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An In-Sample Evaluation of Exchange Rate Models: In Search of Scapegoats

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Abstract

We employ a modified dynamic model averaging framework which permits inferences about the shifting relevance and significance of explanatory variables to assess in-sample performance of exchange-rate models and empirical validity of purchasing-power-parity (PPP). The analysis is based on 16,384 empirical specifications constructed from 14 canonical and newly introduced explanatory variables for six US dollar exchange rates. Our findings indicate the best performing empirical exchange rate specification is unstable and changes frequently; individual explanatory variables display large time- and cross-currency variation in relevance and effects; and the combination of explanatory variables that enhances the empirical evidence of PPP differs by exchange rates. These findings underscore the challenge in applying a single exchange-rate model or the scapegoat hypothesis to explain all exchange rates in all historical periods.

JEL Classifications: C11; F31

Keywords: Bayesian Dynamic Model Averaging; Explaining Exchange Rates; In-Sample Performance; Purchasing Power Parity Deviations

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1. Introduction

Exchange rates are crucial economic variables that link a country's domestic economy to global markets and can materially influence macroeconomic stability and cross-border capital flows. Despite their importance, there is no consensus on a commonly accepted exchange-rate model; theoretical models are persuasive but their in-sample and out-of-sample empirical performance is often unsatisfactory.[1]

Since the seminal studies by Meese and Rogoff (1983a, 1983b), a plethora of empirical studies have evaluated the forecast performance of exchange-rate models. By contrast, systematic examinations of in-sample performance are comparatively scarce. Recognizing this gap, and leveraging comprehensive historical data, our study focuses on in-sample performance rather than out-of-sample forecasting.

While exchange rate forecasting offers valuable information for market participants, in-sample evaluation provides insights on the underlying relationships and patterns in historical data that are essential for constructing models which are both theoretically sound and practically relevant. These insights can also set the stage for value-at-risk (VaR) estimation via calibrating parameters, validating distributional assumptions, identifying stress scenarios, and indicating relevant information for developing stress testing frameworks and risk management strategies. Further, effective policymaking can benefit from guidance derived from historical responses to shifts in economic fundamentals and policy interventions across diverse economic scenarios.

We do not attempt to adjudicate the relative merits of in-sample versus out-of-sample assessments; they are complementary and each contributes to understanding the theoretical and practical usefulness of exchange-rate models.[2] Instead, we conduct an extensive in-sample evaluation to document the patterns of interaction between exchange rates and their determinants and to draw implications for model building and policymaking.

Given the proliferation of proposed exchange-rate models, it is important to focus on specifications and explanatory variables that are well recognized in the literature and represent

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1 For example, Meese and Rose (1991), Evans and Lyons (2002), and Bacchetta and Van Wincoop (2006) note weak in-sample performance and Cheung *et al*. (2005, 2019), Engel (2014), and Rossi (2013) present weak out-of-sample forecast performance. Noted that strong in-sample performance of a model does not necessarily translate into good out-of-sample performance.

2 Clements and Hendry (2005) argue, although forecast performance is often touted as the ultimate test of a model, in-sample analysis is essential for understanding a model's dynamic structure, internal mechanics, and statistical reliability. Inoue and Kilian (2005) demonstrate that, in many instances, in-sample tests provide valid and credible evidence – challenging the notion that significant in-sample results are spurious or less credible.

significant efforts in modeling exchange rates. Our in-sample performance study focuses on specifications that are readily implementable and replicable. The basic specification is based on the longstanding purchasing power parity (PPP) condition and is extended to include momentum trading measures, interest-rate differentials, elements of the monetary model, the Balassa-Samuelson productivity effect, market uncertainty, liquidity, and lagged real exchange rates. Additionally, we assess two aggregate specifications that combine our set of explanatory variables.

Although we list a subset of exchange-rate models from the literature in the next section, our empirical exercise considers 16,384 specifications constructed from various combinations of the selected explanatory variables. Our goal is not to declare a single “best” model; given the large and evolving set of competing specifications, identifying a universally best model is challenging and potentially elusive. Instead, we cast a wide net to investigate in-sample performance and the roles of these explanatory variables.

