

Subjective Risk Premia in Bond and Currency Markets

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Abstract

This paper studies subjective expectations of bond and currency excess returns for the G10 economies. Subjective risk premia are time-varying, cyclical, positively correlated with quantities of risk, and predict future realised returns. These findings support asset pricing models that generate return predictability through cyclical variation in risk aversion, economic uncertainty, time-varying disaster risk, or learning. Exploiting surveys, we estimate a subjective SDF decomposition into permanent and transitory components which provides restrictions on the design of international asset pricing models.

JEL classification: D9, E3, E4, G12

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Measuring risk premia is a long standing endeavour in financial economics, which is usually approached by approximating conditional expectations with projections of realizations onto observable factors. This paper proposes an alternative. Subjective risk premia are obtained directly from a panel of investor forecasts of interest rates and exchange rates for the G10 countries.

Survey forecasts allow us to measure model free risk premia out-of-sample across both sovereign bond and exchange rate markets. The properties of the subjective risk premia we derive are useful to learn about the validity of existing asset pricing models and provide guidance for the design of future models that seek to explain stylized features of financial markets such as the predictability in objective returns. Focusing on the 1-year forecast horizon we begin by studying the properties of domestic bond risk premia (*BRP*) and exchange rate risk premia (*XRP*), and document a number of novel facts.

First, *BRP* are highly correlated across countries. The average cross-country correlation is 62% and they are significantly positive for all country pairs. Second, subjective *BRP* are close to mean zero but volatile and persistent, and they tend to be countercyclical. In fact, they are significantly negatively linked to measures of subjective expected growth measures, also obtained from surveys. This is an important result since leading asset pricing models featuring priced long run risks (Bansal and Yaron, 2004), habit preferences (Campbell and Cochrane, 1999), and rare disasters (Wachter, 2013) predict that risk premia vary cyclically and are increasing in states of high marginal utility (low realised growth or expected growth). Third, subjective *BRP* are significantly positively linked to the realized volatility of bond returns; thus survey expectations preserve the basic risk-return relation which predicts positive link between quantity of risk and perceived compensation for risk. This is a second important take-away since detecting a link between realised returns and measures of volatility is notoriously difficult (see, e.g., Moreira and Muir, 2017 or Eraker, 2020). This result is consistent with Buraschi, Piatti, and Whelan (2021), but while they document a positive link between quantity of risk and subjective bond risk premia for the U.S, we extend this result to all G10 countries.

Results for the subjective *XRP* are consistent with the literature and with the standard ‘carry trade’ intuition. In fact, the average exchange rate risk premium for the standard ‘investment currencies’ within the carry trade, i.e. Switzerland and Japan, is largely negative, while it is largely positive for Norway and Sweden. For the other countries the average *XRP* is closer to zero, but it is still highly time-varying. Also exchange rate risk premia display a large degree of

co-movement, since all pairwise correlations are positive and significant, and 45% on average. The large cross-sectional correlation between individual countries risk premia, that we discover both in the fixed income and currency markets, is consistent with highly globalized markets, in which sources of risk and risk compensations are common across countries. Subjective exchange rate risk premia also display interesting cyclical properties: they are negatively linked to expected growth in the foreign economy and positively linked to expected growth in the U.S, consistent with an expected U.S Dollar appreciation in crisis periods.

Combining interest rates and exchange rate forecasts allows us to study the expected excess return, denominated in U.S dollars, of a strategy that goes long foreign long term bonds and shorts a long term U.S bond. Risk compensation for this strategy is the sum of the exchange rate risk premium and a bond risk premium differential:

$$\text{Foreign Bond Dollar Risk Premium} = \text{Exchange Rate Risk Premium} + \text{Foreign Bond Risk Premium} - \text{U.S Bond Risk Premium}.$$

This is an economically relevant investment strategy to study since in recent decades sovereign bond markets have grown increasingly integrated implying many investors have exposure to the risks embedded in such a trade. Indeed, in the OECD countries on average, only about 60% of government debt is held domestically.¹ Despite this economic relevance, little is known empirically about the sources of risk and risk compensation for investing in foreign bond markets. This trade has also received recent academic attention, beginning with Lustig, Verdelhan, and Stathopoulos (2019), who argue expected returns on this trade are close to zero and unpredictable which presents a challenge for existing asset pricing models.

We analyse the properties of the Foreign Bond Dollar Risk Premium ($\Delta BRP^{\$}$). Summarising, we document that survey-implied $\Delta BRP^{\$}$ are highly time-varying, ranging between around -10% and +15% for all individual countries, and for the majority of countries it displays the clear pattern of being mostly positive in the first part of the sample and turning negative around the 2008 financial crisis. A decomposition of the overall dynamics into its components suggests that the switch in the sign is mainly driven by a corresponding flip in the exchange rate risk premia, which tends to drive a large fraction of the $\Delta BRP^{\$}$ variation. Interestingly, the exchange rate risk premium and bond risk premium differentials tend to offset each other, but we find a number of subperiods when the correlation between the two elements becomes zero or positive. This

¹See figure A.1 in the Online Appendix (OA).

is in contrast with Lustig, Verdelhan, and Stathopoulos (2019), who compute risk premia based on projections of future realized returns on interest rate differentials and the slope of the term structure. They show that projection-based bond risk premium differential and exchange rate risk premia are always negatively correlated, and they offset each other leading to an insignificant risk premium on the long term foreign bond dollar trade.

In general, the dynamics of bond and exchange rate risk premia based on standard statistical models is very different from the corresponding dynamics of the survey-based premia. In fact, the correlation between an equally-weighted average of each country's ΔBRP^s and the same time series obtained with benchmark statistical models is slightly negative at around -0.15.

After constructing and discussing our measures of subjective risk premia, we estimate a set of predictability regressions in order to characterise the informational content of our proposed survey measures with respect to traditional alternatives. As benchmark predictors we consider the interest rate differential between the foreign country and the U.S and the slope of the yield curve, for the exchange rate and bond realized returns, respectively. Summarising, we show that survey forecasters not only significantly positively predict future realized excess returns in both the fixed income and the foreign exchange market, but also they do not just use the information in the current term structures of interest rates in the different countries. This result suggests that survey forecasters combine information in the term structures with other variables as well as their own judgement and intuition when they build forecasts about interest and exchange rates. While identifying the exact information and models that survey forecasters use is not an easy task, we show that survey forecasts can be used as an aggregate, observable proxy of these unobservable and time-varying predictive information and models.

Finally, we explore the implications of our empirical findings for the design of dynamic no-arbitrage models. We rely on Alvarez and Jermann (2005)'s decomposition of the pricing kernel into a permanent and a transitory component and derive conditions that these components need to satisfy in order to match the stylized facts of foreign bond risk premia that we document. For the simple case of a one factor model we explicitly use our survey-based proxies of the bond risk premia, exchange rate risk premia and foreign bond dollar risk premia to solve for the volatilities of the permanent and transitory components of the SDF.

We find that the volatilities of the permanent components are extremely highly correlated across countries, with pairwise correlations between 79% and 99%, while transitory component

volatilities are still mostly positively cross-correlated but display a lower degree of correlation. We also show that the permanent component is largely dominant, driving between 92% and 96% of the SDF variance. The almost perfect correlation of permanent component volatilities across countries, and the fact that the volatility of the permanent components drives by far the largest fraction of the market price of risk in all countries, imply the large co-movement of subjective bond risk premia that we observe in the data.

$\Delta BRP^{\$}$ is given by the product of the negative of the market price of risk, which is mostly driven by the US permanent component volatility, and the difference between the permanent components of the US and the foreign country. Abstracting from the transitory component, which as we have shown has a limited impact on the market price of risk, $\Delta BRP^{\$}$ will be positive when the US permanent component volatility is larger than the foreign permanent component volatility, in absolute value, which highlights the importance of the international ranking of systematic risk in explaining the dynamics and the switches in the sign of $\Delta BRP^{\$}$.

We also note that the permanent component volatilities in all countries are mostly positive, meaning that the market price of risk for bonds (in their domestic currencies) is usually negative, which implies that bonds are perceived as hedges against bad shocks, consistent with a negative subjective bond risk premium measured from the raw survey forecasts.

RELATED LITERATURE:

A number of papers have shown that survey-based economic forecasts contain valuable information about macroeconomic quantities such as GDP and inflation (Ang, Bekaert, and Wei, 2007 and Aiolfi, Capistran, and Timmermann, 2011), supporting models with rational expectations. A related literature studies expectations about future financial variables: Froot (1989) for exchange rates, Greenwood and Schleifer (2014) for equity, Cieslak (2017) for short term interest rates, and Buraschi, Piatti, and Whelan (2021) for long term interest rates. Baley and Veldkamp (2021) (macro) and Adam and Nagel (2022) (asset pricing) provide recent (excellent) surveys articles on learning and expectation formation. Different than these papers we analyse survey-based risk premia contemporaneously across different markets, namely the foreign exchange and fixed income markets. Nagel and Xu (2021) also analyse survey-based risk premia across different asset classes, namely for aggregate portfolios of stocks, bonds, currencies, and commodity futures. These authors also find a positive link between subjective perceptions of risk and subjective risk premia in the equity market. We instead focus on the subjective risk premia in a cross-section

of Sovereign bond and currency markets and show that in both markets not only do risk premia vary with cyclical measures of growth but they also vary positively with measures of volatility, consistent with basic predictions from rational consumption based asset pricing models.

Our paper is also linked to the Uncovered Interest rate Parity (UIP) and Expectation Hypothesis (EH) literatures. The UIP dominates the discussion on exchange rate determination in international finance despite the widespread empirical evidence against it, at least at frequencies less than one year (see e.g., Bekaert and Hodrick, 1993 and Engel, 1996). The evidence against the EH is less mixed and the literature almost unanimously rejects the null hypothesis (see, e.g., Cochrane and Piazzesi, 2005). We depart from this strand of literature in that we use survey forecasts to measure risk premia and test the UIP and EH directly, while the literature has mostly used ex post realized exchange rate changes to test the validity of these hypotheses, due to the inherent difficulty in measuring expectations, implicitly assuming rational expectations.

Given our focus on the dollar risk premium of foreign bonds in excess of a U.S bond, our paper is related to Lustig, Verdelhan, and Stathopoulos (2019), who argue that carry trades using long term bonds are not profitable since term premia differential and currency risk premia offset. Andrews, Colacito, Croce, and Gavazzoni (2021) suggest that the zero excess returns on this strategy are the result of a negative pre-crisis and a positive post-crisis return. Contrary to these papers, we study the properties of foreign bond risk premia using survey forecasts directly rather than projections of ex-post return realizations.

Finally, we extend the decomposition of Alvarez and Jermann (2005) to an international setting in order to estimate subjective permanent and transitory components. Consistent with the findings of Alvarez and Jermann (2005) we find that pricing kernels are dominated by their permanent components (see also Hansen and Scheinkman, 2009). However, we provide point estimates for these components, implied by subjective expectations, and also for the cross-section of G10 economies.

I. Data

Survey Data. Our survey data is supplied by Consensus Economics (CE). Professional financial market participants submit monthly forecasts of (i) spot exchange rates; (ii) 3-month interest rates; and (iii) yields on 10 year government bonds for a variety of countries. We focus on the most heavily-traded G10 currencies vis-a-vis the United States (USD): Australia (AUD), Canada

(CAD), Switzerland (CHF), Europe (EUR), United Kingdom (GBP), Japan (JPY), New Zealand (NZD), Norway (NOK) and Sweden (SEK). CE reports projections for two horizons, 3 and 12 months, for both exchange rate and interest rate expectations. In this paper we focus on the 12-month forecasts. Forecasts begin in *(i)* 1990 for the USD, CAD, EUR, GBP, JPY; *(ii)* in 1995 for AUD, NZD and SEK; and *(iii)* in 1998 for NOK and CHF. All results in the paper, unless otherwise stated, are based on the period from January 1995 to December 2020, for a total of 300 monthly observations.

Consensus Economics has maintained a consistent questioning procedure over time and survey respondents face the same questions for each country. Forecasters receive the questionnaire in the first few days of the month, and survey forecasts are collected the second week of every month on Monday and then released by CE three days after on the Thursday of the same week. We sample all yields, spot rates and exchange rates on the date when the survey goes public, i.e. the release date, that is normally around the middle of the month, in order to avoid any look-ahead bias. Moreover, the survey focuses on experts for each region, with respondents generally located in the country for which they are asked to make predictions. Thus, the dataset is comparable across a large cross-section of countries, is available at monthly frequency for an extended sample period, and covers a large set of forecast variables.

In addition to interest rate and foreign exchange forecasts CE covers a large set of indicators but we focus on: real GDP growth, industrial production growth, personal consumption growth, and the rate of unemployment. A complication with the survey projections is that respondents are asked to report expectations over the current and the next calendar year (except for interest rates, which are constant maturity forecasts); thus, the dataset represents a set of variable maturity events. For example, in July 2003 each contributor to the survey made a forecast for the percentage change in GDP for the remaining two quarters of 2003 (6 months ahead), and an average percentage change for 2004 (18 months ahead). The December 2003 issue contains forecasts for the remaining period of 2003 (1 month ahead) and an average for 2004 (13 months ahead). The moving forecast horizon induces a seasonal pattern in the survey. We compute an implied constant maturity forecast for each individual forecaster as in Buraschi and Whelan (2022) and Fendel, Lis, and Rülke (2011). Let j be the month of the year, so that $j = 1$ for January and $j = 1, 2, \dots, 12$. A constant maturity expectation is formed taking as weight $(1 - \frac{j}{12})$, for the short term projection (the remaining forecast for the same year), and $\frac{j}{12}$, for the long-term projection

(the forecast for the following year). Figure A.4 in the Online Appendix (OA) illustrates the weighting procedure visually.

We also note that for interest rate expectations, CE asks its panellists to provide their estimates of “yields on 10 year government bonds”, without specifying what type of yield. However, it is generally understood that they are providing estimates of the on-the-run bond yield to maturity, which is effectively a par yield forecast. Since we only have two maturities available, we cannot bootstrap directly zero coupon bond yield estimates from the par yields provided. Therefore, in what follows, we treat par yield forecasts as zero coupon forecasts, given that our theory below is written in terms of zeros. We show in the Online Appendix that par yields and zero-coupon bond yields are empirically very close for 10-year government bonds. The compounding frequency of the yields provided is also not explicitly stated, so for simplicity we assume they are continuously compounded, i.e. log yields. Section A.1 in the OA shows that our results are practically unchanged if we instead assumed the yields were annually or semi-annually compounded.

Realised Data. We obtain monthly G10 FX spot and 3-month forwards, and zero coupon bond yields from Thomson Reuters Eikon for the sample period January 1995 to December 2021, which are generally available for maturities 3, 6, 9 and 12-months, and 3, 5, 10 and 15 years. Missing maturities are replaced from Bloomberg data. Below we require country-specific yields for three bond maturities: the 12-month rate (risk-free), the 10-year rate, and the 11-year rate. While Eikon provides the former two series, it does not provide us with the latter. To remedy this, we fit a cubic spline to all available maturities and sample the desired yield.

II. Framework and Notation

In this section we introduce some notation and the formulas used to compute subjective risk premia on long term domestic bonds, currencies and foreign bonds.²

²The literature studying return predictability typically interprets expected excess log returns as risk premia. This is not quite correct since risk premia should be measured as expected excess simple returns. Assuming log-normality, arithmetic average return differs from the geometric average return by half the variance (the Jensen’s terms). In realized data the approximation is known to be small. Computing Jensen’s terms from BlueChip Financial Forecasts, Buraschi, Piatti, and Whelan (2021) show that the approximation is even tighter using survey expectations. In what follows we interpret expected log returns as risk premia.

A. Risk premia in the fixed income market

Let $P_t^{(k)}$ be the time t price of a risk-free zero-coupon bond of maturity k years. Spot n -year yields are then defined as $i_t^{(k)} = -\frac{\ln P_t^{(k)}}{k}$. The bond risk premium is defined as the expected excess return on the bond, so we start by computing the realized holding horizon return of a k -year bond, with a j -year holding horizon:

$$\ln \frac{P_{t+j}^{(k-j)}}{P_t^{(k)}} = -(k-j)i_{t+j}^{(k-j)} + ki_t^{(k)} \quad (1)$$

The annualised expected excess return on a k -year bond with a j -year holding horizon is then:

$$E_t \left[rx_{t+j}^{(k)} \right] = -\frac{k-j}{j} E_t \left[i_{t+j}^{(k-j)} \right] + \frac{k}{j} i_t^{(k)} - i_t^{(j)}, \quad (2)$$

where continuously compounded yields are annualised and k and j are expressed in years. We denote the bond risk premium for maturity k and horizon j by

$$BRP_t^{(j,k)} \equiv E_t \left[rx_{t+j}^{(k)} \right]. \quad (3)$$

Note that under the Expectation Hypothesis (EH), $E_t \left[i_{t+j}^{(k-j)} \right] = f_t^{(j,k)}$, where $f_t^{(j,k)} = \frac{ki_t^{(k)} - ji_t^{(j)}}{k-j}$ is the forward rate for k periods starting from j periods from time t , so that the risk premium for investing in long-term bonds is zero, $BRP_t^{(j,k)} = 0$.

B. Risk premia in the foreign exchange market

Denote by s_{t+j} the log of the exchange rate, expressed in units of foreign currency per US Dollar, and by Δs_{t+j} the change in the log exchange rate from time t to time $t+j$. Therefore, a positive Δs_{t+j} corresponds to an appreciation of the US Dollar relative to the foreign currency. The j -period interest rate in the foreign country is denoted by $i_t^{(j)*}$. The annualised log currency excess return is given by:

$$rx_{t+j}^{FX} = (i_t^{(j)*} - i_t^{(j)}) - \frac{1}{j} \Delta s_{t+j}. \quad (4)$$

The exchange rate risk premium is defined as the conditional expectation of the excess return in Equation (4), i.e. $XRP_t^{(j)} \equiv E_t \left[rx_{t+j}^{FX} \right]$:

$$XRP_t^{(j)} = (i_t^{(j)*} - i_t^{(j)}) - \frac{1}{j} (E_t [s_{t+j}] - s_t), \quad (5)$$

where $E_t[s_{t+j}]$ is the forecast of the exchange rate in j periods. $XRP_t^{(j)}$ can be interpreted as the annualised expected excess return of investing for j periods (using a j -period instrument, e.g. a 3-month bill if $j = 0.25$) in the foreign currency, financing the investment selling the local currency (e.g. selling a 3-month T-bill). Also note that interest rates are annualised, so we also annualise the exchange rate change by dividing by j .

According to the Uncovered Interest Rate Parity (UIP), high interest rate countries are expected to experience an exchange rate depreciation to equalise expected exchange rate adjusted returns on assets. The idea behind UIP is that when the foreign interest rate is higher than the local interest rate, i.e. $i_t^{(j)*} > i_t^{(j)}$, the foreign currency will depreciate by the difference, i.e. s_{t+j} increases by $i_t^{(j)*} - i_t^{(j)}$, so that in local currency terms the return on investing in the two countries is exactly the same, i.e. XRP is zero.

C. Risk premia on foreign bonds

Denote by $rx_{t+j}^{(k),*}$ the annualised excess return of a k -year foreign bond with a j -year holding period, expressed in the foreign currency, and by $rx_{t+j}^{(k),\$}$ the equivalent annualized excess return of the foreign bond expressed in the local currency, i.e. the U.S Dollar. The j -period holding period return of the foreign bond expressed in local currency is:

$$\ln \frac{P_{t+j}^{(k-j),*}/S_{t+j}}{P_t^{(k),*}/S_t} = -(k-j)i_{t+j}^{(k-j),*} + ki_t^{(k),*} - s_{t+j} + s_t \quad (6)$$

This return is realized over a j period, so again if we want to annualise it we need to divide by j :

$$r_{t+j}^{(k),\$} = -\frac{k-j}{j}i_{t+j}^{(k-j),*} + \frac{k}{j}i_t^{(k),*} - \frac{1}{j}\Delta s_{t+j}. \quad (7)$$

The annualised expected excess return on a foreign k -year bond with a j -year holding horizon is then the sum of the foreign bond risk premium and the exchange rate risk premium:

$$\begin{aligned} E_t[rx_{t+j}^{(k),\$}] &= -\frac{k-j}{j}E_t(i_{t+j}^{(k-j),*}) + \frac{k}{j}i_t^{(k),*} - \frac{1}{j}(E_t[s_{t+j}] + s_t) - i_t^{(j)} \\ &= BRP_t^{(j,k),*} + XRP_t^{(j)}. \end{aligned} \quad (8)$$

The equivalent of the UIP condition that measures subjective risk compensation for investing

in foreign countries with respect to the U.S is given by

$$\begin{aligned}\Delta BRP_t^{(j,k),\$} &\equiv E_t \left[rx_{t+j}^{(k),\$} \right] - E_t \left[rx_{t+j}^{(k)} \right] = XRP_t^{(j)} + BRP_t^{(j,k),*} - BRP_t^{(j,k)} \\ &= XRP_t^{(j)} + \Delta BRP_t^{(j,k),*}\end{aligned}\tag{9}$$

which is zero under the null hypothesis no risk compensation. Clearly, this can happen if all risk premia are equal to zero (the short term UIP holds and the EH also holds in both countries) or if risk premia in the foreign exchange and fixed income markets offset each other. $\Delta BRP_t^{(j,k),\$}$ in Equation (9) is the dollar denominated holding period expected excess return for selling a U.S Treasury bond and investing into a long-term foreign bond.

The next section derives empirical estimates of the expected excess return on the foreign bond trade as well as its components using survey forecasts to approximate the expected bond yield $E_t \left[i_{t+j}^{(k-j)} \right]$ and exchange rate change $E_t [s_{t+j}]$.³

III. Subjective Risk Premia

In this section we compute the bond risk premium $BRP_t^{(j,k)}$, exchange rate risk premium $XRP_t^{(j)}$ and the overall dollar risk premium on foreign bonds in excess of U.S bonds $\Delta BRP_t^{(j,k,\$)}$, respectively, for a twelve-month forecast horizon j and a bond maturity k of *eleven years*.⁴ Since j and k are fixed we skip them and just refer to the premia as BRP_t , XRP_t and $\Delta BRP_t^\$$ in what follows to simplify the notation.

A. Bond Risk Premia

We compute bond risk premia from Equation (3). Figure 1 shows the time series of survey-based BRP and panel A of Table I reports summary statistics. Subjective bond risk premia are close to mean zero but volatile and persistent. For example, the GBP BRP ranges between -8% around the year 2000 to +8% in the aftermath of the 2008 financial crisis. The JPY BRP is less volatile but still displays significant persistence ranging between -4% pre financial crisis to +4% post financial crisis. Expected excess bond returns appear counter-cyclical, consistent with risk premia being

³Note for interest rates we treat surveys as providing us with an approximation for log yields (continuously compounded yields) directly. For exchange rates we are making a different approximation, namely, that $\log E_t[S_t] = E_t[\log S_t] = E_t[s_t]$ i.e., we are assuming that the Jensen's term is small.

⁴Surveys provide us with the expected yield on a 10-year bond for a 1-year forecast horizon. So we are computing subjective bond risk premia as the expected *change* 11-year log bond prices above the 1-year risk free rate.

high in bad states such as the early 2000s and during the 2008 financial crisis, while in more recent years the average risk premia are lower, mainly negative and less volatile.

