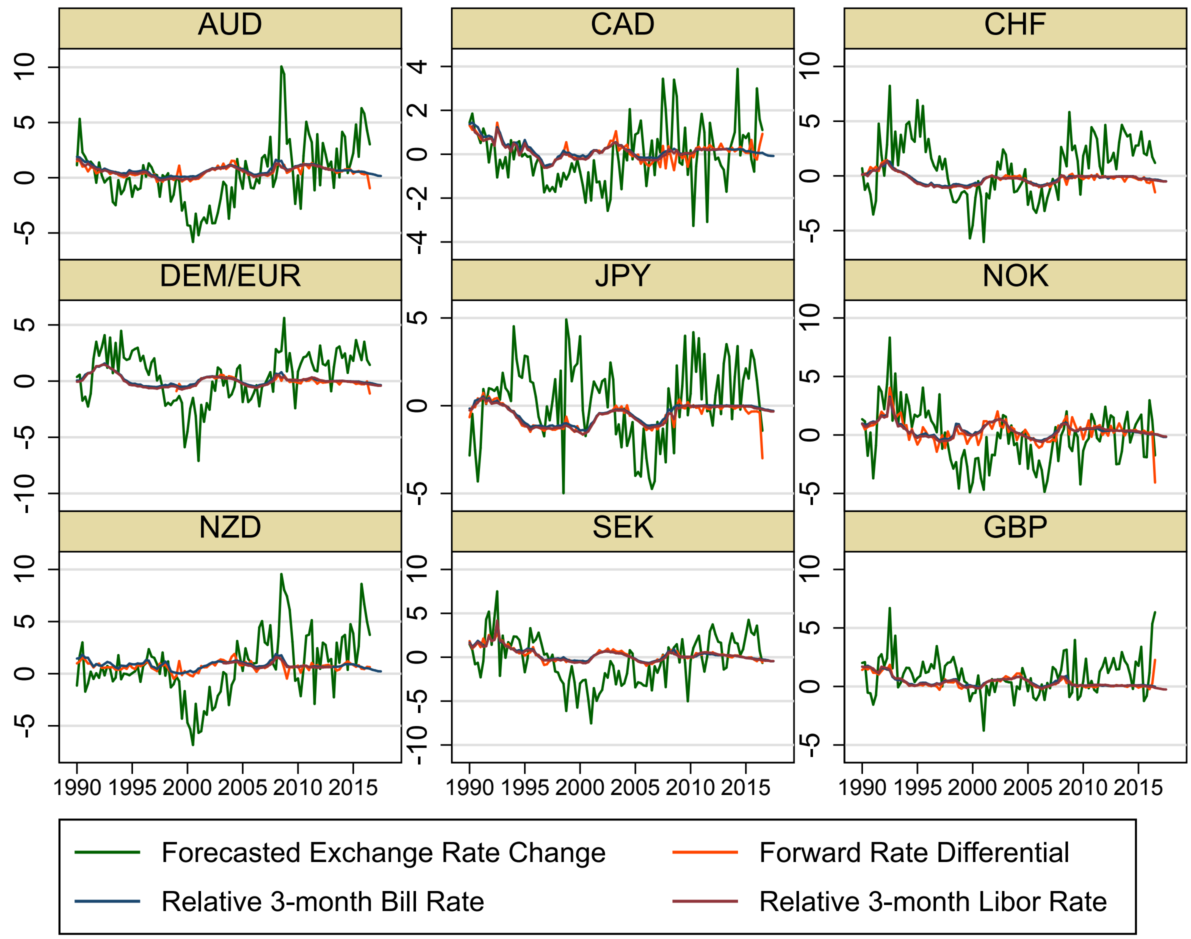


Table A-4: Relationship between Currency Risk Premia and Cross Country Net Exposures

	All Counterparties	Interbank
Net Exposure	-1.05^{**}	-1.76^{**}
	(0.44)	(0.71)
Constant	0.04	0.06^{*}
	(0.03)	(0.02)
Adj. R^2	0.01	0.01
# of Observations	932	928

Note: The dependent variable is the expected excess return defined as being long the dollar and short the currency of country i between the end of period t and the end of period t+1. The independent variable is the net domestic currency financial sector liabilities owed to the rest of the world by country i in period t calculated using BIS data. Heteroskedasticity-robust standard errors clustered by currency pair are reported in parentheses.