In view of reported exchange rate behaviors, our in-sample analysis employs a modified dynamic Bayesian model averaging approach (Raftery et al., 2010; West and Harrison, 1997).[3] Specifically, it incorporates a dynamic linear specification and provides a data-driven method to evaluate time-varying behavior and exchange-rate-specific behavior (Baillie and Kilic, 2006; Rossi, 2013; Sarno and Valente, 2009). The shifting relevance and importance of individual models and explanatory variables are assessed with retrospective statistical inferences,[4] that use information from the entire sample. Results on shifting relevance and importance shed light on the scapegoat hypothesis, which stipulates that market participants sporadically change their views on the relative importance of exchange rate determinants (Bacchetta and Van Wincoop, 2004). Over time, different factors are perceived as scapegoats influencing trading strategies and exchange rate movements.[5] Similarly, different vintages of exchange rate models include different explanatory variables. One example is that models introduced in the 21st-century have brought in market uncertainty, liquidity, and lagged real exchange rates as significant explanatory factors.[6]

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3 A typical Bayesian model averaging approach is used as a forecast tool. Appendix B presents the dynamic Bayesian model averaging setup used in our exercise to conduct in-sample analysis.

4 Shmueli (2010), for example, discusses the differences between explanatory and predictive modeling, and suggests explanatory modeling is retrospective.

5 Cheung and Chinn (2001) report that the views of market participants on the importance of economic variables have shifted over time. Fratzscher *et al*. (2015) use survey data to quantify scapegoat measures.

6 See, for example, Du *et al*. (2018), Engel and Wu (2023b, 2024), Jiang *et al*. (2021), Lilley *et al*. (2022) and Miranda-Agrippino and Rey (2020).

Using the modified dynamic Bayesian model averaging approach and the associated in-sample inferences, we characterize time-varying behavior, the ability of specifications to explain exchange-rate movements, shifts in the relevance of individual predictors, empirical variations in the links between exchange rates and fundamentals, and the performance of the PPP relationship conditional on other variables.

The remainder of the paper is organized as follows. Section 2 describes the data, exchange rate models and explanatory variables. Section 3 outlines the modified Bayesian model averaging framework. Section 4 presents the empirical findings on the in-sample performance, the roles of individual explanatory variables, and evidence on empirical PPP. Section 5 reports robustness checks based on (a) quarterly averages of daily exchange rates instead of quarter-end rates, (b) a lagged exchange rate in place of a lagged real exchange rate variable, and (c) first differences instead of levels of the VIX index, a realized variance variable, and a liquidity measure. Section 6 offers concluding remarks.

2. Data and Selected Exchange Rate Specifications

We examine the US dollar exchange rates of the G7 currencies, which include the US dollar, Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound (GBP), Japanese yen (JPY) and for the period 1999Q1 to 2023Q3.[7] Data on end-of-quarter exchange rates are analyzed to facilitate comparisons with existing studies. Given that end-of-quarter exchange rates closely follow a random walk, the quarterly averages of daily exchange rates often display serial correlation (Working, 1960); such behavior is a statistical artifact and not typically the focus of exchange rate modeling.[8] During the sample period, the G7 currencies were the most traded currencies in the BIS triennial central bank surveys of foreign exchange market activity, except for the year 2022.[9] The sources and definitions of the exchange rates and other explanatory variables used in this empirical study are given in Appendix A.

During the floating exchange rate era, the number of exchange rate models has grown considerably. Alternative exchange rate models have been introduced to address market developments not captured by earlier models. In general, we select models and variables

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7 Note that the G-7 currencies are not identical to the currencies of the Group of seven Countries.
8 We summarize the results based on quarterly averages of daily exchange rates in Section 5.1.
9 In the 2022 Survey, the Chinese renminbi is the fifth and the Swiss franc is the eighth most traded currency.

recognized in the economics literature, ensuring that the resulting reduced-form specifications are readily implementable and that empirical results are replicable. We begin with six exchange rate specifications selected from the literature and two additional ones derived from these six specifications – they are listed in the following subsections. The entire set of exchange rate specifications in our empirical exercise contains specifications formed by all possible combinations of the 14 variables included in the six selected models.

2.1 The Purchasing Power Parity (PPP) Condition

The first and basic empirical specification is based on the PPP condition expressed as

$$\Delta s_t = \alpha + \beta \Delta \tilde{p}_t + \varepsilon_t , \tag{1}$$

where s_t is the log exchange rate (units of home currency per foreign currency and the US is treated as the foreign country), Δ is the first difference operator, "~" is the inter-country difference operator and $\tilde{p}_t$ is the inter-country price differential given by $\tilde{p}_t \cong p_t - p_t^*$ (p_t and p_t^* are the log domestic and foreign price indexes), α and β are parameters, and ε_t is the error term.[10] Since these end-of-quarter exchange rates are close to a random walk process, (1) does not include their lagged changes.