Another striking feature of our subjective measures of bond risk premia is their co-movement. Figure 1 displays a clear systematic pattern across countries, which is confirmed by a very high average cross-country correlation equal to 62%, and all pairwise correlations are positive ranging from 35% (between GBP and JPY) to 80% (between EUR and SEK).⁵

Table II analyses the cyclical properties of subjective bond risk premia, by showing the results of a panel regression of $BRPs$ on the expected state of the economy, measured using survey forecasts about GDP growth, industrial production growth, consumption growth, and the rate of unemployment in each country. In general, we find that lower expected growth of the local economy is significantly linked to higher subjective bond risk premia. This holds for all the different measures of the expected state of the economy that we consider and suggests that survey-based bond risk premia are countercyclical, consistent with economic intuition. While the R-squared of these regressions are typically relatively small, the effect of the expected unemployment rate on the risk premia is quite sizeable, with an R^2 of almost 7%. Table II also shows a highly significant and positive link between subjective bond risk premia and realized volatility of bond returns, as a measure of the current quantity of risk in bond markets. In summary, subjective risk premia are countercyclical and positively correlated with the quantity of risk, consistent with benchmark asset pricing models. Section A.2 in the OA analyzes the properties of survey forecast errors and shows that they are not predictable by forecast revisions, suggesting that survey expectations for interest rates display no direct evidence of irrationality or information frictions, despite featuring a small persistent bias.

[Insert Figure 1 and Tables I and II here]

B. Exchange Rate Risk Premia

We compute exchange rate risk premia using Equation (5). Figure 2 displays the dynamics of the $XRPs$ and Panel B of Table I reports summary statistics. They are time-varying and volatile relative to their mean, with standard deviations between 0.25 (CAD) and 0.55 (NZD). The average XRP is largely negative for Switzerland and Japan, equal to -1.67% and -2.75%, consistent with the idea that these are ‘safe-haven’ or ‘investment currencies’ within the carry trade, and

⁵See Table A.7 in the Online Appendix.

largely positive around 3.5% for Norway and Sweden. For the other countries in our sample average exchange rate risk premia are smaller, approximately between -1% and +1%. All pairwise correlations between exchange rate risk premia are positive and their average is 45%. The XRP of Japan is less correlated to the remaining countries' XRP , in fact excluding Japan from the sample of countries the average pairwise correlation increases to around 54%.

We then investigate the cyclicity of our subjective exchange risk premium measures in a similar way to what we have done for subjective bond risk premia. However, for exchange rates, we would expect risk premia to be high not only when the expected growth in the foreign country is low, but also when the expected growth in the U.S is high. Therefore, Table III shows the results of a panel regression of $XRPs$ on the expected state of the economy of both the foreign country and the U.S, measured using survey forecasts about GDP growth, industrial production growth, consumption growth, and the rate of unemployment. While results are not as clearcut as for the subjective bond risk premia, we do find that the regression coefficients for the U.S expected growth have the right sign and are significant when using the consumption growth and unemployment measures. On the other hand, the foreign expected growth has a significant impact, and in the expected direction, only when using the unemployment measure. Overall, the effect of the expected foreign and local unemployment rate on the subjective foreign exchange risk premia is quite large, with an R^2 of around 7%. Table III also shows a positive and significant link between subjective exchange rate risk premia and realized volatility of FX rates. These results suggest that foreign exchange risk premia tend to be countercyclical with respect to the foreign economy and procyclical with respect to the U.S, consistent with the U.S Dollar appreciation in crisis periods.

[Insert Figure 2 and Table III here]

C. Risk Premia on Foreign Bonds

Dollar denominated subjective risk premia on foreign bonds are computed from Equation (9). Figure 3 displays the time-series of the $\Delta BRP^{\$}$ s and panel C of Table I reports summary statistics. Subjective domestic risk premia on foreign bonds are clearly time-varying and display a common pattern of being mostly positive in the first part of the sample and turning negative around 2007. Moreover, we note the strong correlation in individual bond risk premia and exchange rate risk premia carries over into the cross-section of $\Delta BRP^{\$}$ with an average pairwise correlation of 45%.

[Insert Figure 3 here]

Unconditional average $\Delta BRP^{\$}$ s range between -1.36% (CHF) and 3.38% (SEK). The $\Delta BRP^{\$}$ for the JPY is also negative equal to -1.05% which means that Swiss and Japanese bonds are, on average, a hedge from the perspective of a domestic US investor. On the contrary, US investors require a positive risk premium, between around 2.37% and 3.38%, to buy Australian, Norwegian and Swedish bonds. Moreover, large negative values for Switzerland and Japan and the large positive values for the Scandinavian countries are mostly carried over from their corresponding subjective carry trade expectations (see again panel B of Table I).

Panels (a) and (b) of Figures 4 and 5 display a time-series decomposition of $\Delta BRP^{\$}$ into BRP and XRP components, for the EUR and JPY pairs, respectively.

Considering first the EUR, we display year by year medians of $\Delta BRP^{\$}$ which is negative in the early sample, peaks at 10% in the year 2000, becomes gradually smaller during the early 2000s and again flips sign around 2007 attains a minimum of -5% in 2013, and becomes positive again in the recent sample. Panel (b) shows that over the full sample the XRP contributes more to the overall variation in $\Delta BRP^{\$}$ than ΔBRP does and their effect is often in offsetting directions. In other words, from the perspective of a U.S investors, most of the subjective risk investing in foreign bonds originates from the exchange rate component of the trade. Panel (c) studies this point further by providing a variance decomposition of $\Delta BRP^{\$}$ into ΔBRP , XRP contributions and their covariance for different subsamples. Here we see that the variance of bond risk premia differential contributes little to the variation variation of $\Delta BRP^{\$}$ and that the covariance between the BRP and XRP changes sign throughout the sample.

Next, Figure 5 considers the JPY, which is strongly negative in the first half of the sample, flips sign in the run up to the financial crisis, and thereafter becomes strongly negative again. As with the EUR, we find that the variation in XRP dominates the variation in $\Delta BRP^{\$}$ and the covariance term is mostly negative but switches sign in two subperiods.

[Insert Figures 4 and 5 here]

D. Comparison with Statistical Models

We now compare the dynamics of our survey-based bond risk premia (BRP), exchange rate risk premia (XRP) and foreign bond dollar risk premia ($\Delta BRP^{\$}$) with standard projection-based statistical models of expected excess returns that are used in the literature. In particular, projection-based bond risk premia for each country are obtained by regressing realised excess

returns at time $t+12$ on the slope of the country yield curve at time t , defined as the spread between the 10-year and the 1-year yield. For exchange rate risk premia, we use the forecasts implied by the interest rate differential between the foreign country and the U.S. The statistical forecasts require computing the factor loadings, which we estimate in-sample using realized returns from January 1996 to December 2021 and predictive variables from January 1995 to December 2020. Note that these projection-based risk premia obviously suffer from a look-ahead bias, contrary to the survey-based forecasts which are forward looking by construction. However, we do not attempt to compute projection-based estimates in real time, i.e. out-of-sample, as our goal here is just to compare the time series dynamics of the survey and statistical-based foreign bond risk premia, not their predictive power.

Model-based dollar denominated risk premia on foreign bonds are obtained from Equation (9), as the sum of the projection-based exchange risk premium and bond risk premium differential.

Table IV reports summary statistics for the risk premia based on these statistical models for each country in our sample, while Figures A.7-A.9 in the Online Appendix display their time-series dynamics. Comparing Table IV with the corresponding summary statistics of the survey-based premia in Table I reveals strong differences between the two sets of premia. For example, the bond risk premia using statistical models (see Panel A) tend to be positive and significant for all countries on average, while they are on average slightly negative for all countries except Japan using surveys, consistent with the idea that forecasters see long term bonds as hedges. The ranking of the country average exchange rate risk premia in Panel B is also clearly not the same as for the survey-based XRP . In particular, the negative exchange rate risk premia of SEK and NOK seem inconsistent with the standard intuition behind carry trade strategies. The overall foreign bond dollar risk premia based on statistical models (see Panel C) are in general closer to zero and less volatile than their survey-based counterparts, consistent with Lustig, Verdelhan, and Stathopoulos (2019), who argue that projection-based bond risk premium differential and exchange rate risk premia tend to offset each other leading to an insignificant risk premium on the long term foreign bond dollar trade.

The dynamics of the statistical model based premia in Figures A.7-A.9 of the Online Appendix is also very different from the corresponding dynamics of the survey-based premia in Figures 1-3. However, a shared feature of the two sets of premia is their high cross-sectional correlation (see Tables A.7 and A.8 in the Online Appendix), which in the case of the projection-based premia is

driven by the high cross-sectional correlation of the predictors, i.e. yield curve slopes and interest rate differentials, across countries.

Given this large cross-sectional correlation among dollar-denominated foreign bond risk premia, to facilitate the comparison between our survey-based measures and statistical models, Figure 6 shows the time series of an equally-weighted average of each country's ΔBRP^S against the same time series obtained with statistical models as described above. The correlation between the two time series is slightly negative at around -0.15 , meaning that the risk premia dynamics implied by survey forecasts is very different from what one would obtain with standard statistical models.

[Insert Table IV and Figure 6 here]

IV. Predictability Regressions

In this section we estimate a set of predictability regressions in order to characterise the informational content of our proposed survey measure and contrast it to more traditional alternatives. We consider the interest rate differential between the foreign country and the U.S and the slope of the yield curve as benchmark predictors for the exchange rate and bond realized returns, respectively. To simplify the notation we denote the interest rate differential as $IRD_t \equiv i_t^{(1)*} - i_t^{(1)}$ and the slope of the yield curve as $Slope_t \equiv i_t^{(10)} - i_t^{(1)}$.⁶

A. Bond Risk Premia

We then look at the predictive content of survey forecasts in the bond market. Table V shows the point estimates and Driscoll and Kraay (1998) standard errors for panel regressions of the form:

$$rx_{t+12}^{(11)} = a + b_1 Slope_t + b_2 BRP_t + \mu_i + \epsilon_{t+12}.$$

[Insert Table V here]

We find that the slope of the yield curve significantly positively predicts future realized returns, as expected. More surprisingly, survey-based expected excess bond returns are also positively and highly significantly linked to future realized excess bond returns, consistent with the results of

⁶The results that follow are very similar using a 10-year minus 1-year or 11-year minus 1-year definition of the slope of the yield curve.

Buraschi, Piatti, and Whelan (2021) for the U.S but contrary to what Greenwood and Schleifer (2014) document for the equity market. Interestingly, the predictive power of our survey-based measure does not disappear when adding the slope as an additional predictor, even if the estimated coefficient b_2 drops from 0.58 to 0.34 going from column (ii) to column (iii). This results suggests that in the domestic bond markets, survey forecasts contain valuable information to predict future returns, that is not completely spanned by the information included in the current shape of the local term structures.

B. Exchange Rate Risk Premia

Table VI shows the estimation results of the following exchange rate panel predictability regression:

$$rx_{t+12}^{FX} = a + b_1 IRD_t + b_2 XRP_t + \mu_i + \epsilon_{t+12},$$

where a_i denotes country fixed effects.

[Insert Table VI here]

Table VI shows that the coefficient for the usual UIP predictor, the interest rate differential, is significantly positive, consistent with the literature. Similarly, the sign of the survey-based measure in column (ii) is positive and significant. Most interesting is the estimation of the kitchen sink specification in column (iii). Both the interest rate differential and the survey-based measure are statistically significant at the 5% confidence level. In fact, the point estimate of coefficient b_2 even slightly increases from 0.59 to 0.64. Considering the measure's stability even when controlling for natural predictors, these results hint at a strong informational value of surveys. Notably, the R-squared of the single-variable regressions in columns (i) and (ii), i.e. 9% and 5%, almost add up to the R-squared of the multivariate regression in column (iii), that is 15%. This results suggest that survey forecasters not only significantly positively predict future realized excess returns in the foreign exchange market, but survey forecasts do not only use information in the current term structures of interest rates in the different countries.

A natural null hypothesis for the XRP coefficient is $b_2 = 1$. Since XRP is the (survey-based) expected excess FX return, if surveys were fully efficient we should have $rx_{t+12}^{FX} = XRP_t + \epsilon_{t+12}$, i.e. $b_2 = 1$ and $a = 0$. It is interesting to note that while all b_2 coefficient estimate is smaller than one, the hypothesis $b_2 = 1$ cannot be rejected (the 95% confidence interval contains unity).

C. Foreign Bond Risk Premia

Equation (9) shows that $\Delta BRP_t^{\$}$, our ultimate object of interest, is the sum of two terms: (1) the exchange rate risk premium; and (2) the difference between the foreign and US bond risk premia. Thus, we next consider the information content of ΔBRP for future realized returns of foreign bonds in excess of the US bond, in their local currencies. A visual inspection of the time series of ΔBRP (see Figure A.3 in the OA) displays a pronounced co-movement. Between 1995 and 2001, the ΔBRP seems to be decreasing for all countries in the panel, followed by a brief boom period that crashed around the time of the GFC. Since then, the ΔBRP are close to zero.

Adapting the predictive regressions above, we estimate

$$rx_{t+12}^{*,(11)} - rx_{t+12}^{(11)} = a + b_1(Slope_t^* - Slope_t) + b_2\Delta BRP_t + \mu_i + \epsilon_{t+12}.$$

Inspecting Table VII, we discover that both, the yield curve slope differential and our proposed survey-based measure yield significantly positive coefficient estimates. Interestingly, the regression using only the survey-based ΔBRP beats the yield curve slope in terms of R^2 , with a value of 12.5% against 10.4%. Moreover, the regression coefficient b_2 is not significantly different from 1, both in the univariate panel regression and when adding the slope differential as an additional regressor. The coefficient b_2 is also quite stable across specifications, while the slope differential coefficient decreases substantially from column (i) to the multivariate specification in column (iii). The interpretation here is again that the survey measure contains information that is distinct from that contained in the term structure slopes.

[Insert Table VII here]

Given the informational value of both survey-based expected FX and local bond returns, it is not surprising that foreign bond excess dollar returns can also be significantly predicted by our $\Delta BRP_t^{\$}$ measure. We confirm this by running the following panel regressions (see Table VIII):

$$rx_{t+12}^{(11),\$} - rx_{t+12}^{(11)} = a + b_1IRD_t + b_2(Slope_t^* - Slope_t) + b_3\Delta BRP_t^{\$} + \mu_i + \epsilon_{t+12}.$$

When estimating regression setups with only one of the predictors, the interest rate differential and the survey measure yield significantly positive coefficients. Interestingly, the R^2 for the interest

rate differential (4.88%) and the slope differential (0.67%) are much smaller than that for the survey measure (8.34%). When including all predictors at once, all coefficients are positive and significant at a level of at least 10%. Moreover, while coefficients of the traditional measures change significantly, the coefficient for the survey measure remains almost constant. This observation suggests that the information contained in the survey panel is important and close to orthogonal of the information contained in the interest rate differential and the yield curve slope.

[Insert Table VIII here]

Importantly, this result does not mean that survey forecasters do not use information in the slope of the term structures or the yield curve differentials at all. Most likely, they combine information in the term structures with other variables as well as their own judgement and intuition when they build forecasts about interest and exchange rates. Identifying the exact information and models that survey forecasters use is not an easy task, if at all feasible, since they are very likely to assign time-varying weights to alternative models. For example, they might rely fully on their own judgement one month and instead follow a standard slope predictor another month. Moreover, individual forecasters probably follow different rules, and observing only the consensus of an unbalanced panel does not allow us to recover these individual rules. Overall however, our results show that we can use the consensus survey forecast as an aggregate, observable proxy of these unobservable and time-varying predictive information and models.

V. Subjective SDF Decompositions

This section investigates the implications of the new set of stylized facts that we document for the design of no-arbitrage models. Starting from a preference-free setting we derive the conditions that no-arbitrage models need to satisfy to match the empirical features of exchange rate and international risk premia on long-term bonds. We rely on a decomposition of the stochastic discount factor into a permanent and a transitory component (see Alvarez and Jermann (2005)). We explicitly use our survey-based proxies of the bond risk premia, exchange rate risk premia and foreign bond dollar risk premia to solve for the volatilities of the permanent and transitory components of the SDF for the simple case of a one factor model.

A. *Permanent vs Transitory Components*

Alvarez and Jermann (2005) show that the stochastic discount factor (SDF) can be factorized into a permanent martingale component and a transitory component that is related to the return on a long term discount bond. Formally, supposing that $\Lambda_t^P = \lim_{s \rightarrow \infty} E_t[\Lambda_s]$ is a martingale, this Λ_t^P will be the permanent component of the state price process, while the transitory component Λ_t^T is defined as the residual so that in general, the SDF for each country can be written as:

$$\Lambda_t = \Lambda_t^P \Lambda_t^T. \quad (10)$$

Let us write the return process for a long term zero-coupon bond prices with maturity τ as

$$\frac{dP_{t,\tau}}{P_{t,\tau}} = dR_{t,\tau} = \mu_{t,\tau}dt + \sigma'_{t,\tau}dZ_t, \quad (11)$$

where dZ_t is a vector of Brownian shocks. The riskfree security pays the riskless rate as a dividend and follows

$$\frac{dB_t}{B_t} = r_t dt \quad (12)$$

We assume the existence of a unique SDF:

$$\frac{d\Lambda_t}{\Lambda_t} = -r_t dt - \Theta'_t dZ_t, \quad (13)$$

where Θ_t is the vector of market prices of risk associated to each shock.⁷ The dynamics of the permanent and residual components, in continuous time, can be defined as follows:

$$\frac{d\Lambda_t^P}{\Lambda_t^P} = \sigma_t^{P'} dZ_t \quad (14)$$

$$\frac{d\Lambda_t^T}{\Lambda_t^T} = \mu_t^T dt + \sigma_t^{T'} dZ_t \quad (15)$$

⁷Note that in the following subsection we will focus on the case of one shock, so that Z_t , $\sigma_{t,\tau}$ and Θ_t will all be one-dimensional.

It follows from Ito's lemma that the drift and diffusion terms of the state price process (Equation (13)) are given by:

$$r_t = -\mu_t^T - \sigma_t^{P'} \sigma_t^T \quad (16)$$

$$\Theta_t = -\sigma_t^P - \sigma_t^T \quad (17)$$

From the definition of the permanent and transitory components we also have that the price of the bond with infinite maturity is given by

$$P_{t,\infty} = \lim_{s \rightarrow \infty} E_t \left[\frac{\Lambda_s}{\Lambda_t} \right] = \frac{\Lambda_t^P}{\Lambda_t} = \frac{1}{\Lambda_t^T} \quad (18)$$

Therefore,

$$\mu_{t,\infty} = \sigma_t^{T'} \sigma_t^T - \mu_t^T \quad (19)$$

$$\sigma_{t,\infty} = -\sigma_t^T. \quad (20)$$

Domestic bond pricing and risk premia follow from the first order condition

$$\begin{aligned} BRP_{t,\tau} &= -\frac{1}{dt} E_t \left[\frac{d\Lambda_t}{\Lambda_t} \frac{dP_{t,\tau}}{P_{t,\tau}} \right] \\ &= \Theta_t' \sigma_{t,\tau}. \end{aligned} \quad (21)$$

In a frictionless complete market, the pricing of foreign securities follows symmetrically and both SDFs are unique, which also pins down the exchange rate uniquely. Investors can trade in both domestic and foreign bond markets. Denote X_t the real exchange rate in the US good per unit of the foreign good. When X_t goes up, the US dollar depreciates in real terms. If markets trade without frictions then the US dollar price of the foreign bond ($P_{t,\tau}^f$) is given by

$$\Lambda_t X_t P_{t,\tau}^f = E_t [\Lambda_{t+1} X_{t+1} P_{t+1,\tau-1}^f] \quad (22)$$

which implies that exchange rates are determined by the difference between SDFs in the two countries:

$$\Lambda_t^f = \Lambda_t X_t \quad (23)$$

The dynamics of the exchange rate in levels is given by:

$$\begin{aligned} \frac{dX_t}{X_t} &= \frac{d\Lambda_t^f}{\Lambda_t^f} - \frac{d\Lambda_t}{\Lambda_t} + \left(\frac{d\Lambda_t}{\Lambda_t} \right)^2 - \frac{d\Lambda_t^f}{\Lambda_t^f} \frac{d\Lambda_t}{\Lambda_t} \\ &= \left[r_t - r_t^f + \Theta_t' (\Theta_t - \Theta_t^f) \right] dt + (\Theta_t - \Theta_t^f) dZ_t \end{aligned} \quad (24)$$

From the perspective of a US investor who converts USD to foreign currency, invests in a foreign bond, and converts back in the future, her domestic excess return is

$$\begin{aligned} \frac{d \left(X_t P_{t,\tau}^f \right)}{X_t P_{t,\tau}^f} - \frac{dB_t}{B_t} &= \frac{dX_t}{X_t} + \frac{dP_{t,\tau}^f}{P_{t,\tau}^f} + \frac{dX_t}{X_t} \frac{dP_{t,\tau}^f}{P_{t,\tau}^f} - r_t dt \\ &= \left[\mu_{t,\tau}^f - r_t^f + (\Theta_t + \sigma_{t,\tau}^f)' (\Theta_t - \Theta_t^f) \right] dt + (\Theta_t - \Theta_t^f + \sigma_{t,\tau}^f) dZ_t \end{aligned}$$

So the expected excess return is

$$\begin{aligned} BRP_{t,\tau}^{f,\$} &= \frac{1}{dt} E_t \left[\frac{d \left(X_t P_{t,\tau}^f \right)}{X_t P_{t,\tau}^f} - r_t dt \right] \\ &= \underbrace{\mu_{t,\tau}^f - r_t^f}_{BRP_{t,\tau}^f} + \underbrace{(\Theta_t + \sigma_{t,\tau}^f)' (\Theta_t - \Theta_t^f)}_{XRP_t} \end{aligned} \quad (25)$$

Therefore, the bond risk premium on the foreign bond from the perspective of the US investor, in excess of the US bond risk premium is given by:

$$\begin{aligned} \Delta BRP_t^{\$} &= BRP_{t,\tau}^{f,\$} - BRP_{t,\tau} \\ &= \sigma_{t,\tau}^{f'} \Theta_t^f - \sigma_{t,\tau}' \Theta_t + (\Theta_t + \sigma_{t,\tau}^f)' (\Theta_t - \Theta_t^f) \\ &= \Theta_t' (\Theta_t - \sigma_{t,\tau} - \Theta_t^f + \sigma_{t,\tau}^f) \end{aligned} \quad (26)$$

Using (17) and (20) and considering infinite maturity bonds, the bond risk premium, exchange rate risk premium and dollar foreign bond risk premium can be written in terms of the volatilities of the permanent and transitory components of the SDF as follows:

$$BRP_{t,\infty} = (\sigma_t^P + \sigma_t^T)' \sigma_t^T \quad (27)$$

$$XRP_{t,\infty} = (\sigma_t^P + \sigma_t^T + \sigma_t^{T,f})' (\sigma_t^P + \sigma_t^T - \sigma_t^{P,f} - \sigma_t^{T,f}) \quad (28)$$

$$\Delta BRP_{t,\infty}^{\$} = (\sigma_t^P + \sigma_t^T)' (\sigma_t^P - \sigma_t^{P,f}). \quad (29)$$

B. One Factor Model Estimation

We now focus on the simple case of one risk factor, which means that the Brownian vector of shocks dZ_t in the equations above is now assumed to be one-dimensional. In this case, from (27)-(29), the risk premium expressions can be summarized as follows:

$$BRP_{t,\infty} = \sigma_t^T (\sigma_t^P + \sigma_t^T) \quad (30)$$

$$BRP_{t,\infty}^f = \sigma_t^{T,f} (\sigma_t^{P,f} + \sigma_t^{T,f}) \quad (31)$$

$$XRP_{t,\infty} = (\sigma_t^P + \sigma_t^T + \sigma_t^{T,f}) (\sigma_t^P + \sigma_t^T - \sigma_t^{P,f} - \sigma_t^{T,f}) \quad (32)$$

$$\Delta BRP_{t,\infty}^{\$} = (\sigma_t^P + \sigma_t^T) (\sigma_t^P - \sigma_t^{P,f}). \quad (33)$$

Our goal is to estimate the volatilities of the permanent and transitory SDF components for the US, i.e. σ_t^P and σ_t^T , and for each foreign country, i.e. $\sigma_t^{P,f}$ and $\sigma_t^{T,f}$ using our survey-based estimates of the risk premia. In the univariate case at every time t we have four unknowns and four nonlinear observation equations, (30)-(33). However, these four equations are redundant since the foreign bond dollar risk premium is a linear combination of the other risk premia. Therefore, the system is under-identified and we need additional information to be able to recover the volatilities of the SDF components. We exploit the fact that the bond return volatility is equal to the negative of the transitory component volatility (Equation (20)), as well as the availability of high-frequency data on long term U.S bonds, to obtain an estimate of σ_t^T , and then use the estimated risk premia to recover the value of the other unknowns from the system. More precisely, we follow the steps below:

1. We estimate US bond return volatility as the square root of the quadratic variation of 1-

minute returns on the 10-year treasury future contracts within each month (see figure A.21 in the online appendix) and set σ_t^T equal to the negative of the bond return volatility.

2. Using the estimated σ_t^T and Equation (30) we obtain the permanent component for the US as

$$\sigma_t^P = \frac{BRP_t}{\sigma_t^T} - \sigma_t^T. \quad (34)$$

3. Then, from (33), using our $\Delta BRP_t^\$$ estimate we can recover the volatility of the permanent component for each foreign country:

$$\sigma_t^{P,f} = \sigma_t^P - \frac{\Delta BRP_t^\$}{\sigma_t^T + \sigma_t^P}. \quad (35)$$

4. Finally, from Equation (31) or (32), we obtain the foreign transitory component. We can also use both equations to take into account the noise in our risk premium estimates and obtain $\sigma_t^{T,f}$ minimizing the sum of the squared differences between left and right-hand side of Equations (31) and (32), which are both quadratic in $\sigma_t^{T,f}$.

C. Empirical Subjective SDF Decomposition

Following the steps above at every point in time t we obtain a time series of the volatilities of the permanent and transitory components for all countries. Table A.10 (Online Appendix) shows the cross-sectional correlations between the volatilities of the transitory (Panel A) and permanent (Panel B) SDF components of all countries. We find that the volatilities of the permanent components are extremely highly correlated across countries, with values between 0.79 and 0.99. On the other hand, transitory component volatilities are still positively cross-correlated but display a lower degree of correlation, with values that range from 0.04 (between GBP/NZD) to 0.66 (between AUD/NZD). The strong positive correlations across permanent components is in line with Sandulescu, Trojani, and Vedolin (2020), who report a value of around 0.98 for integrated markets based on a model-free estimation of minimum-dispersion international SDFs, and Lustig, Verdelhan, and Stathopoulos (2019), who argue that in order to match the relatively smooth exchange rates and highly volatile SDFs the implied correlation of the permanent components in a symmetric two-country case must be above 0.9.

Table IX reports the time series averages of the σ^T s (Panel A) and σ^P s (Panel B) over the full

sample for each country, as well as their standard deviation and skewness. We can see that the volatility of the transitory components on average is at least one order of magnitude smaller than the volatility of the permanent component. To highlight this point, Panel C of Table IX shows the fraction of the SDF variance that is driven by the permanent component, which ranges between 92% and 96%. Our result is consistent with Alvarez and Jermann (2005), who derive a lower bound for the volatility of the permanent component and conclude empirically that it accounts for most of the SDF volatility based on the size of the equity premium relative to the term premium. More precisely, the lower bound that they obtain, with either yields or holding-period returns on long-term bonds, range from 0.76 to 1.11, implying that the variance of the permanent component is at least 76% of the total variance of the SDF. Interestingly, ours are point estimates rather than lower bounds and they are obtained using ex-ante measures of subjective risk premia rather than realized excess returns.

[Insert Table IX here]

The almost perfect correlation of permanent component volatilities across countries, and the fact that the volatility of the permanent components drives by far the largest fraction of the market price of risk Θ in all countries, imply the large comovement of subjective bond risk premia that we observe in the data.

We now turn to the dynamics of the estimated permanent and transitory component volatilities. To simplify the exposition, also given the large and positive correlation across countries, we do not report time series for each foreign country against the US, and instead report results for the US, EUR, GBP and JPY. For each year in the sample, Figure 7 displays the median of the monthly σ^P s for these four countries. As expected from the correlations above, the values of the volatility of the permanent component for the US and the foreign countries are very close to each other and range between around -0.50 and +2.5. Overall σ^P is large (in absolute value), volatile, is on average mostly positive and is persistent.

From Equation (33) it is clear that the dollar foreign bond risk premium for each country against the US is mostly driven by the US permanent component volatility. However, the sign of $\Delta BRP_t^{\$}$ also depends on the sign of the difference between the permanent components of the US and the foreign country, $\sigma^P - \sigma^{P,f}$. More precisely, remember that $\Delta BRP_t^{\$}$ is given by the product of the negative of the market price of risk Θ , which is mostly driven by σ^P , and the difference between the permanent components of the US and the foreign country, $\sigma^P - \sigma^{P,f}$.

Overall, abstracting from the transitory component, which as we have shown has a limited impact on the market price of risk, $\Delta BRP_t^{\$}$ will be positive when the US σ^P is positive and larger than $\sigma^{P,f}$, and when it is negative and smaller than $\sigma^{P,f}$. So, in other words, when σ^P is larger than $\sigma^{P,f}$ in absolute value. Figure 9 shows the difference between the absolute values of the permanent component volatilities in the US and in the foreign countries, i.e. $|\sigma^P| - |\sigma^{P,f}|$, for the three countries we are focusing on, i.e. EUR, GBP and JPY. Comparing this figure with panel (a) in Figures 4-5, respectively, shows that indeed the difference in the size of the permanent component volatilities fully explains the dynamics of $\Delta BRP_t^{\$}$, and in particular its changes in sign. For example, for the EUR, $|\sigma^P| - |\sigma^{P,f}|$ is mostly positive in the first half of the sample, then turns negative around 2007 and positive again in the last 4 years of the sample, exactly as $\Delta BRP_t^{\$}$.

[Insert Figures 7, A.2 and 9 here]

It is interesting to note that Θ is the (subjective expected) Sharpe ratio of a local long term bond. Therefore, a positive Θ - which usually means a negative permanent component volatility σ^P - implies that bonds are seen as risky assets, while a positive σ^P often corresponds to bonds being hedges against bad shocks. Similarly, given the relative sizes of the permanent and transitory components, the cross-sectional ranking of permanent component volatilities σ^P should be linked to the relative ranking of international bond risk premia (in local currencies). We find that σ^P is mostly positive, so the market prices of risk are negative most of the times and bonds are generally perceived as hedges.

The time series for the volatilities of transitory components of the US and foreign SDFs are displayed in Figure A.2. Consistent with their unconditional values in Tables A.10 and IX, the σ^T s are much smaller (lower than 7% in absolute value) and less correlated. The σ^T for the US is set equal to the negative of the volatility of US long term bond returns, so it is negative by construction (see Figure A.21 in the Online Appendix). For the foreign countries, we do not restrict the σ^T to be negative but still mostly find negative values, with a few exceptions.

Assuming that the volatility of the transitory component is a small negative value and approximately the same for all countries, we can simplify the risk premium expressions and gain further insights into the role of the different $\Delta BRP_t^{\$}$ components. Setting $\sigma^T \approx \sigma^{T,f} \approx -\epsilon$, we get:

$$BRP_{t,\infty}^f - BRP_{t,\infty} \approx \epsilon_t(\sigma_t^P - \sigma_t^{P,f}) \quad (36)$$

$$XRP_{t,\infty} \approx (\sigma_t^P - 2\epsilon_t) (\sigma_t^P - \sigma_t^{P,f}) \quad (37)$$

$$\Delta BRP_{t,\infty}^{\$} \approx (\sigma_t^P - \epsilon_t) (\sigma_t^P - \sigma_t^{P,f}). \quad (38)$$

When ϵ is very close to zero, the bond risk premium differential is close to zero and $\Delta BRP^{\$}$ is approximately equal to XRP . When instead σ_t^P is equal to $2\epsilon_t$, i.e. positive and relatively small, XRP is equal to zero and $\Delta BRP_t^{\$}$ is only driven by the bond risk premium differential. The sign of the exchange rate risk premium and the dollar foreign bond risk premium will tend to be the same, and a combination of the sign of $\sigma_t^P - \sigma_t^{P,f}$ and of σ_t^P , unless σ_t^P is very small in absolute value. These expressions also help understand why the covariance between the two elements of the $\Delta BRP_t^{\$}$, i.e. ΔBRP and XRP , is usually negative. In fact, they depend with opposite signs on the transitory component volatility.

VI. Conclusion

This paper exploits survey data on bond yields and exchange rates to jointly estimate risk premia in the foreign exchange and fixed income markets for the G10 countries. Subjective expected excess returns are obtained directly from a panel of investor forecasts allowing us to measure model free real-time risk premia on bonds and currencies, and then combine them to study the risk premium on an economically important investment strategy that buys a foreign long-term bond and sells a long-term U.S bond.

First, we show that international bond risk premia are highly correlated across countries, close to zero on average but highly volatile and persistent, and they tend to be countercyclical, consistent with leading asset pricing models. We also show that subjective bond risk premia are significantly positively linked to the realized volatility of bond returns, and therefore consistent with a standard risk-return tradeoff.

Second, the ranking of subjective exchange rate risk premia is consistent with the intuition behind the standard carry trade. In fact, investment currencies like Switzerland and Japan have a large and negative premium, while it is largely positive for Norway and Sweden. As for bond risk premia, subjective exchange rate risk premia are highly time-varying, correlated across countries

and cyclical, in the sense that they tend to be negatively linked to expected growth in the foreign economy and positively linked to expected growth in the U.S.

Combining the risk premia on foreign and local bonds, as well as the exchange rate risk premia, we study the properties of the Foreign Bond Dollar Risk Premium. We find that they are also highly time-varying, ranging between around -10% and +15% for all individual countries, and for the majority of countries it displays the clear pattern of being mostly positive in the first part of the sample and turning negative around the 2008 financial crisis, where the switch in the sign is mainly driven by a corresponding flip in the exchange rate risk premia.

Interestingly, we show that the subjective risk premia that we estimate, both in the fixed income and exchange rate markets, significantly positively predict future realized excess returns and the predictive power goes beyond that of standard predictors like the interest rate differential and the slope of the term structure. This finding suggests that survey forecasters do not just use the information in the current term structures of interest rates in the different countries to build their expectations.

Finally, we study the implications of our risk premia estimates for the design of dynamic no-arbitrage models, relying on Alvarez and Jermann (2005)'s decomposition of the stochastic discount factor into a permanent and a transitory component. For the simple case of general one-factor models, we estimate the time series of the volatilities of permanent and transitory components of the SDF of each country based on the survey-based bond and exchange rate risk premia. Our main takeaways are the following: First, we show that the variance of the SDF in all countries is largely dominated by the permanent component, consistent with the previous literature. Contrary to the literature though our conclusion is based on point estimates rather than bounds and uses measures of expected excess returns instead of future realizations. Second, we show that the permanent component volatility is extremely highly correlated across countries, suggesting that - at least based on market participants' beliefs - international markets are highly integrated and the martingale components of the SDFs in all countries have similar exposures to a common shock.

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VII. Tables

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	USD
<u>Panel A: BRP</u>										
Mean	-0.79	-0.44	-1.91	-1.19	-0.56	0.27	-2.66	-0.88	-1.58	-1.43
Std	0.34	0.38	0.21	0.22	0.31	0.17	0.33	0.37	0.36	0.28
Skew	0.73	0.68	0.13	0.39	0.44	0.59	-0.30	0.23	0.27	0.40
<u>Panel B: XRP</u>										
Mean	1.73	1.05	-1.66	0.19	0.22	-2.74	3.55	1.16	3.53	
Std	0.49	0.24	0.44	0.40	0.26	0.42	0.40	0.55	0.43	
Skew	0.62	-0.28	0.05	0.85	0.15	-0.22	0.13	0.62	0.53	
<u>Panel C: $\Delta BRP^{\\$}$</u>										
Mean	2.37	2.03	-1.36	0.42	1.09	-1.04	3.23	1.70	3.38	
Std	0.51	0.37	0.49	0.43	0.35	0.52	0.52	0.62	0.56	
Skew	0.47	-0.10	-0.11	0.54	0.14	0.04	0.05	0.70	0.33	

Table I. Descriptive Statistics for Subjective Risk Premia

This table presents the means, standard deviations, and skewness for subjective exchange rate risk premia (XRP s), subjective bond risk premia (BRP s), and subjective foreign bond dollar risk premia ($\Delta BRP^{\$}$ s) as defined in equations (3), (5) and (9), respectively. The sample period is 1995.1 to 2020.12.

	(i)	(ii)	(iii)	(iv)	(v)
<i>gdp</i>	-0.584** [0.250]				
<i>ip</i>		-0.217** [0.104]			
<i>consum</i>			-0.481* [0.259]		
<i>unem</i>				0.610*** [0.129]	
<i>BondVola</i>					0.410*** [0.102]
$R^2(\%)$	2.90	1.89	1.73	6.68	7.44
Nobs	2942	2942	2942	2100	2942

Table II. Explaining Subjective Bond Risk Premia

This table reports results from the panel regression

$$BRP_t = a + b^\top X_t + \mu_i + \epsilon_t$$

where μ_i is a country fixed effect and BRP_t is the survey implied bond risk premium and X_t is vector of explanatory variables containing 12-month *expected gdp* growth, industrial production growth (*ip*), consumption growth (*cons*), the rate of unemployment (*unem*), and 10-year bond return volatility (*BondVola*). A constant is included but not reported. Standard errors reported in square parenthesis are computed using a Driscoll and Kraay (1998) estimator with 3 lags. The superscripts *, **, and *** denote statistical significance at 90%, 95% and 99% levels, respectively. The sample period is 1995.1 to 2020.12.

	(i)	(ii)	(iii)	(iv)	(v)
<i>gdp</i>	0.0498 [0.298]				
<i>U.S. gdp</i>	0.530 [0.400]				
<i>ip</i>		0.351** [0.164]			
<i>U.S. ip</i>		-0.278 [0.203]			
<i>cons</i>			-0.160 [0.222]		
<i>U.S. cons</i>			0.837** [0.402]		
<i>unem</i>				0.770*** [0.143]	
<i>U.S. unem</i>				-0.434*** [0.129]	
<i>FXVola</i>					0.0673** [0.0328]
<i>R</i> ² (%)	1.92	1.41	2.85	7.25	0.53
Nobs	2642	2642	2642	1800	2700

Table III. Explaining Subjective FX Risk Premia

This shows reports results from the panel regressions

$$XRP_t = a + b^\top X_t + \mu_i + \epsilon_t$$

where μ_i is a country fixed effect and XRP_t is the survey implied bond risk premium and X_t is vector of explanatory variables containing 12-month *expected gdp* growth, industrial production growth (*ip*), consumption growth (*cons*), the rate of unemployment (*unem*), for the foreign countries and the U.S, and the exchange rate volatility (*FXVola*). A constant is included but no reported. Standard errors reported in square parenthesis are computed using a Driscoll and Kraay (1998) estimator with 3 lags. The superscripts *, **, and *** denote statistical significance at 90%, 95% and 99% levels, respectively. The sample period is 1995.1 to 2020.12.

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	USD
<u>Panel A: BRP-projected</u>										
Mean	4.79	5.15	3.97	5.21	4.76	3.59	3.64	3.52	6.19	4.63
Std	0.30	0.32	0.18	0.29	0.28	0.26	0.34	0.25	0.37	0.19
Skew	0.04	0.40	0.29	0.27	0.23	0.47	-0.32	0.09	0.54	0.15
<u>Panel B: XRP-projected</u>										
Mean	1.43	0.29	-0.69	-1.32	-0.32	-3.02	-0.89	2.19	-1.21	
Std	0.42	0.12	0.42	0.35	0.14	0.32	0.34	0.38	0.37	
Skew	0.06	-0.13	0.01	0.12	0.25	-0.33	0.57	-0.42	0.28	
<u>Panel C: $\Delta BRP^{\\$}$-projected</u>										
Mean	1.59	0.80	-1.35	-0.74	-0.20	-4.06	-1.88	1.08	0.35	
Std	0.34	0.22	0.25	0.31	0.16	0.13	0.19	0.25	0.38	
Skew	-0.08	0.42	0.09	-0.25	0.59	0.58	0.29	-0.39	0.62	

Table IV. Descriptive Statistics for Projected Risk Premia

This table presents the means, standard deviations, and skewness for exchange rate risk premia ($XRPs$), subjective bond risk premia ($BRPs$), and subjective foreign bond risk premia ($\Delta BRP^{\$}$ s) where the expectational quantities defined in Equations (3), (5) and (9), are replaced by projections. These predictions are obtained by regressing realized ex-post excess returns on the slope of the yield curve (for bond risk premia) and the interest rate differential between the foreign country and the United States (for exchange rate risk premia). The sample period is 1995.1 to 2020.12.

	(i)	(ii)	(iii)
b_1	3.876*** [0.677]		3.404*** [0.771]
b_2		0.582*** [0.156]	0.336* [0.176]
$R^2(\%)$	18.27	6.53	19.21
Nobs	3000	2918	2918

Table V. Bond Return Panel Predictability Regression

This table reports results from the panel predictability regression

$$rx_{t,t+12}^{(11)} = a + b_1 Slope_t + b_2 BRP_t + \mu_i + \epsilon_{t,t+12}$$

where μ_i is a country fixed effect, $Slope_t = (i_t^{(10)} - i_t^{(1)})$ is the slope of the domestic yield curve, and BRP_t is the survey implied bond risk premium. A constant is included but no reported. Standard errors reported in square parenthesis are computed using a Driscoll and Kraay (1998) estimator with 12 lags. The superscripts *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively. The sample period is 1995.1 to 2020.12.

	(i)	(ii)	(iii)
b_1	2.117** [0.884]		2.233*** [0.799]
b_2		0.585* [0.348]	0.640** [0.304]
$R^2(\%)$	9.23	5.14	15.37
Nobs	2700	2700	2700

Table VI. FX Return Panel Predictability Regression

This table reports results from the panel predictability regression

$$rx_{t,t+12}^{FX} = a + b_1 IRD_t + b_2 XRP_t + \mu_i + \epsilon_{t,t+12}$$

where μ_i is a country fixed effect, $IRD_t = (i_t^{*,(1)} - i_t^{(1)})$ is the one-year interest rate differential, and XRP_t is the survey implied currency risk premium. A constant is included but no reported. Standard errors reported in square parenthesis are computed using a Driscoll and Kraay (1998) estimator with 12 lags. The superscripts *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively. The sample period is 1995.1 to 2020.12.

	(i)	(ii)	(iii)
b_1	2.140*** [0.711]		1.629** [0.703]
b_2		0.855*** [0.144]	0.762*** [0.130]
$R^2(\%)$	10.43	12.53	18.30
Nobs	2700	2618	2618

Table VII. Bond Differential Returns Panel Predictability Regression

This table reports results from the panel predictability regression

$$rx_{t,t+12}^{*,(11)} - rx_{t,t+12}^{(11)} = a + b_1(Slope_t^* - Slope_t) + b_2\Delta BRP_t + \mu_i + \epsilon_{t,t+12}$$

where μ_i is a country fixed effect, $Slope_t = (i_t^{(10)} - i_t^{(1)})$ is the slope of the domestic or foreign yield curve and $\Delta BRP_t = BRP_t^* - BRP_t$ is the survey implied bond risk premium differential. A constant is included but not reported. Standard errors reported in square parenthesis are computed using a Driscoll and Kraay (1998) estimator with 12 lags. The superscripts *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively. The sample period is 1995.1 to 2020.12.

	(i)	(ii)	(iii)	(iv)
b_1	1.577* [0.916]			3.510*** [1.269]
b_2		-0.899 [1.406]		3.175* [1.683]
b_2			0.645** [0.305]	0.635** [0.282]
$R^2(\%)$	4.88	0.67	8.34	16.53
Nobs	2700	2700	2618	2618

Table VIII. Foreign Bond Dollar Return Panel Predictability Regression

This table shows results of a panel regression of the form

$$rx_{t,t+12}^{\$, (11)} - rx_{t,t+12}^{(11)} = a + b_1 IRD_t + b_2 (Slope_t^* - Slope_t) + b_3 \Delta BRP_t^{\$} + \mu_i + \epsilon_{t,t+12}$$

where $IRD_t = (i_t^{*, (1)} - i_t^{(1)})$, $Slope_t = (i_t^{(10)} - i_t^{(1)})$ is either the foreign (indicated with a superscript *) or domestic slope of the yield curve, and $\Delta BRP_t^{\$}$ is the survey implied foreign bond dollar risk premium differential. Standard errors reported in square parenthesis are computed using a Driscoll and Kraay (1998) estimator with 12 lags. The superscripts *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively. The sample period is 1995.1 to 2020.12.

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	USD
<hr/>										
<u>Panel A: σ_T</u>										
Mean	-0.09	-0.07	-0.04	-0.06	-0.07	-0.04	-0.06	-0.07	-0.06	-0.08
Std	0.03	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Skew	-1.01	-0.96	-1.37	-1.38	-1.44	-2.38	-1.64	-1.71	-1.78	-0.76
<u>Panel B: σ_P</u>										
Mean	0.23	0.24	0.59	0.33	0.21	0.06	0.66	0.28	0.45	0.34
Std	0.42	0.59	0.59	0.45	0.45	0.65	0.74	0.61	0.60	0.42
Skew	-0.60	0.04	0.59	0.35	0.00	0.94	0.71	1.01	0.42	0.33
<u>Panel C: $\frac{\sigma_P^2}{\sigma_P^2 + \sigma_T^2}$</u>										
Mean	0.78	0.88	0.92	0.85	0.83	0.88	0.90	0.86	0.87	0.80
Min	0.75	0.86	0.90	0.82	0.80	0.85	0.88	0.84	0.85	0.77
Max	0.81	0.91	0.95	0.88	0.86	0.90	0.93	0.89	0.90	0.83

Table IX. Permanent vs Transitory Components: Summary Statistics

This table shows the mean, standard deviation and skewness of the transitory (Panel A) and permanent (Panel B) components of the SDF decomposition, as outlined in Section V, between the ten countries in the sample. Panel C provides the mean, minimum and maximum for the fraction of the SDF variance that is driven by permanent component. The sample period is 1995.1 to 2020.12.