The PPP condition serves as a cornerstone for many exchange rate models and is commonly used to gauge the degree of exchange rate misalignment. Empirical evidence suggests that the parity condition does not hold in the short run but provides a reasonable description of long-run behavior.[11]

2.2 Extended Specifications

Since PPP does not hold in the short run, what are the other factors that affect short-term exchange-rate movements? With (1) as the baseline case, we examine the augmented PPP specification given by $\Delta s_t = \alpha + \beta \Delta \tilde{p}_t + \boldsymbol{x}_t' \boldsymbol{\delta} + \varepsilon_t$, where $\boldsymbol{x}_t$ is the vector containing additional explanatory variables and $\boldsymbol{\delta}$ is the corresponding coefficient vector (Officer, 1982). The

10 We adopt the normality assumption as four of these six quarterly exchange rate series do not reject the assumption. It is noted that the Kalman filter type recursive model is not too sensitive to the normality assumption. Under non-normality, the estimates are best linear estimators, the predict–update Bayesian formulation is still valid, and the posterior credible intervals typically underestimate the true one.

11. Recent studies examining the empirical relevance of PPP include Ca'Zorzi *et al.* (2016), Ca'Zorzi and Rubaszek (2020), Cheung *et al.* (2019), and Jackson and Magkonis (2024).

augmented version allows us to assess the factors that help to explain exchange rate deviations from the baseline PPP condition.

2.2.1 Uncovered Interest Parity and Bandwagon Effect

The uncovered interest parity (UIP) receives attention from academics and market participants for different reasons. An operational form of UIP is $\Delta s_t = \tilde{i}_{t-1,t} \cong \tilde{i}_{t-1}$, where $\tilde{i}_{t-1,t} \cong \tilde{i}_{t-1}$ is the inter-country difference between domestic and foreign one-period interest rates (Chinn, 2006). While the UIP tends to gain empirical support at long horizons (Chinn and Meredith, 2004), the elasticity of inter-country interest differential substantially deviates from unity in the short run.[12] Taking advantage of UIP violations, the carry trade that comprises selling low-interest-rate currencies and buying high-interest-rate currencies is a well-known trading strategy. Against this backdrop, we set $\boldsymbol{x}_t = \tilde{i}_{t-1}$ and consider the specification

$$\Delta s_t = \alpha + \beta \Delta \tilde{p}_t + \delta \tilde{i}_{t-1} + \varepsilon_t \tag{2}$$

to determine the inter-country interest differential effect via the parameter δ.

Another feature that has attracted attention from practitioners and academics is the bandwagon effect displayed by exchange rates; that is, they tend to move in the same direction over time. The bandwagon effect especially in short horizons is reported in survey studies and incorporated in exchange rate models.[13] Momentum traders and chartists exploit this exchange rate pattern to devise various trading strategies. In our exercise, we set $\boldsymbol{x}_t = \Delta s_{t-1}$ and consider the specification

$$\Delta s_t = \alpha + \beta \Delta \tilde{p}_t + \delta \Delta s_{t-1} + \varepsilon_t \, . \tag{3}$$

to capture the extrapolating exchange rate behavior.

2.2.2 Canonical Economic Fundamentals

The monetary model of exchange rate determination advanced in the early 1970s provides an intuitively appealing framework to study exchange rate dynamics. It is a workhorse in

12. See Burnside *et al.* (2011), Cheung and Wang (2022), Engel (2014), Fama (1984) and Sarno (2005).
13 The bandwagon effect is documented in surveys of market participants (Cheung and Chinn, 2001 and Cheung *et al*., 2004) and of exchange rate expectations (Froot and Ito, 1989). Frankel and Froot (1990), De Grauwe and Dewachter (1993) theorize the co-existence of trading strategies based on bandwagon effects and fundamentals.

international finance that has been updated and extended over time.[14] Our exercise considers an extended monetary model with economic explanatory variables $\boldsymbol{x}_t = (\Delta\tilde{m}_t \; \Delta\tilde{y}_t \; \Delta\tilde{i}_t \; \Delta\tilde{\psi}_t \; TB_t)'$, where m_t is log money, y_t is real GDP, i_t *is* the interest rate, ψ_t is the inflation rate, and TB_t is the US trade balance normalized by GDP.[15]

The resulting augmented PPP specification is

$$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \varepsilon_t \,. \qquad (4)$$

Note that (4) is a composite representation that encompasses economic fundamentals from several vintages of the monetary model including the canonical flexible and inflexible price models.[16]

The role of productivity differentials in affecting exchange rates is assessed by the empirical specification

$$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \varepsilon_t \,, \qquad (5)$$

where $\tilde{w}_t$ is the inter-country productivity differential. The productivity differential effect on nominal exchange rates (Clements and Frenkel, 1980; Chinn, 1997) is closely related to the Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964) on real exchange rates.