VIII. Figures

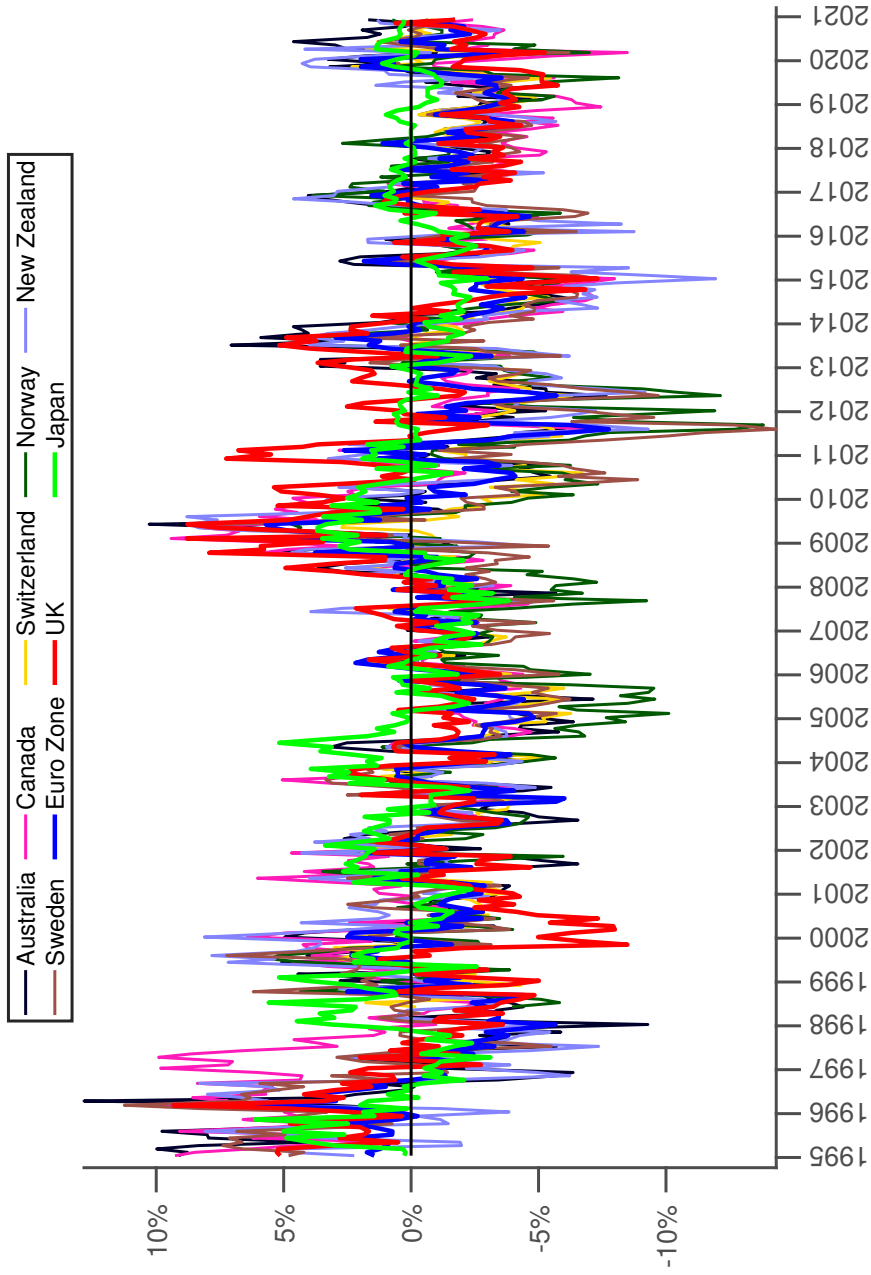


Figure 1. Subjective Bond Risk Premia

Figure displays real-time sovereign bond risk premia

$$BRP_t^{11} = E_t^S [rx_{t+12}^{11}] = E_t^S [p_{t+12}^{10}] - p_t^{(11)} - i_t^1$$

where subjective expectations are elicited from survey forecasts. Lower case p_t^n 's are log zero coupon bond prices for maturity n and i_t^1 is the continuously compounded one-year interest rate. The sample period is 1995.1 to 2020.12.

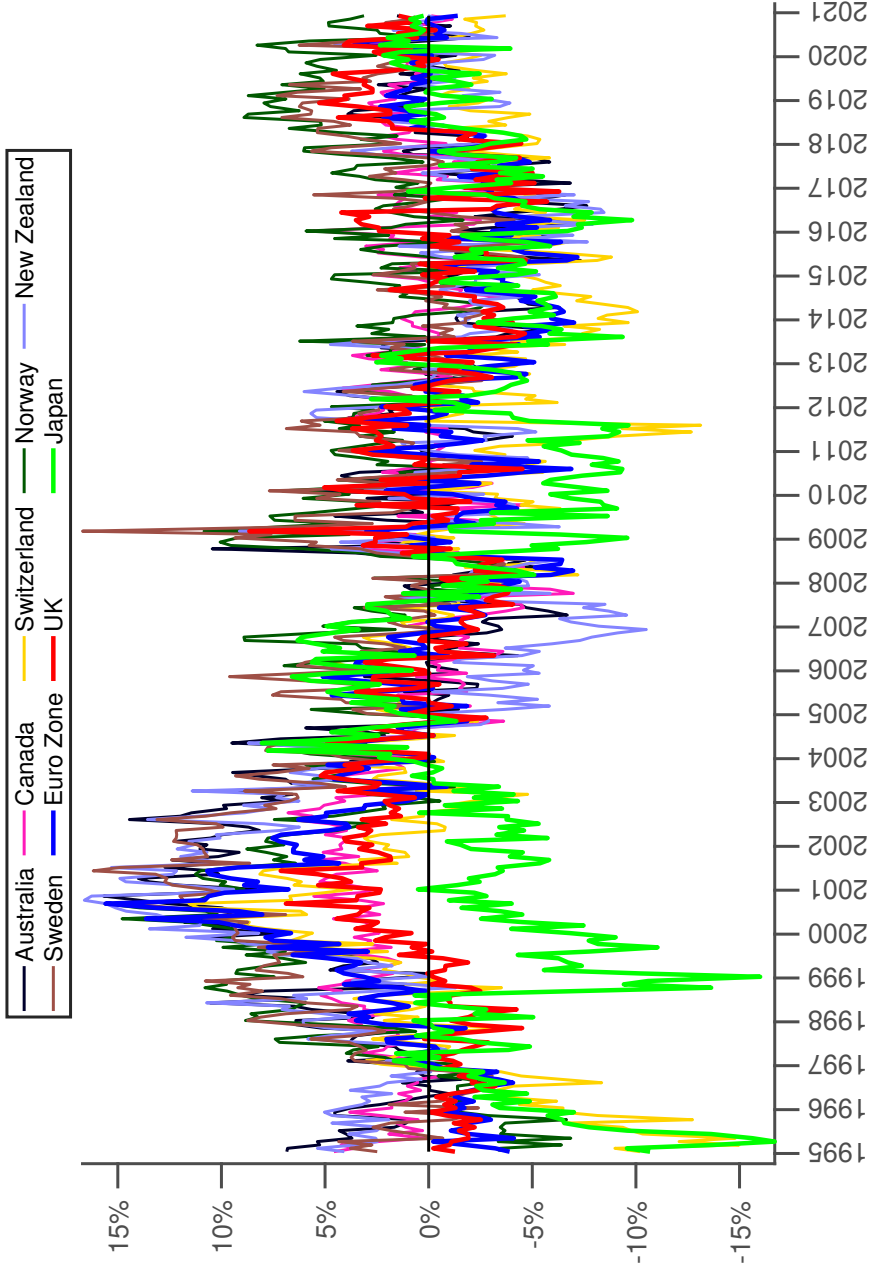


Figure 2. Subjective Exchange Rate Risk Premia

Figure displays real-time exchange rate risk premia

$$XRRP_t = E_t^S [rx_{t+12}^{FX}] = (i_t^{L,*} - i_t^1) - E_t^S [\Delta s_{t+12}]$$

where subjective expectations are elicited from survey forecasts. Lower case s_t 's are log exchange rates and $i_t^{(1)}$'s are the continuously compounded one-year interest rate in the foreign (*) versus domestic (U.S.) markets. The sample period is 1995.1 to 2020.12.

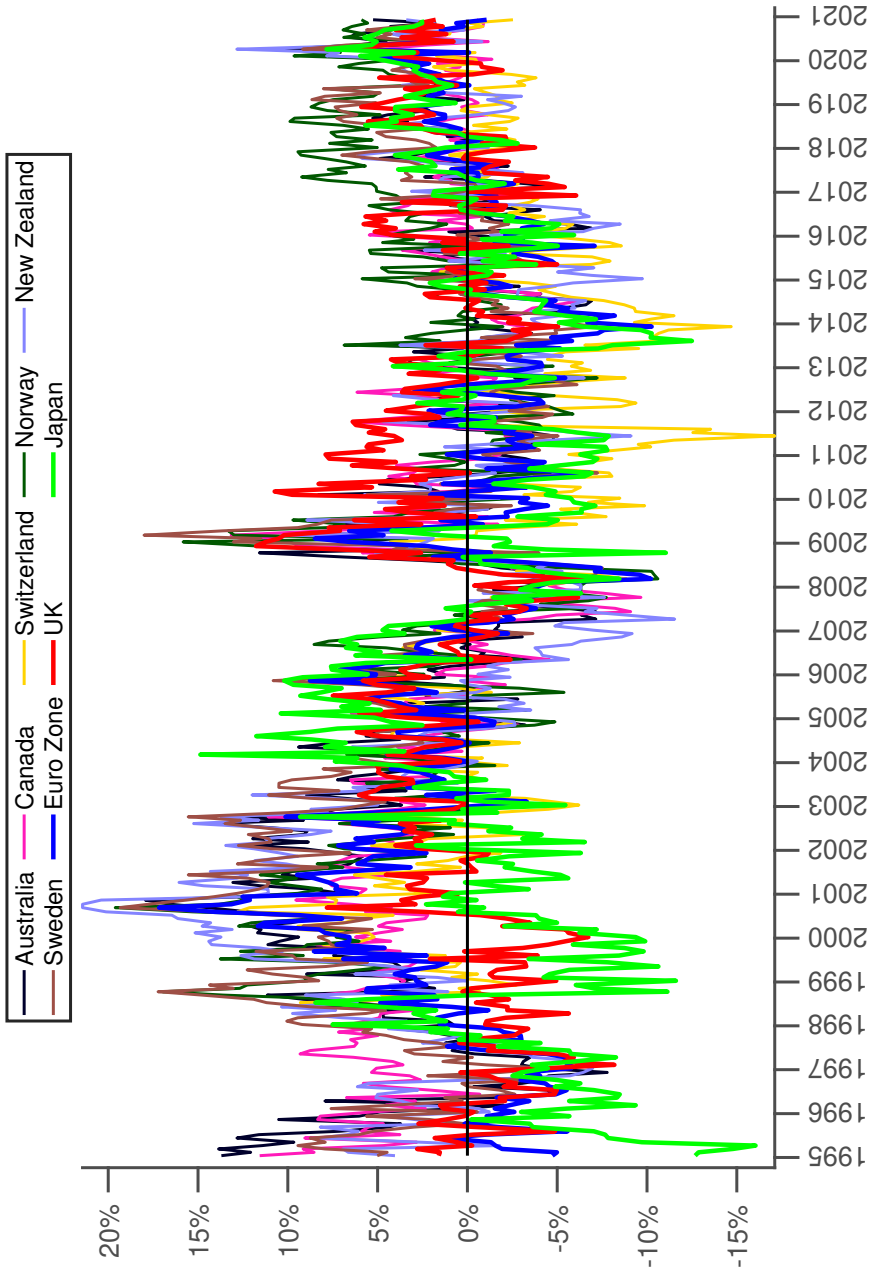


Figure 3. Subjective Foreign Bond Dollar Risk Premia

Figure displays real-time foreign bond risk premium denominated in U.S. dollars

$$\Delta BRP_t^{\$,11} = XRP_t + (BRP_t^{*,11} - BRP_t^{11})$$

where subjective expectations are elicited from survey forecasts. XRP_t is the subjective exchange rate risk premium and BRP_t is the subjective bond risk premium for foreign (*) or domestic (U.S.) bonds. The sample period is 1995.1 to 2020.12.

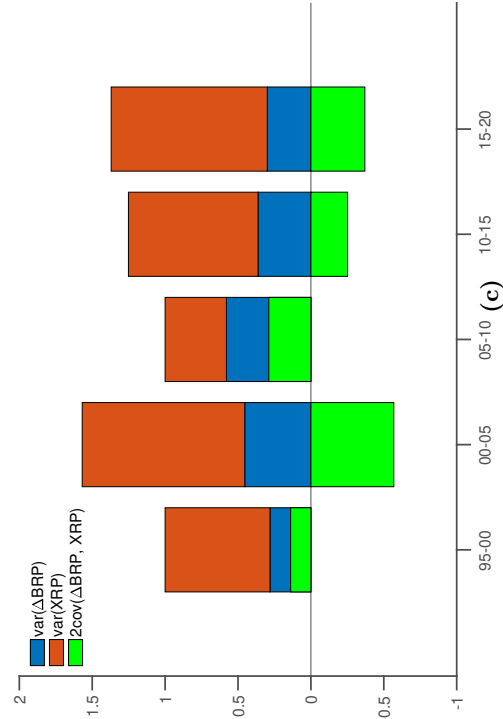
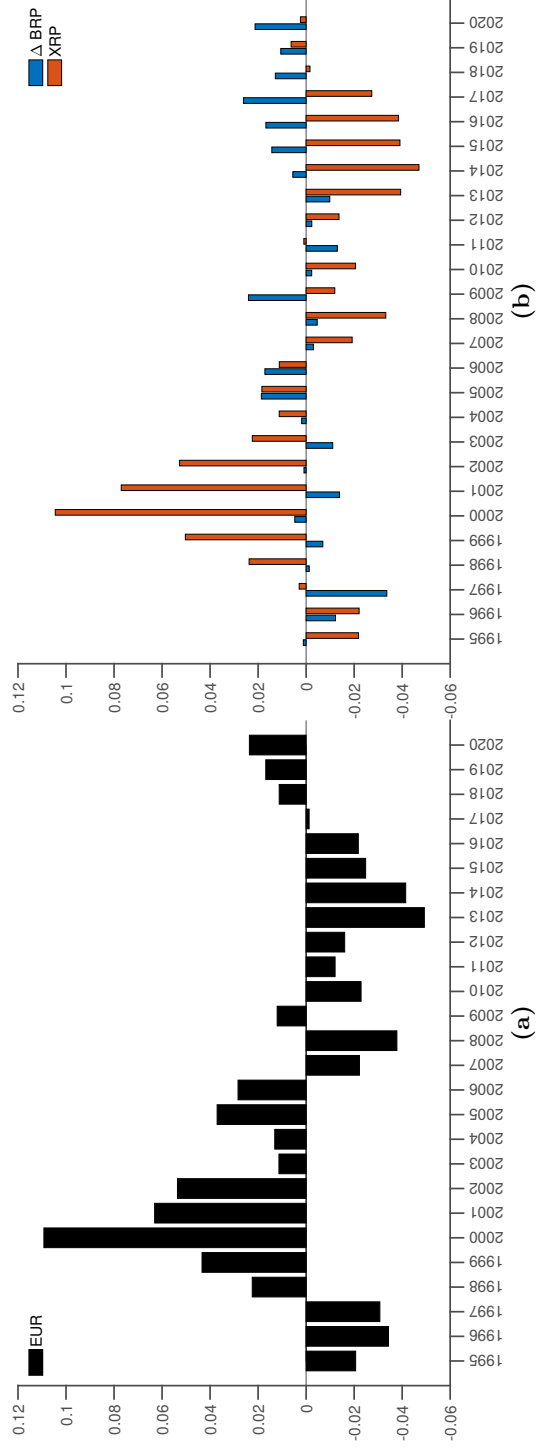


Figure 4. $\Delta BRP_t^{$,11}$ Decomposition: EUR

Figure displays the decomposition of yearly-averages of $\Delta BRP_t^{$,11}$ (panel a) into its ΔBRP and XRP components (panel b), for the EUR. Panel (c) displays a subsample variance decomposition of $\Delta BRP_t^{$,11}$ into its bond versus exchange rate risk premium components. The sample period is 1995.1 to 2020.12.

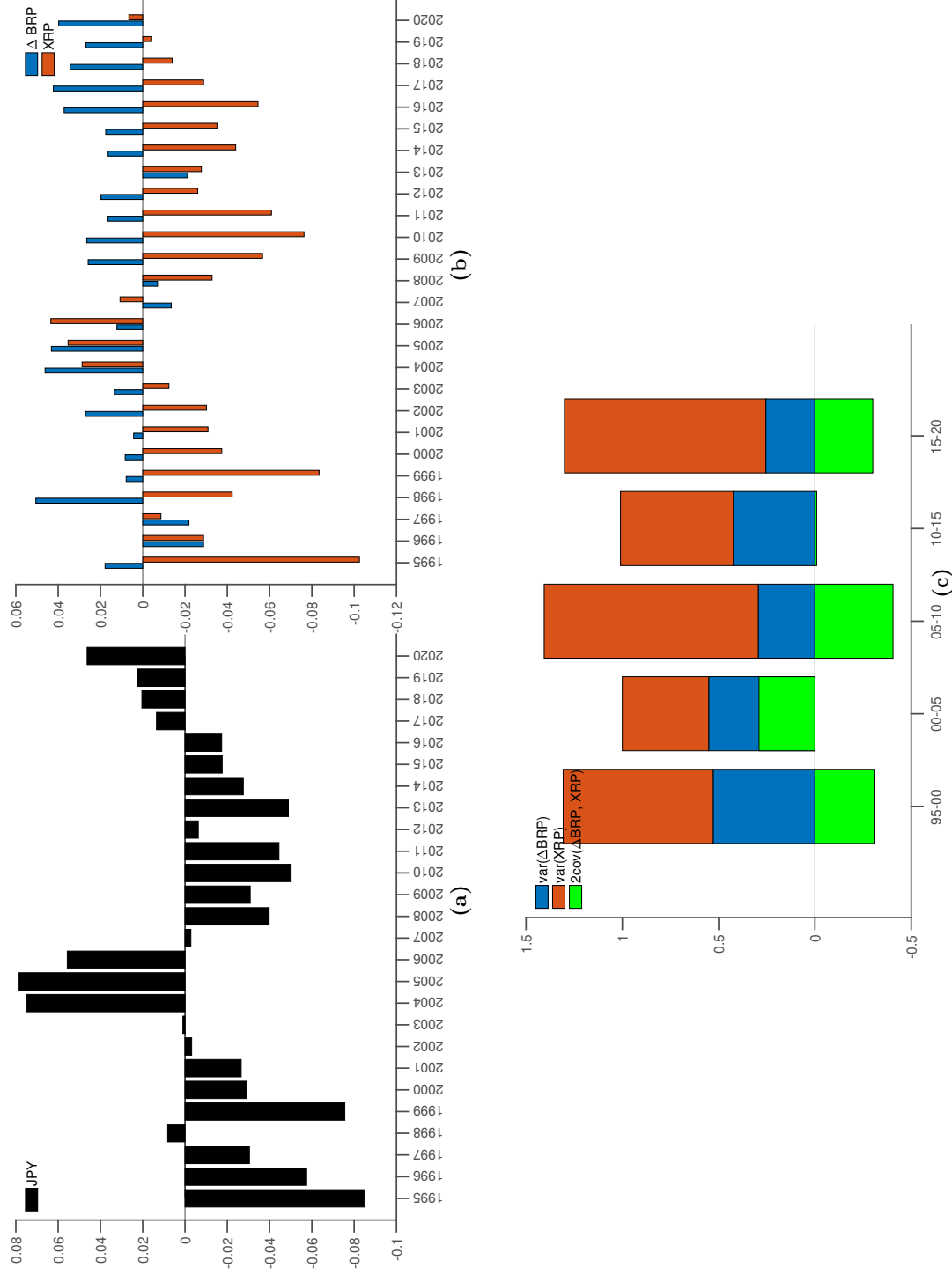


Figure 5. $\Delta BRP^{\$}$ Decomposition: JPY

Figure displays the decomposition of yearly-averages of $\Delta BRP_t^{$,11}$ (panel a) into its ΔBRP^{11} and XRP components (panel b), for the JPY. Panel (c) displays a subsample variance decomposition of $\Delta BRP_t^{$,11}$ into its bond versus exchange rate risk premium components. The sample period is 1995.1 to 2020.12.

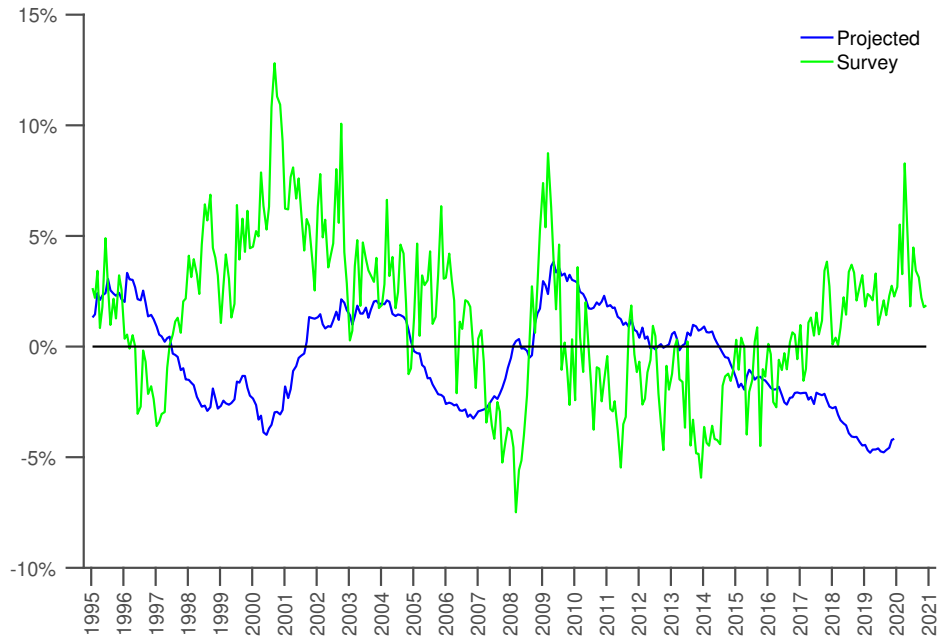


Figure 6. Comparison Survey vs Projected Foreign Bond Dollar Risk Premia

Figure displays subjective risk premia on foreign bonds, denominated in US Dollars, for an equally-weighted average of all countries. The blue line is the average projected foreign bond risk premium while the green line is the average survey-implied foreign bond risk premium. The projections for the foreign bond dollar risk premium are obtained by regressing realised ex-post premia on the slope of the yield curve (for bond risk premia) and the interest rate differential between the foreign country and the United States (for exchange rate risk premia). The sample period is 1995.1 to 2020.12 for survey forecasts and 1995.1 to 2019.12 for projection-based forecasts.

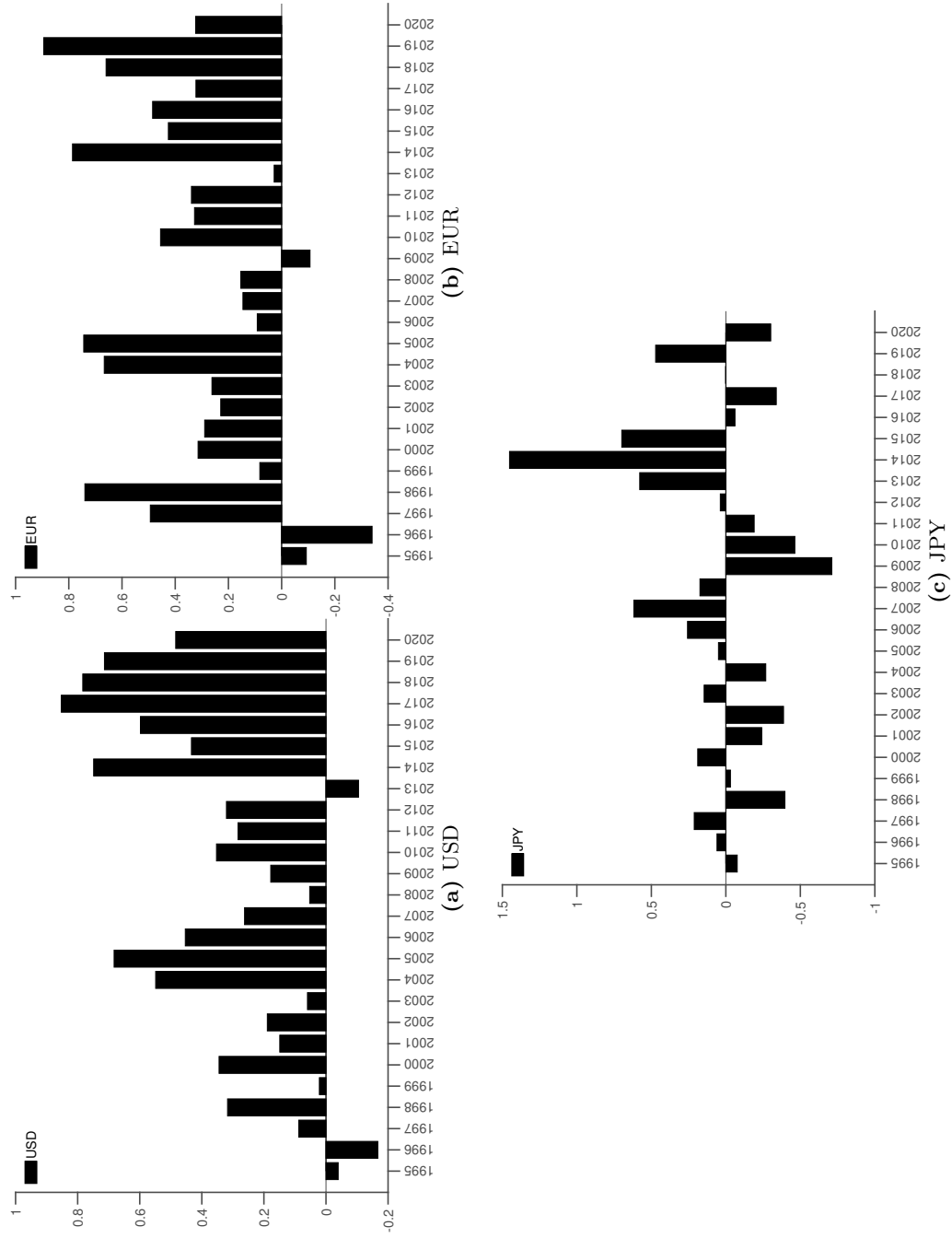


Figure 7. Subjective Permanent Components

This figure displays the dynamics of the estimated permanent σ^P component volatilities of the SDF for the USD (panel a), EUR (panel b), and JPY (panel c). In each panel, for each year in the sample, we compute the median of monthly estimates. The sample period is 1995.1 to 2020.12.

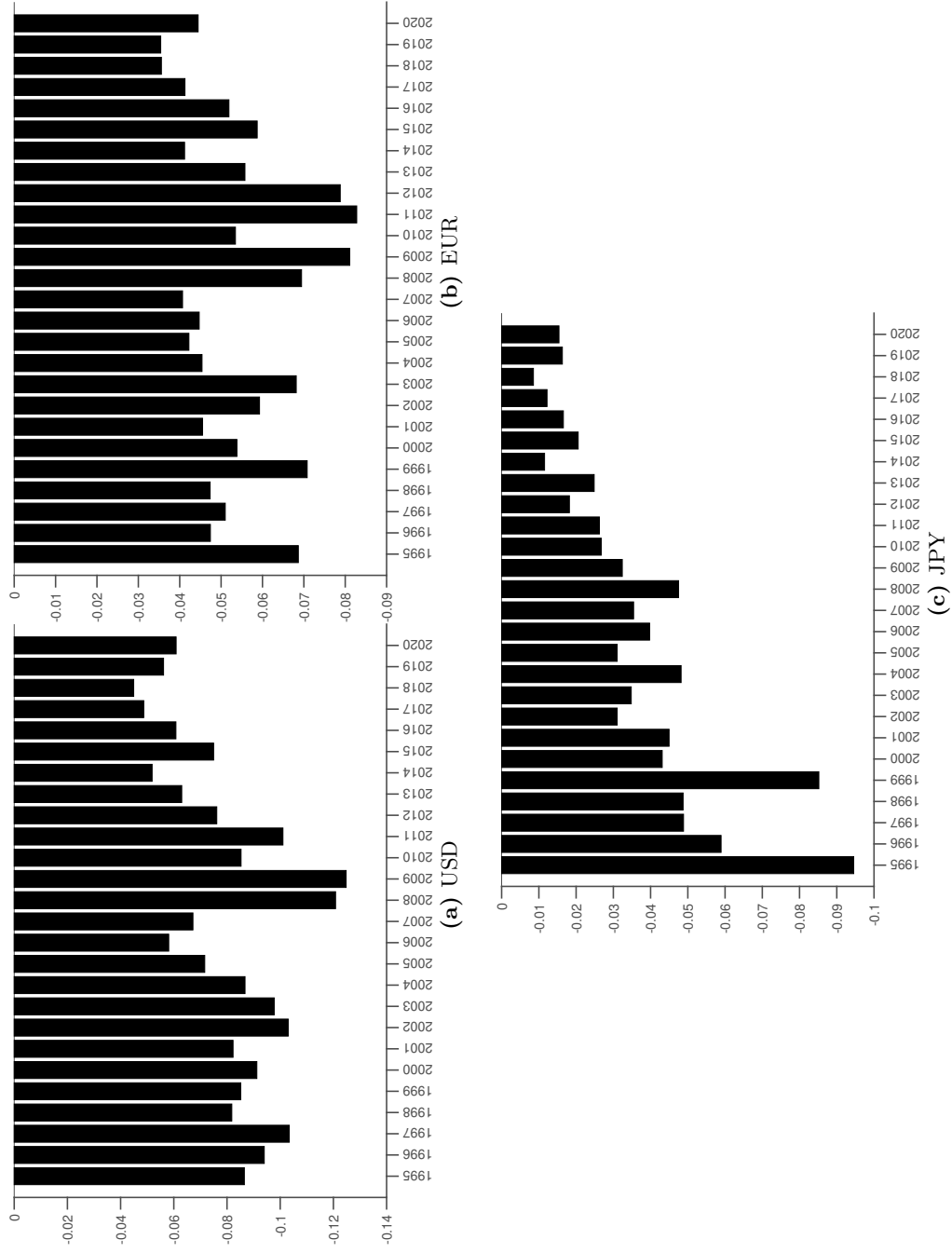


Figure 8. Subjective Transitory Components

This figure displays the dynamics of the estimated transitory σ^T component volatilities of the SDF for the USD (panel a), EUR (panel b), and JPY (panel c). In each panel, for each year in the sample, we compute the median of monthly estimates. The sample period is 1995.1 to 2020.12.

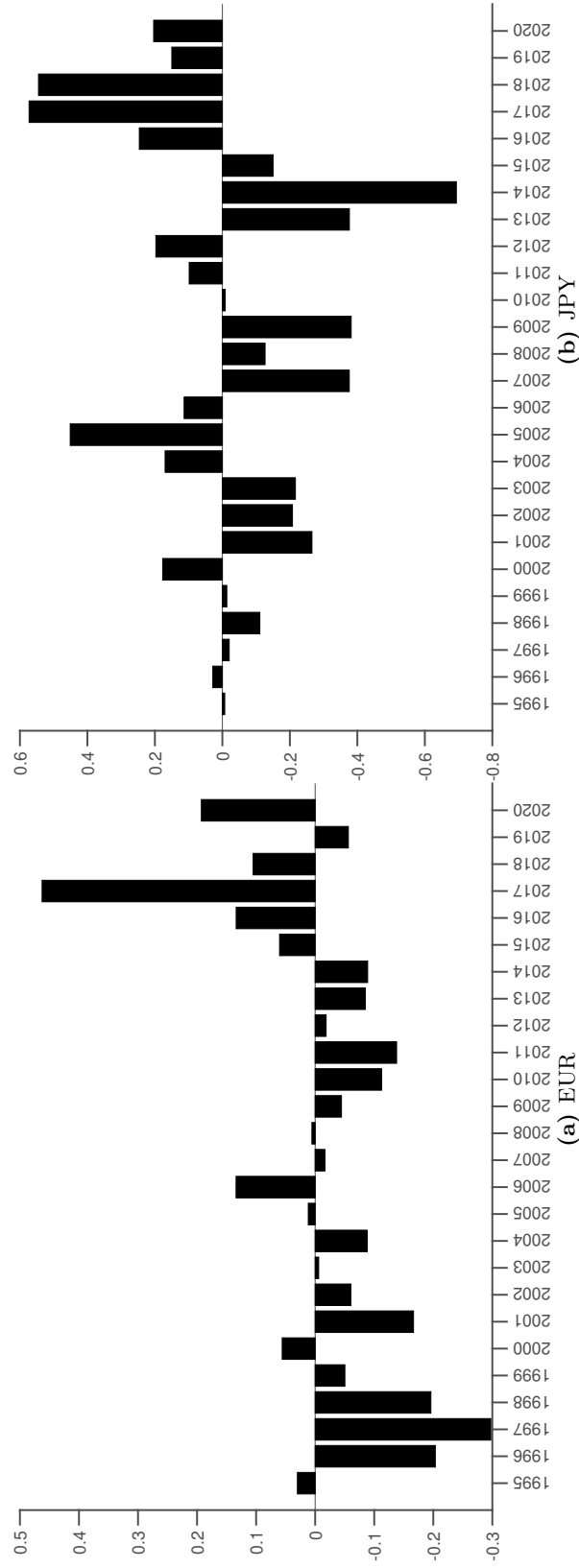


Figure 9. Spread in Absolute Permanent Components

This figure displays the dynamics of the difference in absolute values of the estimated permanent σ^P component volatilities of the SDF for the USD with respect to the EUR (panel a) and JPY (panel b). In each panel, for each year in the sample, we compute the median of monthly estimates. The sample period is 1995.1 to 2020.12.

Subjective Risk Premia on Bonds and Currency

ONLINE APPENDIX

This online appendix is not intended for publication. Section A.1 contains additional details on the construction of our survey dataset and on the high-frequency volatility estimates used in our subjective SDF decomposition. Section A.2 explores the properties of interest rate and exchange rate forecast errors and the tests whether subjective beliefs display evidence consistent with information frictions. Section A.3 asks how many factors are needed to explain the cross-sectional variation in subjective risk premia series you study? Sections A.4 and A.5 contain supplementary tables and figures to the main body of paper.

A.1. Data Appendix

Consensus Economics asks its panellists to provide their estimates of “yields on 10 year government bonds”, without specifying what type of yield. However, it is generally understood that they are providing estimates of the on-the-run bond yield to maturity, which is effectively a par yield forecast. Since we only have two maturities available, we cannot bootstrap directly zero coupon bond yield estimates from the par yields provided. Therefore, in the main body of the text, we treat par yield forecasts as zero coupon forecasts. Moreover, the compounding frequency of the yields provided is also not explicitly stated, so for simplicity we assume they are continuously compounded, i.e. log yields. This appendix shows the robustness of our results with respect to these assumptions, by comparing empirically par yields and zero-coupon bond yields for 10-year government bonds, as well as yields and bond returns based on different compounding frequency assumptions.

Panel A of Table A.1 displays the mean and standard deviation for (1) US 10-year par yields obtained from the Fed (H15), (2) US 10-year zero yields obtained from Bloomberg (BB), and (3) their differences. Figure A.5 shows the time series of the same par (H15) and zero (BB) yields, as well as their difference. We can see that the two series are extremely close and their difference is close to zero and insignificant. A similar picture arises when looking at the bond returns implied by par and zero yields. Panel B of Table A.1 contains similar summary statistics for US 10-year zero log-yields obtained from Bloomberg assuming different compounding frequencies of the raw data. Again, both mean and standard deviation of the yields are extremely similar (see also Figure).

Summarising, we show that par yields and zero-coupon bond yields for 10-year government bonds are empirically very close and that the compounding frequency has little impact on the bond yields, so our results would be practically unchanged if we assumed that yields are annually or semi-annually compounded instead of continuously compounded, and they are robust to our assumption that survey forecasters provide zero yields.

A.2. Are Survey Forecasts Rational?

From survey data we directly observe expectations about exchange rates and bond yields. Our main goal is to exploit these forecasts to obtain direct, forward-looking measures of risk premia in foreign exchange and fixed income markets, as well as the risk premium on foreign long term

bonds, which is a combination of the two. In addition to measurement of risk premia, we also evaluate the extent to which survey forecasts can be considered rational.

In doing so, we evaluate the forecast errors from surveys relative to a random walk (RW) prediction benchmark. Indeed, conventional wisdom suggests RW forecasts are difficult to beat in real-time. More importantly, we treat the random walk estimates as a control group, or placebo, which by construction is silent about rationality. We take consensus (arithmetic average) and RW projections about a target variable y_{t+12} and compute forecast errors as follows:

$$\text{Survey : } y_{t+12} - y_t = E_t^C [y_{t+12} - y_t] + FE_{t,t+12}^S \quad (\text{A.1})$$

$$\text{Random Walk : } y_{t+12} - y_t = FE_{t,t+12}^{RW}. \quad (\text{A.2})$$

Note that by construction the errors of these projections are in real-time (out-of-sample).

Table [A.2](#) provides insights into the properties of forecast errors, by showing summary statistics of 10-year yield and exchange rate expectation errors for all countries in the sample, for both surveys and the random walk. In particular the table displays the two drivers of the RMSE, i.e. the mean and standard deviation of the errors, as well as the minimum and maximum. For interest rates, the mean errors of the two sets of expectations are similar and always negative, meaning that all forecasts over-predicted the level of future interest rates, consistent with a downward trend in rates during our sample that was unpredictable ex-ante. However, the mean of the surveys are more negative, implying that professional forecasters believed that interest rates would mean revert when in fact the trend continued all the way to the zero lower bound.⁸ Such a bias would also be consistent with forecasters holding asymmetric loss functions, which has been postulated as an explanation for biases in equity analyst forecasts (Clatworthy, Peel, and Pope, 2012). Random walk forecast errors tend to be slightly less volatile than survey forecast errors but the values are extremely similar. For exchange rates, the mean errors of both surveys and random walk are close to zero, meaning that there is no systematic bias. Moreover, minimum and maximum errors, as well as error volatility, are still very similar across the two sets of expectations.

However, while errors from RW and surveys are economically and statistically similar, it is important to highlight that survey forecasters are not just using a random walk model to form their expectations. We delay a further discussion of the information content in subjective expectations versus statistical forecasts to Section [IV](#) where we study accuracy and information content.

[Insert table [A.2](#) here]

An important stream of the literature investigate economies with rational but sticky-information (Mankiw and Reis, 2002) and with rational but noisy-information (Woodford, 2002, Sims, 2003, and Mackowiak and Wiederholt, 2009). In the first case, agents update their information sets infrequently as a result of a fixed costs of information acquisition and the degree of information rigidity is the probability of not acquiring new information each period. When agents are subject to noisy information, they rationally update their beliefs but, since they can never fully observe the true state, they use an optimal signal-extraction filter. If one were to aggregate these expectations, Coibion and Gorodnichenko (2015) (CG) show that average forecast errors are predictable by forecast revisions. Considering inflation expectations from the Survey of Professional Forecasters CG find that consensus forecast revisions positively predict forecast errors which in their framework corresponds to under-reaction due to information frictions.

⁸Buraschi, Piatti, and Whelan (2021) provide a detailed discussion of the bias in survey interest rate forecasts at both individual and consensus levels.

We examine the rationality of consensus professional forecasts for the financial variables under consideration in this paper using the CG framework, and comparing the results obtained from survey forecasts with what we would obtain with a simple RW benchmark. Annual forecast errors are computed as above. To proxy for the survey and random walk forecast revisions we consider the one month change in the respective projections⁹

$$\text{Survey : } FR_{t-1,t}^S = E_t^C[y_{t+12}] - E_{t-1}^C[y_{t+12}] \quad (\text{A.3})$$

$$\text{Random Walk : } FR_{t-1,t}^{RW} = y_t - y_{t-1} \quad (\text{A.4})$$

We then estimate a regression of forecast errors on forecast revisions

$$FE_{t,t+12}^i = a^i + b^i FR_{t-1,t}^i + \eta_{t+12}^i, \quad (\text{A.5})$$

The rational expectations hypothesis predicts that forecast errors should be unpredictable conditional on the publicly available information filtration which includes forecast revisions; thus predicting $b^i = 0$. Instead if forecasters under-react to information, because for example they are inattentive or hold adaptive expectations, we expect $b^i > 0$. Similarly, when forecasters over-react to information, because for example they are overly optimistic or pessimistic, we should expect $b^i < 0$.

[Insert table [A.3](#) here]

Table [A.3](#) presents parameter estimates and 95% block bootstrapped confidence intervals. First, consider panel (a) which displays estimates for 10-year interest rate survey forecasts. None of the point estimates for b are statistically different than zero and are generally small in economic terms. The estimated intercepts are, however, uniformly negative and statistically significant consistent with the bias in interest rate forecast errors in table [A.2](#). Second, consider panel (b) which displays estimates for exchange rate survey forecasts. The results here are mixed: while all point estimates are positive only three out of nine of the point estimates (CAD, GBP and NOK) for b are statistically significant consistent with the CG findings of under-reaction. Putting the economic size of the point estimates in context consider panel (c) which displays estimates for exchange rate random walk forecast that, by construction, are silent about rational expectations. Considering the random walk estimates as a control group we find that all point estimates in panel b, with the exception of JPY, lie outside the respective confidence intervals in panel (c).

Summarising, survey expectations for interest rates display little or no evidence of over-reaction or under-reaction but do contain a persistent bias consistent with over-optimism or belief formation conditioned on asymmetric loss functions. Survey expectations for exchange rates, on the other hand, contain no biases but do display some evidence of under-reaction consistent with theories of inattention or adaptive expectations.

A.3. Subjective Risk Premium Factors

How many factors are needed to explain the cross-sectional variation in subjective risk premia series you study? To answer this question we form factors PC_t (principle components) from an

⁹We note that we cannot compute a true forecast revision which should be target on a fixed horizon that gets smaller over time. However, using the BlueChip Financial Forecast dataset for which true forecast revisions can be computed we find that the approximation is a mild. Results available on request.

eigenvalue decomposition of the covariance matrix of subjective risk premia $var(RP_t) = QDQ^\top$. The variance due to the n 'th factor is computed from $D(n, n) / \sum_n D(n, n)$ which is displayed in table A.9. Principle components (PCs) are computed from the rotation $PC_t = RP_t Q$ which are displayed in Figure A.9.

Table A.9 shows that around 60% of subjective risk prema variance is explained by a level factor which from Panel (a) of figure A.10, A.11 is as usual a level factor. The exception is the JPY which for the XRP has a zero loading on $PC1$. Currencies are sorted via their exposure to $PC2$ to interpret this PC as a slope factor. For the BRP it loads negatively on the Scandinavian countries and positive on Canadian and UK bonds. The factor itself was large and positive between 2008-2013 which would have drive a subjective spread between GBP and the NOK BRP 's. We also note that it is not clear economically what this factor represents. $PC2$ for the XPR , on the other hand, has a straightforward economic interpretation: funding versus investment currencies. The factor loads negatively on the JPY and CHF and positively on AUD and NZD. The factor itself was became increasingly negative between 2003 and 2007 implying that agents believed the carry trade was falling apart but increased from 2007-2012 implying that subjectively they were forecasting increasing carry trade returns. Finally, since XRP is the dominant source of variation in ΔBRP^S the loadings and factor dynamics largely carry over. This is what we see in Figure A.12: $PC2$ also has a carry trade factor interpretation driving a spread between funding currencies and investment currencies.

[Insert Table A.9 and Figure A.10, Figure A.11 and Figure A.12]

A.4. Tables

Panel A: Summary Statistics		Yields		Returns	
		Mean	Std Dev	Mean	Std Dev
Par		3.87	1.64	4.53	1.49
Zero		3.98	1.67	4.79	1.55
Difference		−0.13	0.09	−0.28	0.21

Panel B: Frequency Comparison		Yields	
		Mean	Std Dev
Continuous		3.98	1.67
Annually		4.07	1.74
Semi-Annual		4.02	1.70

Table A.1. Summary Statistics: Par Yields and Zero Yields

This table shows the mean and standard deviation for (1) US 10-year par yields obtained from the Fed, (2) US 10-year zero yields obtained from Bloomberg, and (3) their differences (Panel A). Panel B contains similar summary statistics for US 10-year zero log-yields obtained from Bloomberg assuming different compounding frequencies of the raw data. Sample period is monthly observations from between 01/1995 and 12/2020.

Panel A: IR	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	USD
					<u>Surveys</u>					
Mean	-0.57	-0.55	-0.52	-0.64	-0.53	-0.33	-0.55	-0.45	-0.78	-0.60
Std	0.89	0.65	0.58	0.67	0.71	0.47	0.78	0.87	0.81	0.77
Min	-2.74	-2.09	-1.96	-2.38	-2.27	-1.73	-2.38	-2.62	-2.59	-2.48
Max	2.04	1.49	1.21	1.42	1.10	1.15	1.63	1.80	1.75	1.76
AR(1)	-0.18	-0.03	-0.06	-0.16	-0.09	-0.04	0.08	-0.10	-0.11	-0.23
					<u>Random Walk</u>					
Mean	-0.35	-0.31	-0.21	-0.30	-0.33	-0.15	-0.27	-0.28	-0.42	-0.24
Std	0.86	0.63	0.55	0.62	0.69	0.41	0.67	0.80	0.82	0.80
Min	-2.48	-2.07	-1.57	-1.77	-2.14	-1.46	-2.38	-2.06	-2.83	-2.06
Max	1.88	1.42	1.44	1.72	1.38	1.41	1.63	1.91	1.78	1.86
AR(1)	-0.24	-0.04	-0.21	-0.28	-0.15	-0.17	-0.04	-0.34	-0.04	-0.29
Panel B: XR	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	
					<u>Surveys</u>					
Mean	0.01	0.01	0.00	0.02	0.00	0.32	0.34	0.00	0.40	
Std	0.18	0.09	0.12	0.09	0.05	12.33	0.79	0.23	0.90	
Min	-0.42	-0.23	-0.34	-0.20	-0.11	-29.98	-1.71	-0.47	-1.40	
Max	0.54	0.25	0.37	0.29	0.20	35.12	2.43	0.75	3.08	
AR(1)	0.14	0.16	0.29	0.17	-0.10	0.14	0.19	0.14	0.08	
					<u>Random Walk</u>					
Mean	0.00	0.00	-0.01	0.00	0.01	0.54	0.12	0.00	0.08	
Std	0.17	0.10	0.11	0.08	0.05	11.39	0.77	0.22	0.90	
Min	-0.49	-0.27	-0.35	-0.24	-0.10	-31.11	-2.01	-0.60	-2.31	
Max	0.49	0.30	0.32	0.22	0.23	30.79	2.12	0.77	2.99	
AR(1)	-0.02	0.00	0.05	0.02	-0.10	0.06	0.01	0.00	-0.05	

Table A.2. Summary Statistics: Expectation Errors

This table shows the mean, standard deviation, minimum and maximum of the forecast errors of survey forecasts and of a benchmark random walk model. It also shows, at an annualised horizon, the 12 month autocorrelation. For each country in our sample, statistics are reported for long-term (10Y) interest rates (Panel A), and for spot exchange rates w.r.t the US (Panel B). Realised forecast errors are computed for the sample period 2000.1 to 2020.12.

	AUD	CAD	CHF	EUR	JPY	GBP	NZD	NOK	SEK	USD
<i>b</i>	0.38 (0.78)	0.01 (0.03)	0.10 (0.23)	0.04 (0.08)	0.35 (0.89)	0.06 (0.20)	-0.01 (-0.04)	0.32 (0.73)	0.25 (0.62)	0.08 (0.23)
<i>a</i>	-0.01*** (-3.98)	-0.01*** (-5.18)	-0.01*** (-5.07)	-0.01*** (-6.00)	-0.01*** (-4.49)	-0.00*** (-4.56)	-0.01*** (-3.93)	-0.00** (-3.11)	-0.01*** (-5.88)	-0.01*** (-4.95)
$R^2(\%)$	0.45	0.00	0.04	0.00	0.48	0.02	0.00	0.33	0.27	0.03

(a) Interest Rates

	AUD	CAD	CHF	EUR	JPY	GBP	NZD	NOK	SEK
<i>b</i>	0.91 (1.39)	1.09* (1.98)	0.46 (1.22)	0.54 (1.08)	0.06 (0.17)	0.87 (1.64)	0.76 (1.49)	1.07 (1.69)	0.53 (1.00)
<i>a</i>	0.01 (0.44)	0.01 (0.85)	-0.00 (-0.05)	0.02 (1.04)	0.00 (0.51)	0.31 (0.15)	0.34** (2.62)	-0.00 (-0.11)	0.40** (2.74)
$R^2(\%)$	1.60	2.92	0.66	0.77	0.02	2.01	1.42	2.29	0.68

(b) Exchange Rates

Table A.3. Coibion and Gorodnichenko (2015) Regressions

This table shows individual country regressions of either (a) 10-year yield or (b) foreign exchange forecast errors, at the annual horizon, on forecast revisions defined as the monthly change in the respective forecasts

$$FE_{t,t+12}^i = a^i + b^i FR_{t-1,t}^i + \eta_{t+12}^i,$$

Newey-West standard errors computed with 12-lags are reported in parenthesis. The superscripts *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively. The sample period 1995.1 to 2020.12

	AUD	CAD	CHF	EUR	JPY	GBP	NZD	NOK	SEK	USD
b	-0.12** [0.04]	0.03 [0.08]	-0.15*** [0.04]	-0.12** [0.04]	0.02 [0.06]	-0.03 [0.04]	-0.23*** [0.05]	-0.22*** [0.04]	0.03 [0.06]	-0.12** [0.04]
$R^2(\%)$	11.77	0.23	18.62	13.10	0.33	0.68	25.32	26.33	0.63	11.19

(a) Survey IR

	AUD	CAD	CHF	EUR	JPY	GBP	NZD	NOK	SEK
b	-0.07 [0.06]	-0.11** [0.04]	-0.19*** [0.06]	-0.09 [0.06]	-0.04 [0.04]	-0.09* [0.05]	-0.11* [0.04]	-0.10 [0.06]	-0.09 [0.05]
$R^2(\%)$	3.24	12.87	18.83	5.65	1.72	7.26	10.88	5.03	5.67

(b) Survey XR

Table A.4. Belief Extrapolation

This table shows individual country regressions of survey implied subjective risk premia on contemporaneously realised 1-year excess hold period returns

$$BRP_t = a^i + b^i rx_{t-12,t}^{(11)} + \eta_t^i$$

$$XRP_t = a^i + b^i rx_{t-12,t}^{FX} + \eta_t^i$$

Newey-West standard errors computed with 12-lags are reported in parenthesis. The superscripts *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively. The sample period 1995.1 to 2020.12

	AUD	CAD	CHF	EUR	JPY	GBP	NZD	NOK	SEK	USD
<i>b</i>	-0.37 [-0.73,-0.01]	-0.25 [-0.43,-0.06]	-0.16 [-0.42,0.09]	-0.26 [-0.46,-0.05]	-0.10 [-0.29,0.10]	-0.27 [-0.43,-0.11]	-0.24 [-0.42,-0.06]	-0.14 [-0.34,0.06]	-0.39 [-0.70,-0.09]	-0.03 [-0.24,0.18]
<i>a</i>	-0.00 [-0.00,0.00]	-0.00 [-0.00,0.00]	-0.00 [-0.00,0.00]	0.00 [-0.00,0.00]	-0.00 [-0.01,0.00]	0.00 [-0.00,0.00]	-0.00 [-0.00,0.00]	-0.00 [-0.00,0.00]	0.00 [-0.00,0.00]	-0.00 [-0.01,0.00]
$R^2(\%)$	6.95	12.28	3.23	10.20	2.04	19.12	11.98	3.41	11.69	0.17

(a) Random Walk

	AUD	CAD	CHF	EUR	JPY	GBP	NZD	NOK	SEK	USD
<i>b</i>	-0.28 [-0.67,0.12]	-0.18 [-0.39,0.04]	-0.16 [-0.50,0.17]	-0.26 [-0.50,-0.02]	-0.09 [-0.30,0.12]	-0.30 [-0.49,-0.11]	-0.31 [-0.56,-0.07]	-0.20 [-0.43,0.04]	-0.37 [-0.68,-0.07]	-0.13 [-0.34,0.08]
<i>a</i>	-0.00 [-0.01,0.00]	-0.00 [-0.01,-0.00]	-0.00 [-0.01,-0.00]	-0.00 [-0.01,0.00]	-0.00 [-0.01,-0.00]	-0.00 [-0.00,0.00]	-0.00 [-0.01,-0.00]	-0.00 [-0.01,-0.00]	-0.00 [-0.01,0.00]	-0.00 [-0.01,-0.00]
$R^2(\%)$	3.71	5.76	2.30	9.23	1.79	17.92	14.30	5.74	10.60	3.12

(b) Survey

Table A.5. Forecast Error Predictability: Bonds

Newey-West standard errors computed with 12-lags are reported in parenthesis. The superscripts *, **, and * * * denote statistical significance at 10%, 5% and 1% levels, respectively. The sample period 1995.1 to 2020.12

	AUD	CAD	CHF	EUR	JPY	GBP	NZD	NOK	SEK
b	-2.58 [-5.57,0.41]	-1.10 [-4.36,2.16]	-2.50 [-4.54,-0.46]	-1.70 [-3.46,0.06]	-0.25 [-1.63,1.14]	-63.95 [-236.68,108.79]	-9.11 [-21.63,3.41]	-3.22 [-7.50,1.07]	-11.65 [-26.86,3.56]
a	0.05 [-0.02,0.12]	0.00 [-0.03,0.03]	-0.05 [-0.10,-0.00]	-0.01 [-0.04,0.02]	0.01 [-0.01,0.02]	-1.05 [-6.62,4.52]	0.18 [-0.06,0.43]	0.07 [-0.04,0.19]	0.06 [-0.21,0.33]
$R^2(\%)$	6.22	1.01	11.64	7.74	0.28	1.34	4.49	4.95	4.90

(a) Random Walk

	AUD	CAD	CHF	EUR	JPY	GBP	NZD	NOK	SEK
b	-4.33 [-7.34,-1.31]	-1.87 [-5.13,1.40]	-4.63 [-6.60,-2.67]	-2.64 [-4.47,-0.81]	-0.78 [-2.16,0.60]	-201.05 [-385.10,-17.01]	-14.86 [-27.74,-1.98]	-5.15 [-9.63,-0.68]	-20.14 [-34.76,-5.52]
a	0.09 [0.01,0.16]	0.02 [-0.01,0.05]	-0.08 [-0.12,-0.03]	-0.00 [-0.03,0.03]	0.01 [-0.01,0.03]	-4.62 [-10.56,1.31]	0.44 [0.19,0.69]	0.11 [-0.01,0.23]	0.36 [0.10,0.63]
$R^2(\%)$	15.90	3.02	33.55	16.77	2.78	11.27	11.30	11.42	14.67

(b) Survey

Table A.6. Forecast Error Predictability: FX

Newey-West standard errors computed with 12-lags are reported in parenthesis. The superscripts *, **, and * * * denote statistical significance at 10%, 5% and 1% levels, respectively. The sample period 1995.1 to 2020.12

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	USD
<u>Panel A: BRP</u>										
AUD	1.00	0.57	0.67	0.78	0.46	0.31	0.66	0.76	0.61	0.66
CAD	0.57	1.00	0.49	0.70	0.52	0.52	0.48	0.69	0.56	0.70
CHF	0.67	0.49	1.00	0.72	0.22	0.34	0.68	0.61	0.67	0.55
EUR	0.78	0.70	0.72	1.00	0.56	0.38	0.68	0.72	0.69	0.70
GBP	0.46	0.52	0.22	0.56	1.00	0.28	0.23	0.35	0.21	0.56
JPY	0.31	0.52	0.34	0.38	0.28	1.00	0.30	0.35	0.40	0.30
NOK	0.66	0.48	0.68	0.68	0.23	0.30	1.00	0.62	0.72	0.49
NZD	0.76	0.69	0.61	0.72	0.35	0.35	0.62	1.00	0.67	0.66
SEK	0.61	0.56	0.67	0.69	0.21	0.40	0.72	0.67	1.00	0.52
USD	0.66	0.70	0.55	0.70	0.56	0.30	0.49	0.66	0.52	1.00
<u>Panel B: XRP</u>										
AUD	1.00	0.72	0.55	0.78	0.51	−0.06	0.53	0.91	0.78	
CAD	0.72	1.00	0.30	0.54	0.39	−0.13	0.46	0.70	0.59	
CHF	0.55	0.30	1.00	0.83	0.47	0.42	0.72	0.48	0.69	
EUR	0.78	0.54	0.83	1.00	0.66	0.14	0.77	0.72	0.88	
GBP	0.51	0.39	0.47	0.66	1.00	0.10	0.54	0.45	0.62	
JPY	−0.06	−0.13	0.42	0.14	0.10	1.00	0.09	−0.15	0.03	
NOK	0.53	0.46	0.72	0.77	0.54	0.09	1.00	0.47	0.77	
NZD	0.91	0.70	0.48	0.72	0.45	−0.15	0.47	1.00	0.69	
SEK	0.78	0.59	0.69	0.88	0.62	0.03	0.77	0.69	1.00	
<u>Panel A: ΔBRP^S</u>										
AUD	1.00	0.71	0.63	0.75	0.18	0.10	0.60	0.89	0.77	
CAD	0.71	1.00	0.49	0.62	0.33	0.03	0.57	0.65	0.66	
CHF	0.63	0.49	1.00	0.86	0.09	0.44	0.59	0.58	0.72	
EUR	0.75	0.62	0.86	1.00	0.26	0.30	0.69	0.72	0.85	
GBP	0.18	0.33	0.09	0.26	1.00	0.27	0.10	0.09	0.22	
JPY	0.10	0.03	0.44	0.30	0.27	1.00	0.08	−0.07	0.22	
NOK	0.60	0.57	0.59	0.69	0.10	0.08	1.00	0.58	0.74	
NZD	0.89	0.65	0.58	0.72	0.09	−0.07	0.58	1.00	0.73	
SEK	0.77	0.66	0.72	0.85	0.22	0.22	0.74	0.73	1.00	

Table A.7. Cross Country Correlations of Survey Premia

This table shows the correlation coefficients between the measures of subjective risk premia, as defined in section II in the main body of the paper. Based on monthly observations from between 1995.1 to 2020.12.

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	USD
<hr/>										
	Panel A: BRP_{proj}									
AUD	1.00	0.60	0.53	0.69	0.48	0.24	0.43	0.46	0.59	0.36
CAD	0.60	1.00	0.66	0.77	0.62	0.34	0.53	0.43	0.68	0.75
CHF	0.53	0.66	1.00	0.80	0.24	0.55	0.60	0.10	0.63	0.32
EUR	0.69	0.77	0.80	1.00	0.60	0.55	0.72	0.34	0.75	0.44
GBP	0.48	0.62	0.24	0.60	1.00	-0.09	0.52	0.60	0.46	0.72
JPY	0.24	0.34	0.55	0.55	-0.09	1.00	0.25	-0.29	0.29	-0.14
NOK	0.43	0.53	0.60	0.72	0.52	0.25	1.00	0.11	0.72	0.31
NZD	0.46	0.43	0.10	0.34	0.60	-0.29	0.11	1.00	0.39	0.61
SEK	0.59	0.68	0.63	0.75	0.46	0.29	0.72	0.39	1.00	0.36
USD	0.36	0.75	0.32	0.44	0.72	-0.14	0.31	0.61	0.36	1.00
	Panel B: RRP_{proj}									
AUD	1.00	0.72	0.82	0.84	0.55	0.63	0.61	0.82	0.76	
CAD	0.72	1.00	0.69	0.73	0.44	0.57	0.71	0.55	0.79	
CHF	0.82	0.69	1.00	0.89	0.36	0.83	0.76	0.62	0.60	
EUR	0.84	0.73	0.89	1.00	0.69	0.60	0.86	0.78	0.76	
GBP	0.55	0.44	0.36	0.69	1.00	0.02	0.54	0.78	0.69	
JPY	0.63	0.57	0.83	0.60	0.02	1.00	0.45	0.36	0.32	
NOK	0.61	0.71	0.76	0.86	0.54	0.45	1.00	0.50	0.69	
NZD	0.82	0.55	0.62	0.78	0.78	0.36	0.50	1.00	0.76	
SEK	0.76	0.79	0.60	0.76	0.69	0.32	0.69	0.76	1.00	
	Panel A: ΔBRP_{proj}^S									
AUD	1.00	0.79	0.74	0.88	0.81	0.57	0.85	0.80	0.78	
CAD	0.79	1.00	0.54	0.86	0.65	0.50	0.87	0.61	0.88	
CHF	0.74	0.54	1.00	0.78	0.51	0.36	0.66	0.90	0.39	
EUR	0.88	0.86	0.78	1.00	0.69	0.59	0.87	0.84	0.80	
GBP	0.81	0.65	0.51	0.69	1.00	0.73	0.73	0.57	0.70	
JPY	0.57	0.50	0.36	0.59	0.73	1.00	0.54	0.42	0.55	
NOK	0.85	0.87	0.66	0.87	0.73	0.54	1.00	0.68	0.88	
NZD	0.80	0.61	0.90	0.84	0.57	0.42	0.68	1.00	0.51	
SEK	0.78	0.88	0.39	0.80	0.70	0.55	0.88	0.51	1.00	

Table A.8. Cross Country Correlations of Projected Premia

This table shows the correlation coefficients between the measures of subjective risk premia, as defined in section II in the main body of the paper. Based on monthly observations from between 1995.1 to 2020.12.

	PC1	PC2	PC3
BRP	59.91	11.27	8.46
XRP	63.71	13.96	6.88
LRP	58.33	14.64	10.77

Table A.9. PCA Analysis: Variance Explained (%)

Risk premium factors PC_t are formed from an eigenvalue decomposition of the covariance matrix of subjective risk premia $var(RP_t) = QDQ^\top$. This table displays the fraction of subjective risk premium variance due to the n 'th factor which is computed from $D(n, n) / \sum_n D(n, n)$. Factors (principle components) are computed from linear combinations (rotations) of the input series via $PC_t = RP_t Q$. The sample period 1995.1 to 2020.12

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	USD
<hr/>										
	Panel A: σ_T									
AUD	1.00	0.62	0.45	0.54	0.54	0.43	0.54	0.50	0.60	0.61
CAD	0.62	1.00	0.50	0.59	0.65	0.39	0.59	0.58	0.62	0.71
CHF	0.45	0.50	1.00	0.63	0.49	0.18	0.65	0.41	0.47	0.56
EUR	0.54	0.59	0.63	1.00	0.70	0.16	0.74	0.40	0.61	0.62
GBP	0.54	0.65	0.49	0.70	1.00	0.33	0.54	0.47	0.68	0.54
JPY	0.43	0.39	0.18	0.16	0.33	1.00	0.26	0.35	0.53	0.29
NOK	0.54	0.59	0.65	0.74	0.54	0.26	1.00	0.45	0.61	0.58
NZD	0.50	0.58	0.41	0.40	0.47	0.35	0.45	1.00	0.47	0.48
SEK	0.60	0.62	0.47	0.61	0.68	0.53	0.61	0.47	1.00	0.47
USD	0.61	0.71	0.56	0.62	0.54	0.29	0.58	0.48	0.47	1.00
	Panel B: σ_P									
AUD	1.00	0.53	0.60	0.73	0.42	0.31	0.63	0.64	0.61	0.58
CAD	0.53	1.00	0.43	0.62	0.51	0.44	0.45	0.66	0.58	0.72
CHF	0.60	0.43	1.00	0.68	0.25	0.36	0.64	0.52	0.65	0.45
EUR	0.73	0.62	0.68	1.00	0.59	0.33	0.65	0.62	0.66	0.72
GBP	0.42	0.51	0.25	0.59	1.00	0.26	0.23	0.34	0.27	0.64
JPY	0.31	0.44	0.36	0.33	0.26	1.00	0.28	0.33	0.34	0.24
NOK	0.63	0.45	0.64	0.65	0.23	0.28	1.00	0.45	0.63	0.42
NZD	0.64	0.66	0.52	0.62	0.34	0.33	0.45	1.00	0.61	0.58
SEK	0.61	0.58	0.65	0.66	0.27	0.34	0.63	0.61	1.00	0.52
USD	0.58	0.72	0.45	0.72	0.64	0.24	0.42	0.58	0.52	1.00

Table A.10. Correlation of Permanent vs Transitory Components

This table shows the correlation between the transitory (Panel A) and permanent (Panel B) components of the SDF decomposition, as outlined in Section V, between the ten countries in the sample. The sample period 1995.1 to 2020.12

A.5. Figures

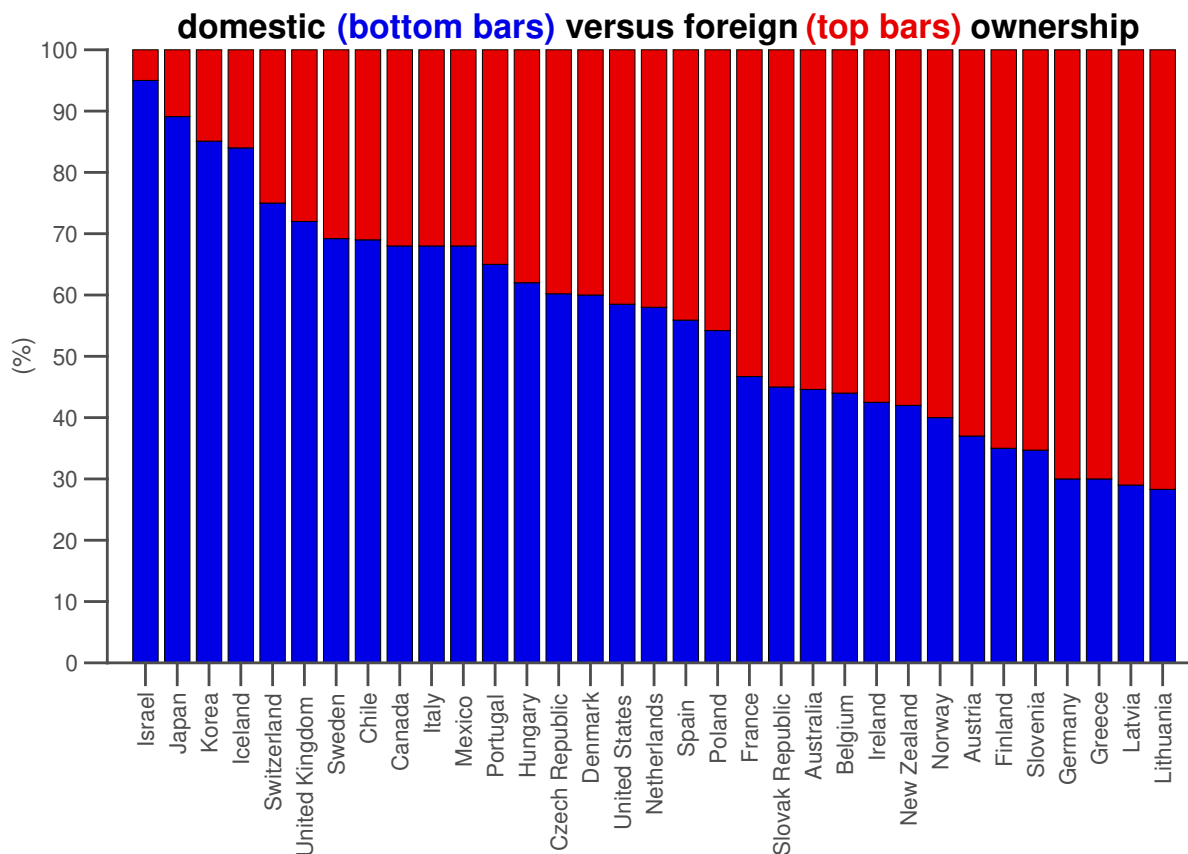


Figure A.1. Foreign Ownership of Domestic Bonds

This figure displays the fraction of domestic versus (blue bars) versus foreign (red bars) ownership of sovereign bonds. i.e., The blue bars for a given country indicate what fraction of that countries Treasury market are owned by citizens of that country and the residual is foreign ownership. Source: OECD. Sample 2019.1 - 2020.1

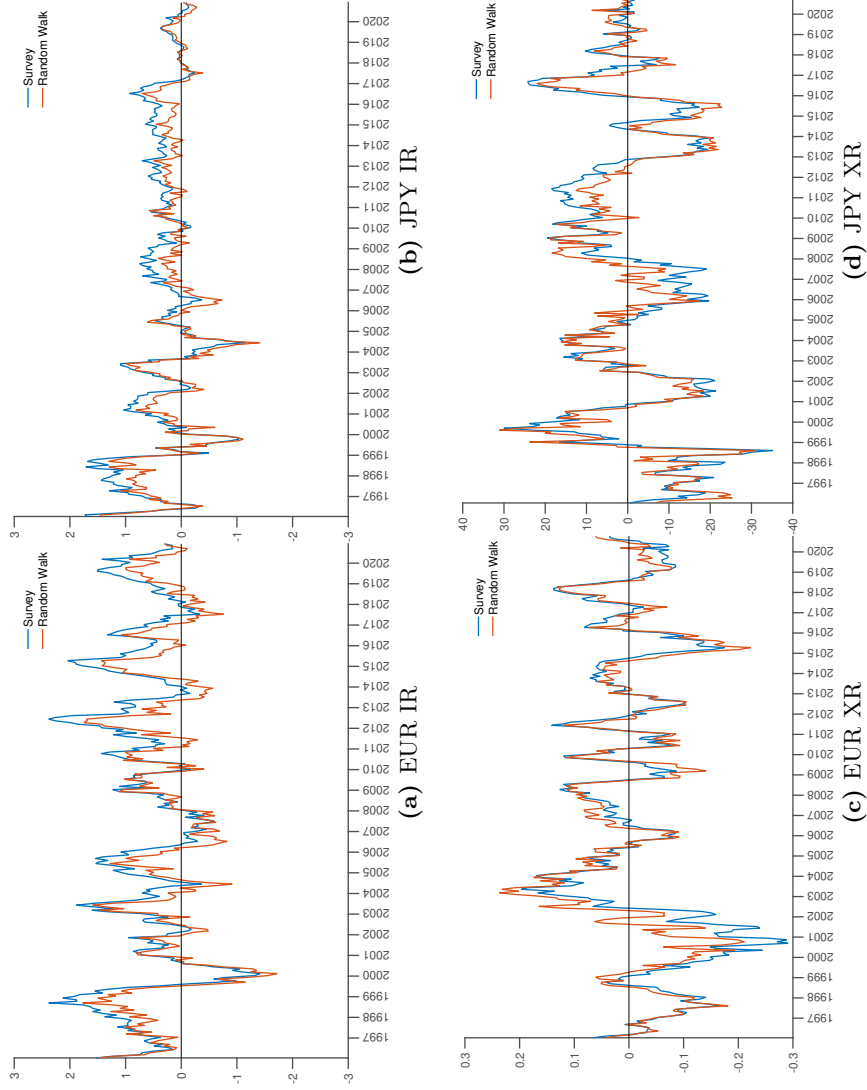


Figure A.2. Forecast Errors

Forecast errors are calculated from

$$\text{Survey : } y_{t+12} - y_t = E_t^C [y_{t+12} - y_t] + \epsilon_{t+12}^S$$

$$\text{Random Walk: } y_{t+12} - y_t = \epsilon_{t+12}^{RW}$$

$$\text{Statistical Model: } y_{t+12} - y_t = \mu_{t-12} + \beta_{t-12}^\top x_t + \epsilon_{t+12}^x$$

and plotted for 10-year interest rates and exchange rates for the 1-year forecast horizon. Panels (a) - (b) display realised forecast errors for interest rate projections and panels (c) - (d) display realised forecast errors for exchange rate projections. Forecast errors are realised over the sample period 1996.1 - 2021.12.

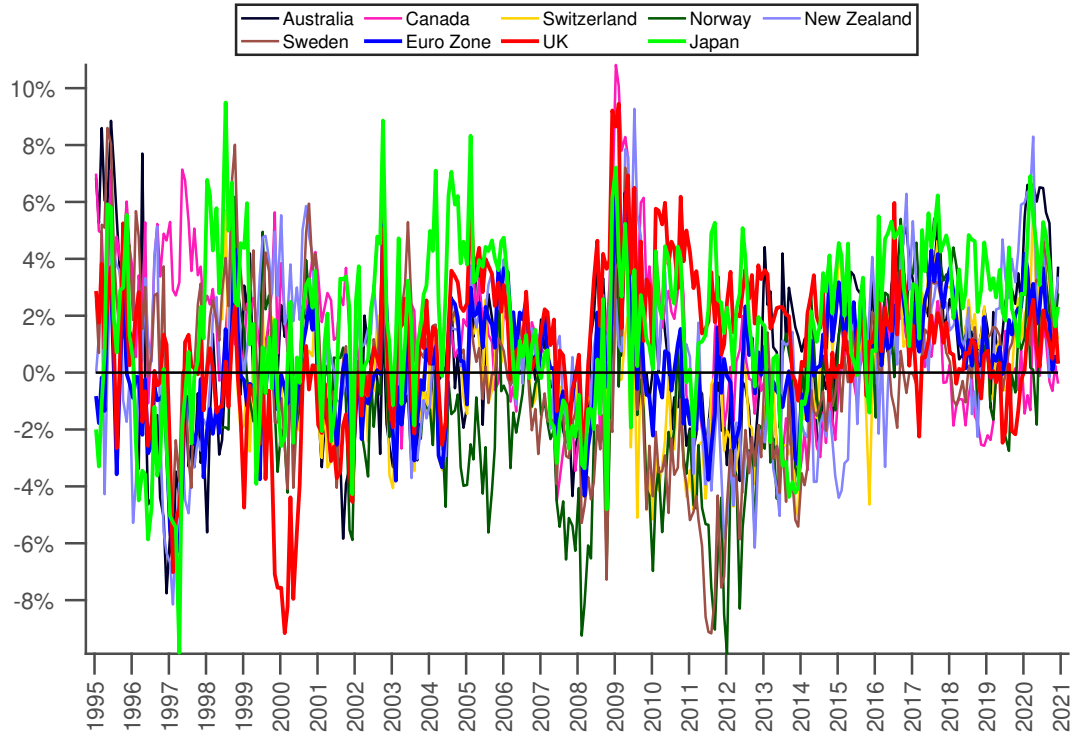


Figure A.3. Subjective Bond Risk Premia Differentials

Figure displays subjective bond risk premium differentials, ΔBRP_t , as defined in Equation (9) for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, and GBP against the USD. The sample period is 1995.1 to 2020.12.

short term forecast

long¹ term forecast²³

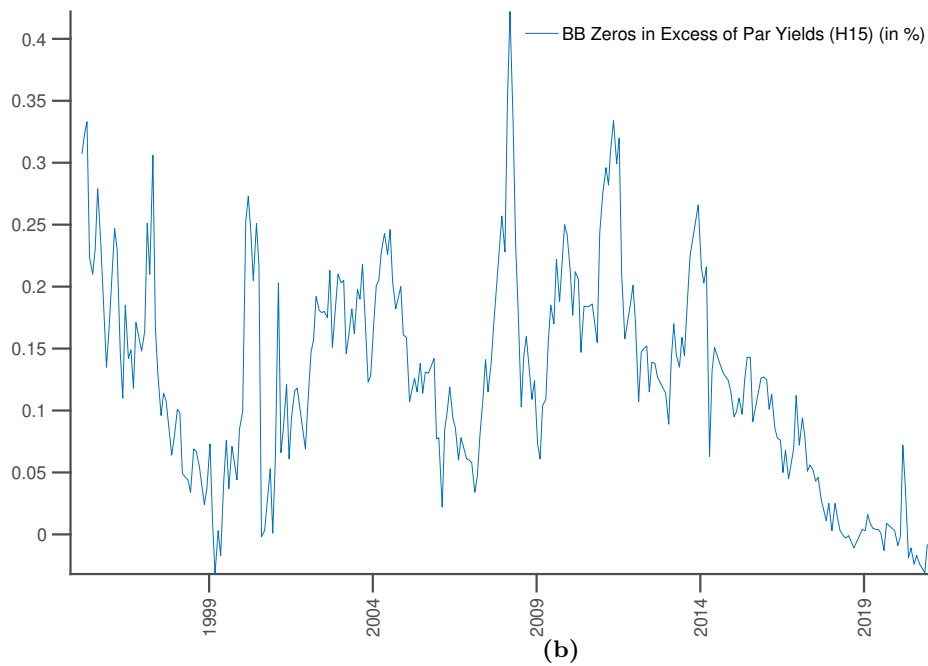
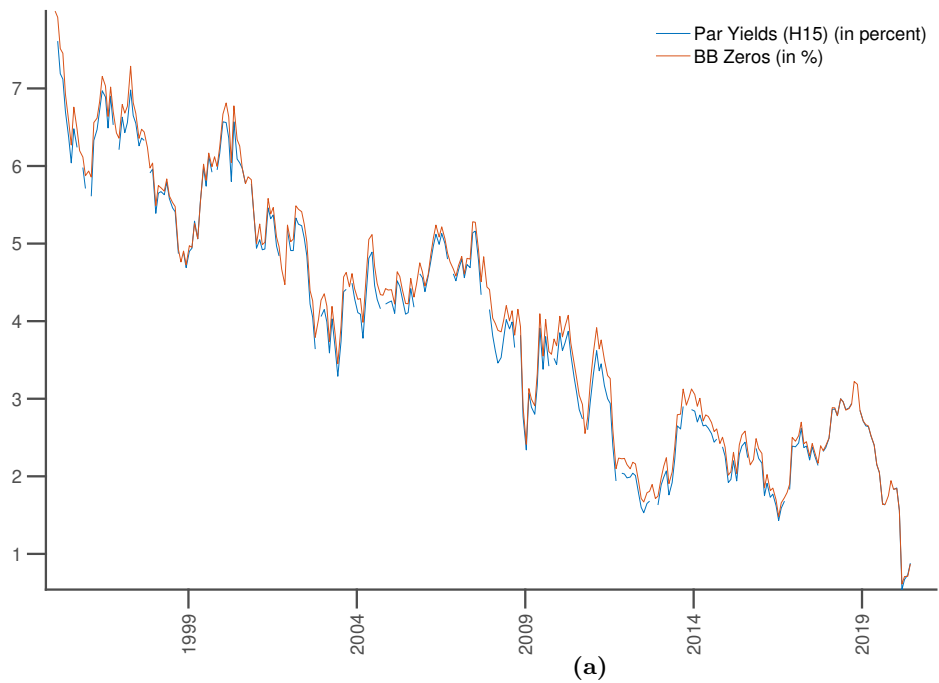


Figure A.5. Comparison of H15 and BB yields

The above figures show the time series of US 10-year par yields obtained from the Fed and US 10-year zero yields obtained from Bloomberg (Figure a) as well as the difference between the two series (Figure b). Data is available for the sample period 2000.1 to 2020.12.

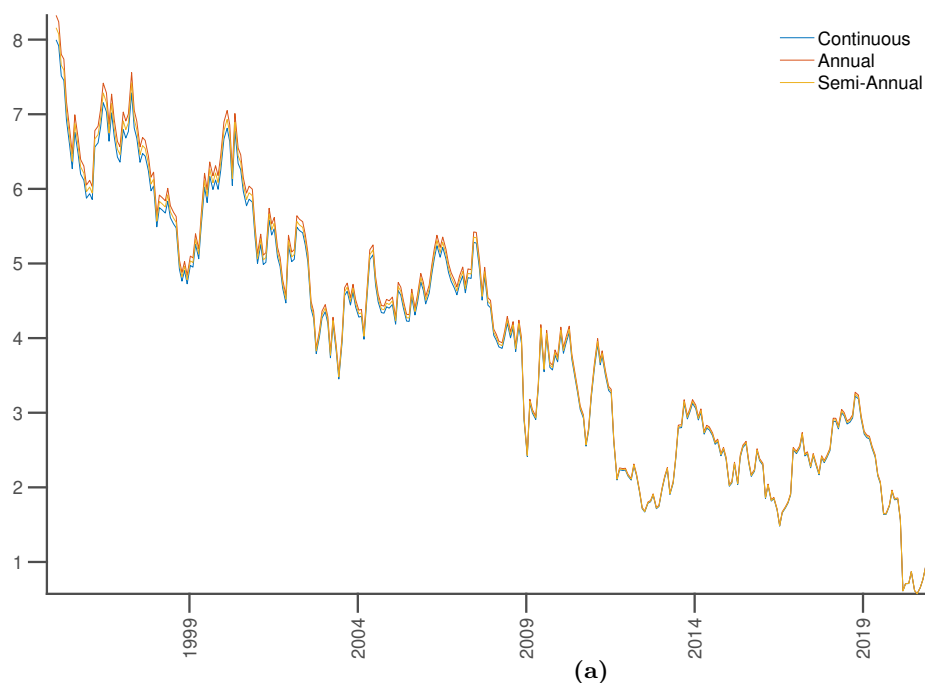


Figure A.6. Comparison of compounding frequencies

The above figure shows the time series of US 10-year zero log yields obtained from Bloomberg that have been generated assuming continuous, annual, and semi-annual compounding. Data is available for the sample period 2000.1 to 2020.12.

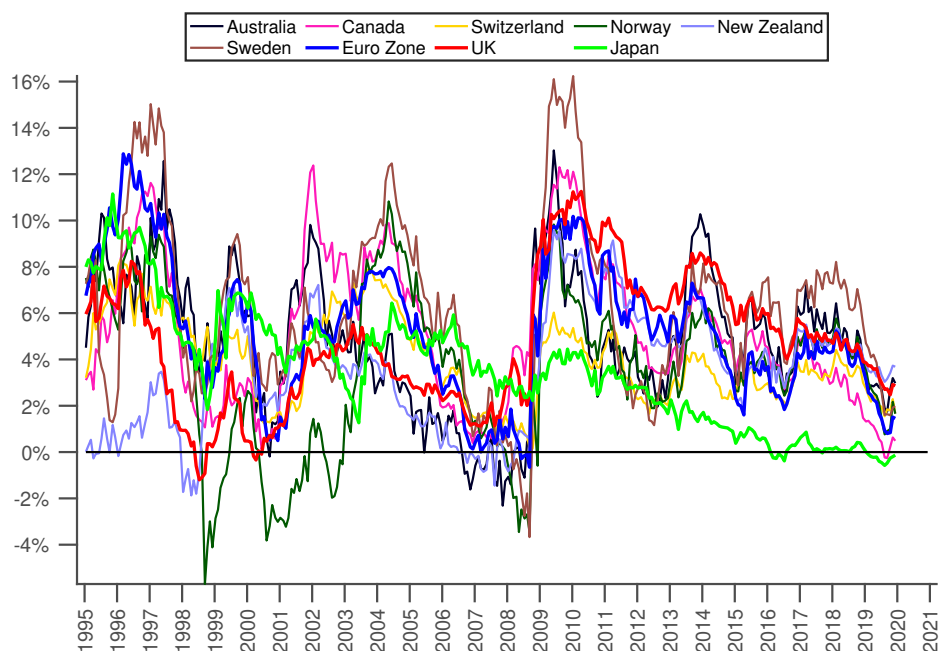


Figure A.7. Projected Bond Risk Premia

Figure displays subjective bond risk premia for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, and GBP. The projections for the bond risk premium are obtained by regressing realised ex-post premia on the slope of the yield curve and then forming 12-month ahead projections. Sample period is monthly observations from between 12/1995 and 12/2019.

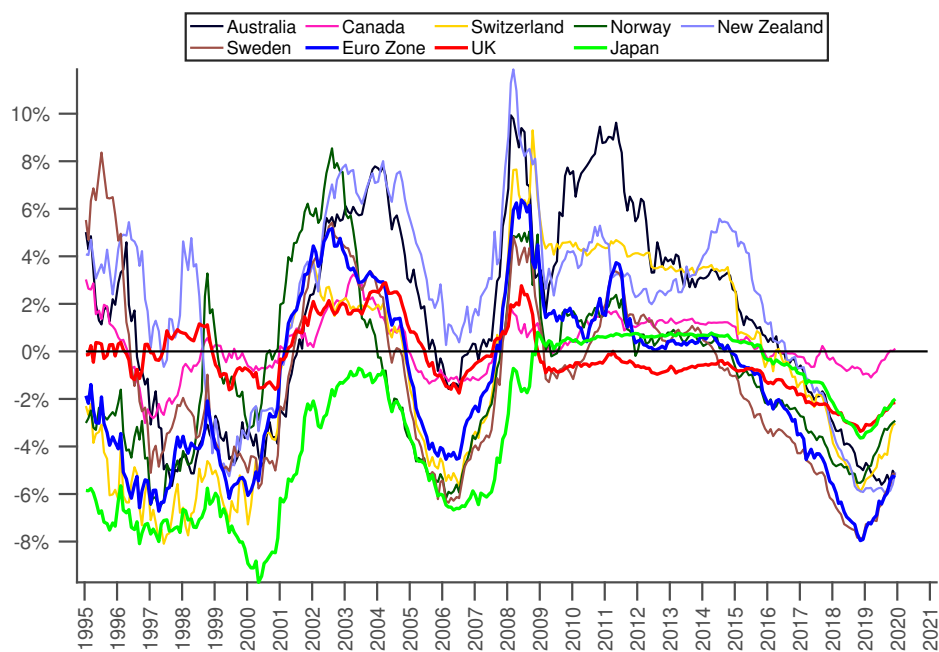


Figure A.8. Projected Exchange Rate Risk Premia

Figure displays subjective exchange rate risk premia for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, and GBP. The projection for the bond risk premium are obtained by regressing realised ex-post premia on the interest rate differential between the foreign country and the United States and then forming 12-month ahead projections. The sample period is 1995.1 to 2020.12.

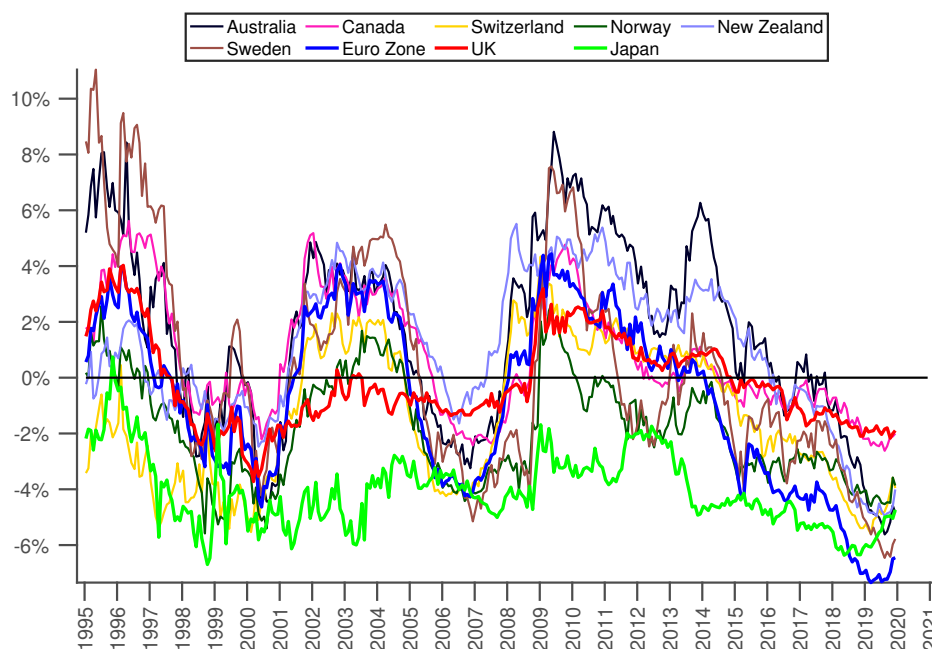


Figure A.9. Projected Foreign Bond Dollar Risk Premia

Figure displays subjective risk premia on foreign bonds, denominated in US Dollars, for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, and GBP. The projections for the foreign bond dollar risk premium are obtained by regressing realised ex-post premia on the slope of the yield curve (for bond risk premia) and the interest rate differential between the foreign country and the United States (for exchange rate risk premia) and then forming 12-month ahead projections. The sample period is 1995.1 to 2020.12.

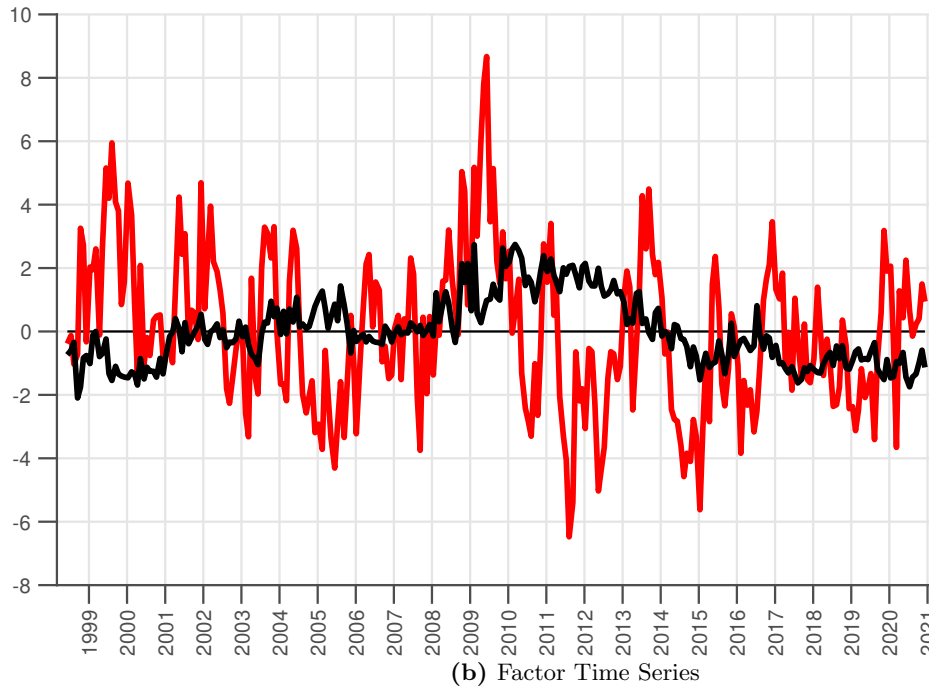
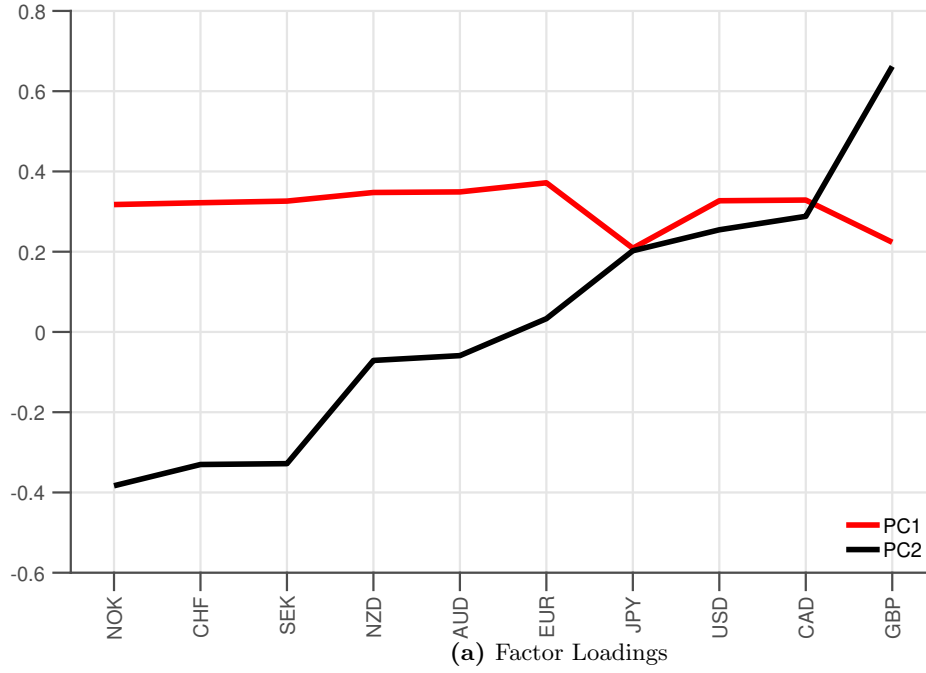


Figure A.10. PCAs of Subjective Bond Risk Premia

Subjective bond risk premia factors PC_t are formed from an eigenvalue decomposition of the covariance matrix of $var(BRP_t) = QDQ^\top$. The variance due to the n 'th factor is computed from $D(n,n)/\sum_n D(n,n)$ which is displayed in the online appendix. Principle components (PCs) are computed from the rotation $PC_t = BRP_t Q$. Panel (a) displays the factor loadings (the columns of Q) and panel (b) displays the dynamics of PC1 and PC2. The sample period is 1995.1 to 2020.12.

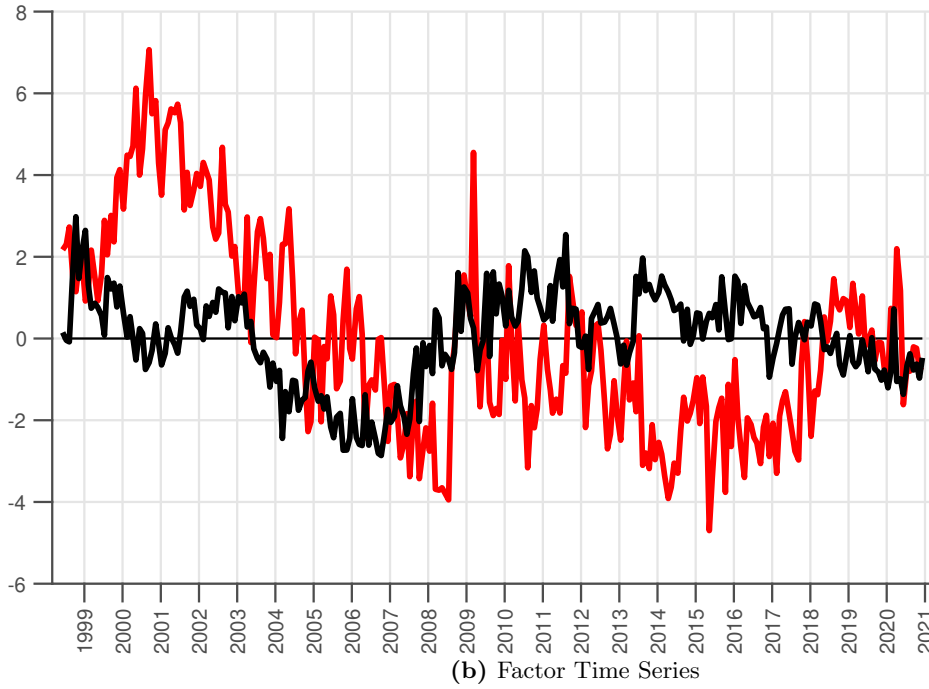


Figure A.11. PCAs of Subjective Exchange Rate Risk Premia

Subjective exchange rate risk premia factors PC_t are formed from an eigenvalue decomposition of the covariance matrix of $var(XRP_t) = QDQ^\top$. The variance due to the n 'th factor is computed from $D(n, n) / \sum_n D(n, n)$ which is displayed in the online appendix. Principle components (PCs) are computed from the rotation $PC_t = XRP_t Q$. Panel (a) displays the factor loadings (the columns of Q) and panel (b) displays the dynamics of PC1 and PC2. The sample period is 1995.1 to 2020.12.

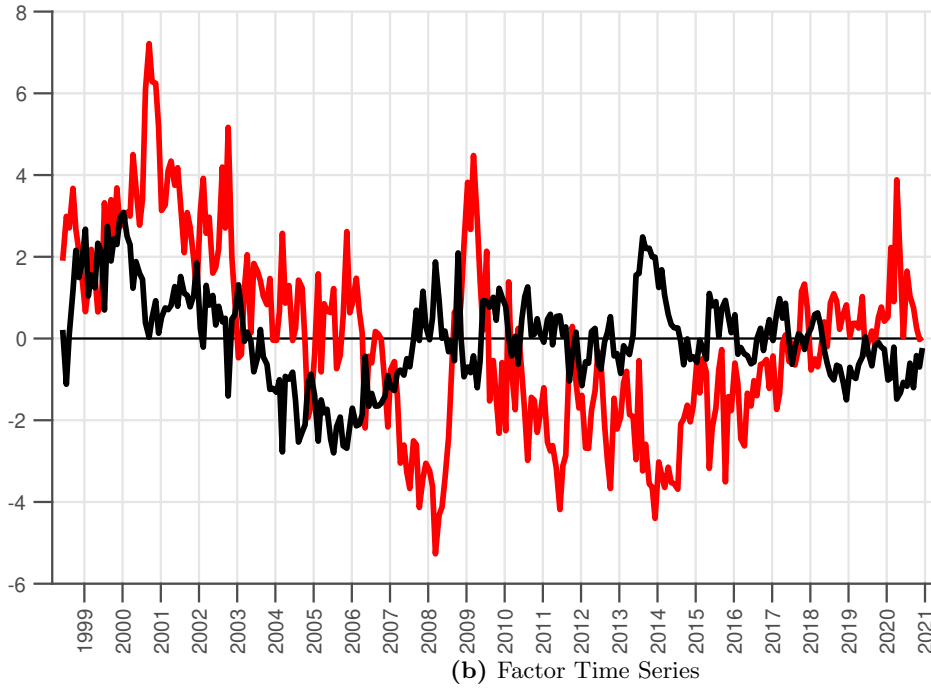


Figure A.12. PCAs of Subjective Foreign Bond Risk Premia

Subjective dollar denominated risk premia on foreign bond factors PC_t are formed from an eigenvalue decomposition of the covariance matrix of $\text{var}(\Delta BRP_t^{\$}) = QDQ^{\top}$. The variance due to the n 'th factor is computed from $D(n,n)/\sum_n D(n,n)$ which is displayed in the online appendix. Principle components (PCs) are computed from the rotation $PC_t = \Delta BRP_t^{\$}Q$. Panel (a) displays the factor loadings (the columns of Q) and panel (b) displays the dynamics of PC1 and PC2. The sample period is 1995.1 to 2020.12.

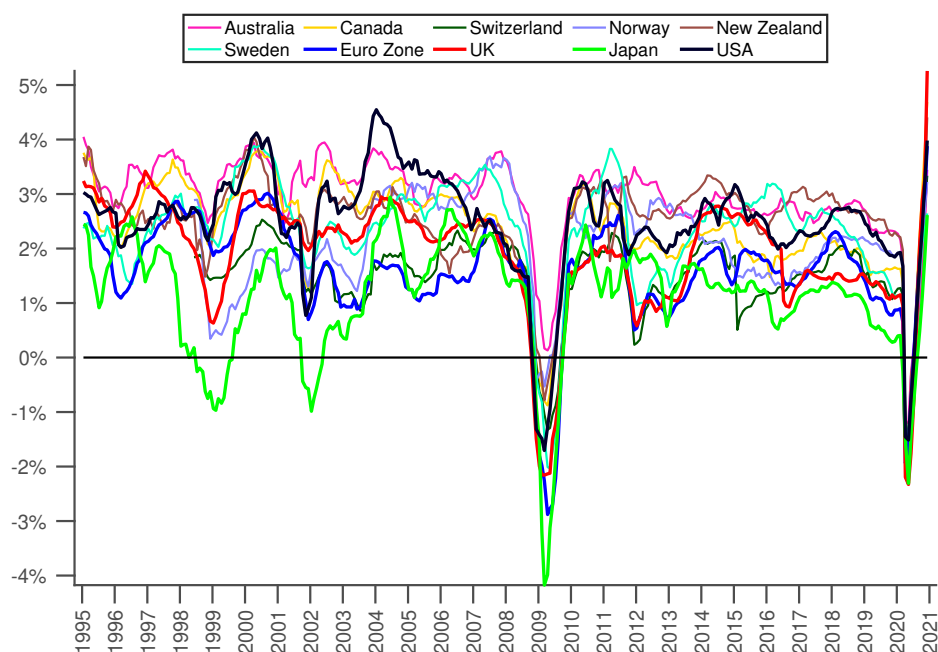


Figure A.13. Mean Expected real GDP Change

Figure displays subjective expectations of 12-month ahead real GDP changes (%), for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, GBP and USD. The sample period is 1995.1 to 2020.12.

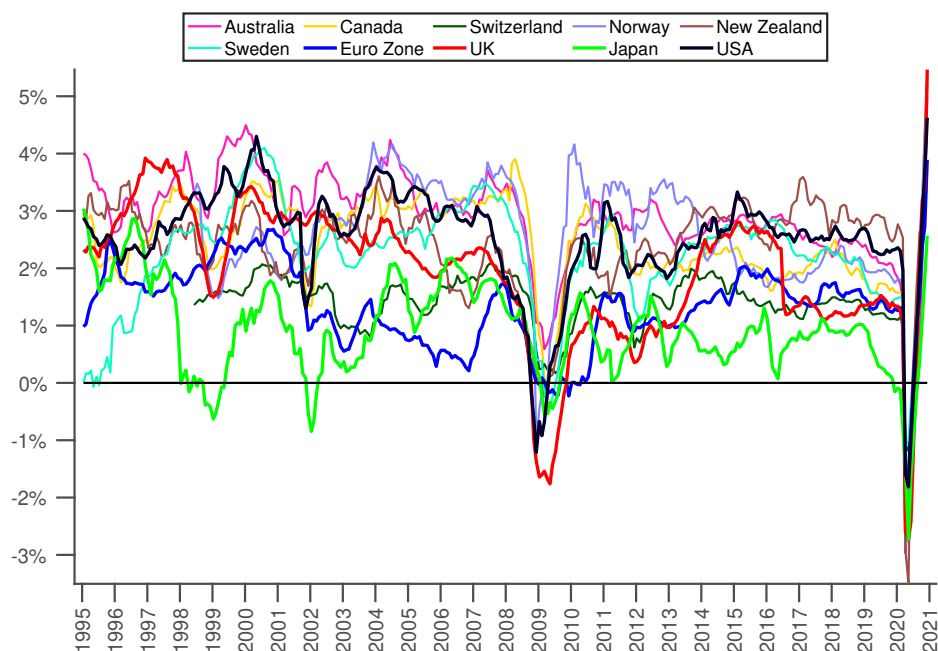


Figure A.14. Mean Expected Private Consumption Change

Figure displays subjective expectations of 12-month ahead real private consumption changes (%), for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, GBP and USD. The sample period is 1995.1 to 2020.12.

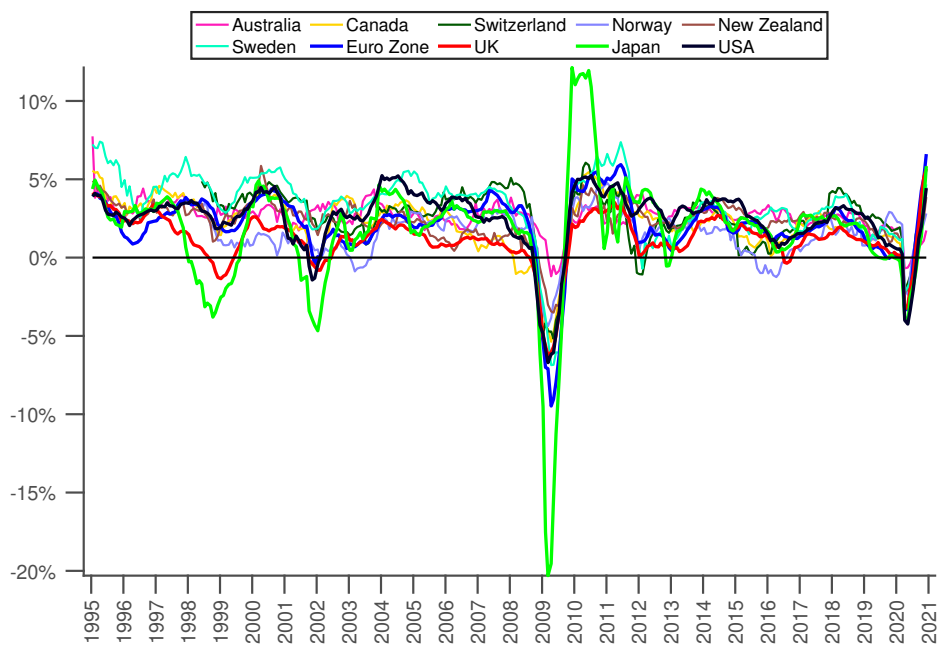


Figure A.15. Mean Expected Industrial Production Change

Figure displays subjective expectations of 12-month ahead real Industrial Production changes (%), for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, GBP and USD. The sample period is 1995.1 to 2020.12.

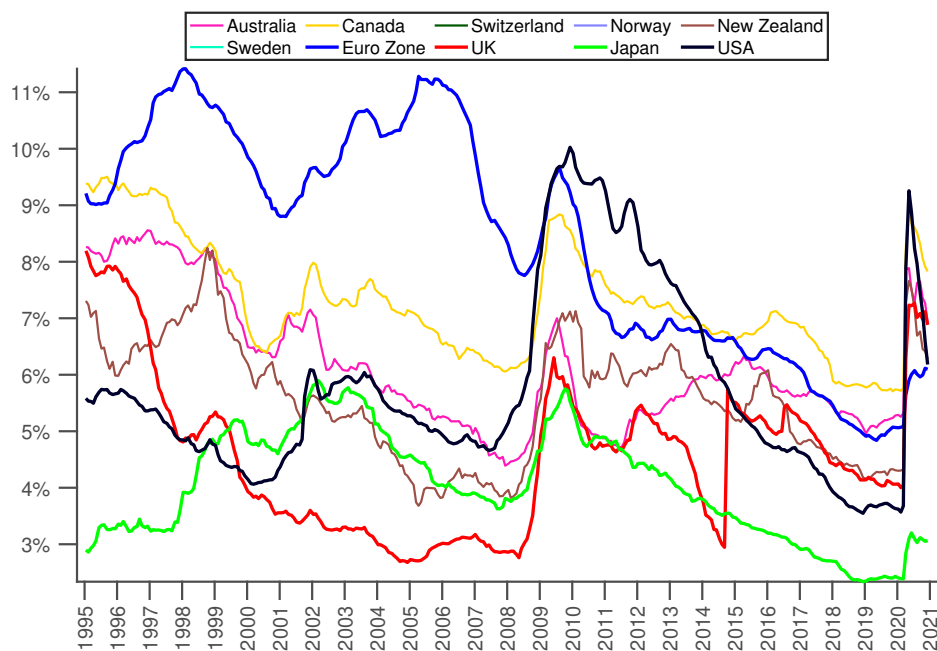


Figure A.16. Mean Expected Unemployment Change

Figure displays subjective expectations of 12-month ahead unemployment rates (%), for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, GBP and USD. The sample period is 1995.1 to 2020.12.

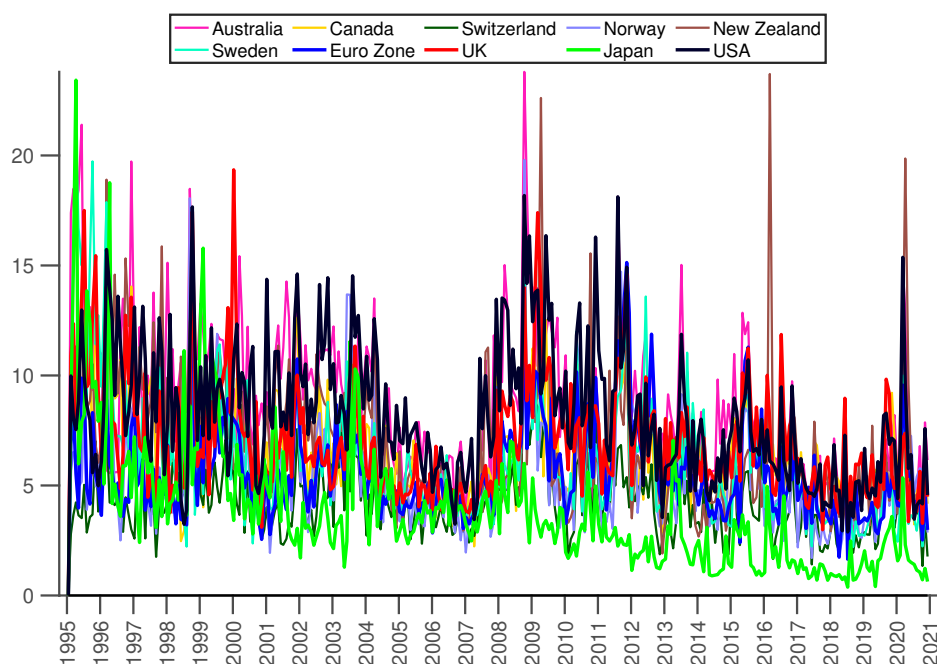


Figure A.17. Volatility of bond prices

Figure displays the volatilities of ten year sovereign bonds for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, GBP and USD. Volatility is measures as the sum of squared differences of daily bond prices in the 24 days preceding a sampled date. Dates are sampled as the survey dates of the Consensus Economics forecasts.

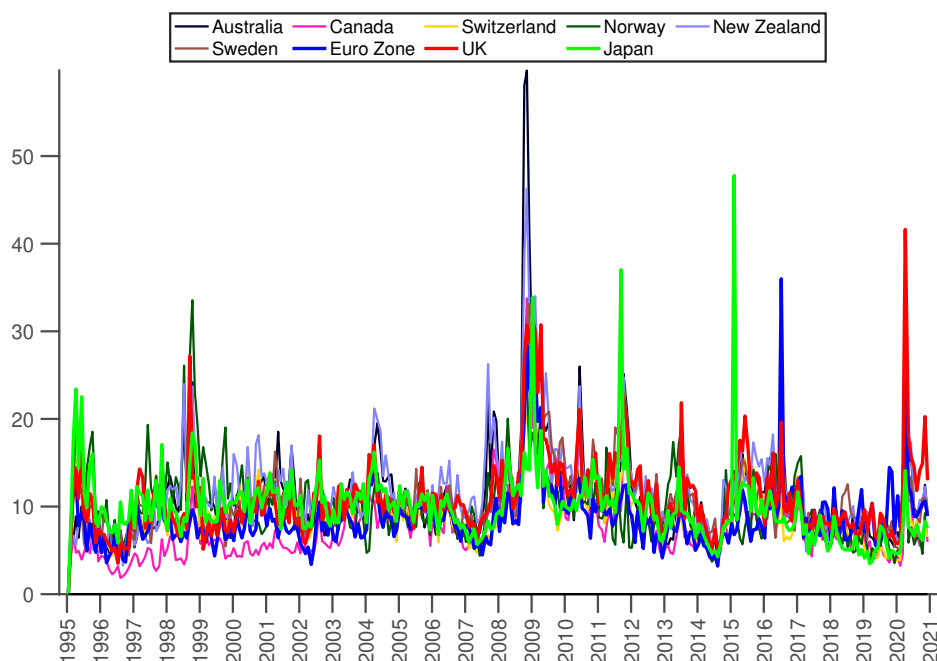


Figure A.18. Volatility of log spot rate changes

Figure displays the volatilities of spot exchange rates for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, GBP and USD. Volatility is measures as the sum of squared differences of log spot exchange rates in the 24 days preceding a sampled date. Dates are sampled as the survey dates of the Consensus Economics forecasts. The sample period is 1995.1 to 2020.12.

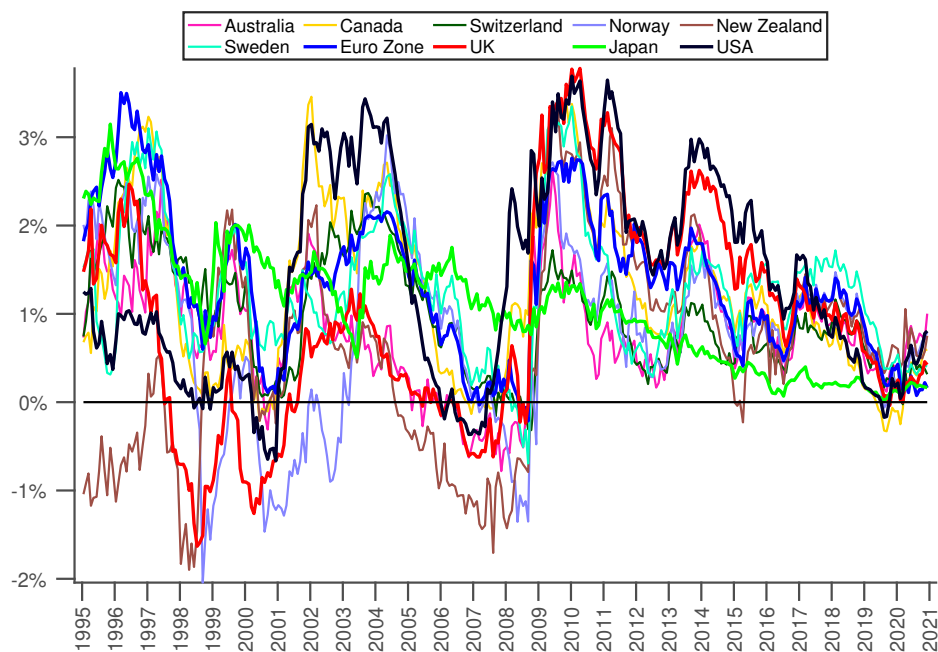


Figure A.19. Slopes

Figure displays the slope of the yield curves for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, GBP and USD. The slope of the yield curve is defined as the difference between the respective country's ten year bond yield and its one year bond yield. The sample period is 1995.1 to 2020.12.

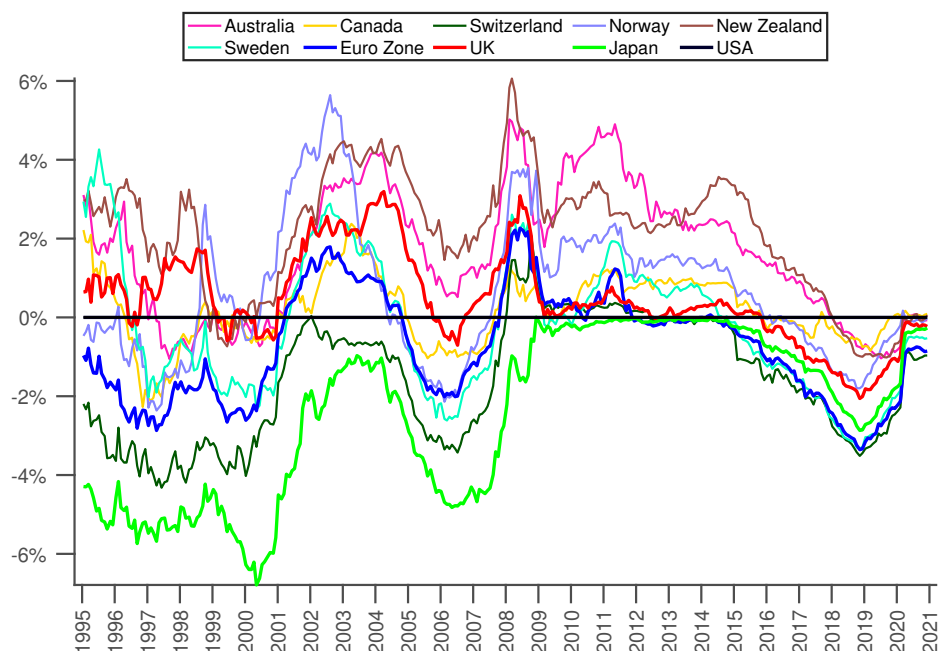


Figure A.20. Interest Rate Differentials

Figure displays the interest rate differentials for AUD, CAD, CHF, NOK, NZD, SEK, JPY, EUR, GBP and USD. The interest rate differential is defined as the difference between the domestic one year bond yield in the United States and the foreign one year bond yield in the respective country. The sample period is 1995.1 to 2020.12.

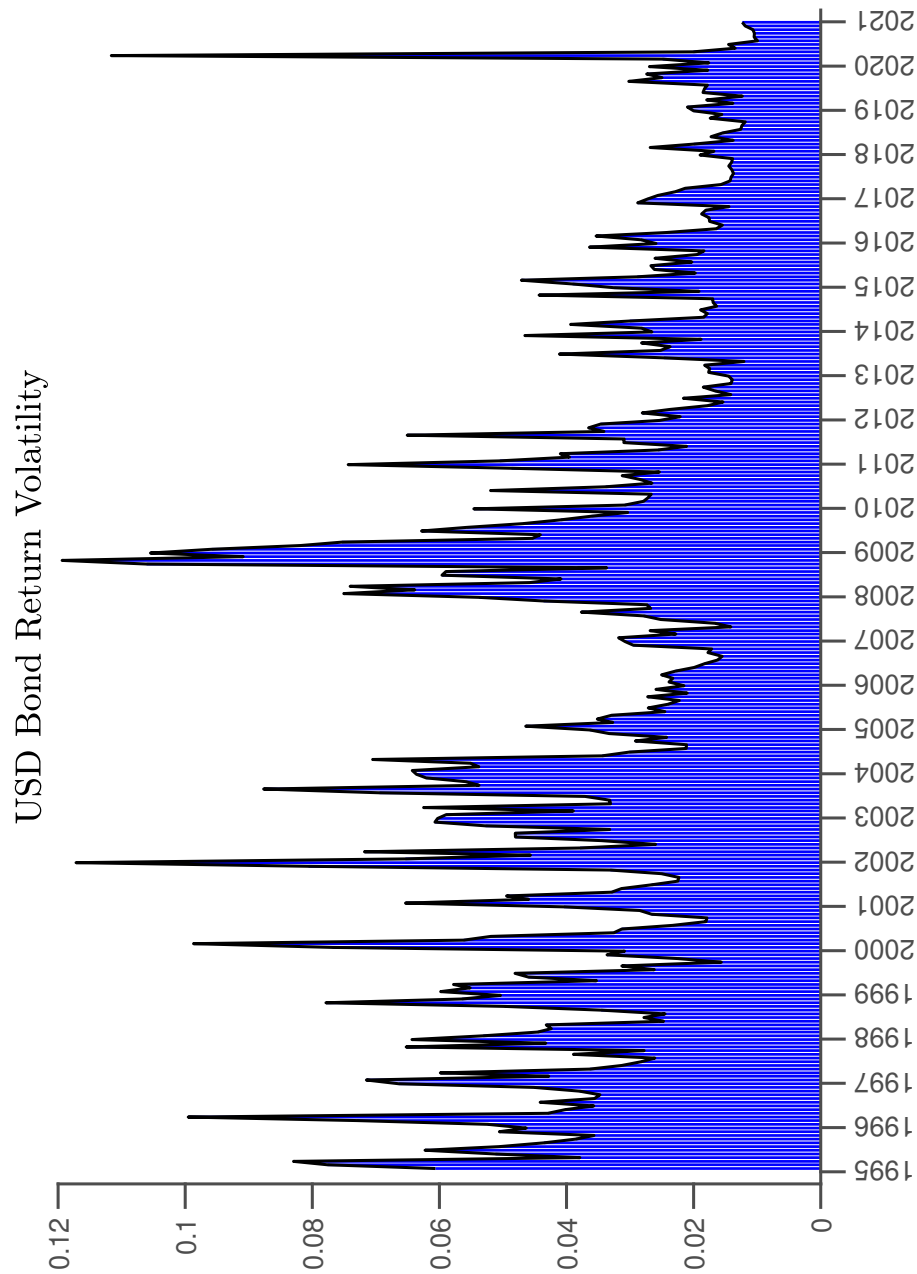


Figure A.21. USD 10-year Treasury Futures Return Volatility

This figure displays the annualised return volatility of the 10-year Treasury futures measured as the square root of the quadratic variation of 1-minute returns sampled during the intraday trading session (9:30 — 16:30 Eastern Standard Time). The sample period is 1995.1 to 2020.12.