2.2.3 Risk and Liquidity Factors

In the 21st century and especially after the 2007-8 global financial crisis, some studies highlight the roles of market uncertainty, liquidity, and lagged real exchange rates in affecting exchange rate movements.[17] To accommodate these recently popularized factors, we consider the specification

$$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \boldsymbol{v}_t'\boldsymbol{\delta}_7 + \delta_8 l_t + \delta_9 q_{t-1} + \varepsilon_t \,, \qquad (6)$$

to assess the marginal effects of the proxies for risk/uncertainty (v_t) and liquidity (l_t), and the lagged real exchange rate q_{t-1}. Our choices of proxies for risk/uncertainty are *i*) the US VIX index

14 Early contributions to the monetary model include Frenkel (1976), Dornbush (1976) and Frankel (1979). Mark (1995), Mark and Sul (2001) and Rapach and Wohar (2002) revive the model's empirical relevance.

15 Hooper and Morton (1982) incorporate the trade balance in exchange rate modeling. Although its perceived importance declined in the 1990s, the trade balance is included in empirical exchange rate studies (Chinn and Meese, 1995; Engel and Wu, 2024; Jackson and Magkonis, 2024; Meese and Rogoff, 1983a, b).

16 See, also the micro-based general equilibrium models of Stockman (1980) and Lucas (1982). Note that the related output and inflation gaps are determinants of Taylor-rule-based exchange rate models.

17 See, for example, Du *et al*. (2018), Engel and Wu (2023b, 2024), Jiang *et al*. (2021), Lilley *et al*. (2022) and Miranda-Agrippino and Rey (2020).

(vix_t), the three-month Treasury-Libor spread (TED_t), and the realized variance given by $RVar_t = \Sigma_{i=1}^{N}[\Delta s_{t-1+i/N})]^2$, where $s_{t-1+i/N}$ is the i-th day logged exchange rate during the period t-1 to t.[18] The liquidity measure is given by $l_t = f_{t,t+1} - s_t + i^*_{bond,t} - i_{bond,t}$, where $f_{t,t+1}$ is the one-year forward rate, and $i^*_{bond,t}$ and $i_{bond,t}$ are one-year government bond rates of, respectively, the US and another G7 country (Engel and Wu, 2023b). These proxies are stationary processes.

2.3 Aggregate Specifications

The specifications in previous sub-sections contain different exchange rate determinants that appeared in different vintages of exchange rate models. Our in-sample exercise also considers two aggregate specifications by combining these different determinants. Specifically, to assess the relative performance of the canonical economic fundamentals (Section 2.2.2) and risk and liquidity factors (section 2.2.3) in the presence of each other, we amalgamate (5) and (6) to obtain

$$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t$$
$$+\boldsymbol{v}_t'\boldsymbol{\delta}_7 + \delta_8 l_t + \delta_9 q_{t-1} + \varepsilon_t . \quad (7)$$

To assess the marginal effects of $\tilde{i}_{t-1}$ and Δs_{t-1} factors in section 2.2.1, we consider the aggregate specification

$$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t$$
$$+\boldsymbol{v}_t'\boldsymbol{\delta}_7 + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \delta_{11}\Delta s_{t-1} + \varepsilon_t , \quad (8)$$

which comprises the 14 explanatory factors considered in our exercise.

To recap, equations (1) to (8) are selected reduced-form specifications of existing exchange rate models with determinants including the PPP, the interest differential and bandwagon factors, macroeconomic variables, the Balassa-Samuelson factor, volatility, uncertainty, and liquidity effects.

18 See, for example, Barndorff-Nielsen and Shephard (2006), Barndorff-Nielsen *et al*. (2010), Busch *et al*. (2011) on realized variance and global foreign exchange market risk.

We do not impose parameter restrictions in these specifications because parameters can assume different values under differing exchange rate models.[19] Thus, we opt to let the data reveal the relationships between exchange rates and these explanatory factors.

Our in-sample exercise is not limited to these selected eight specifications and includes all the empirical specifications that can be constructed from our list of explanatory variables. Given there are 14 explanatory variables, there are in total K=16,384 (=2^{14}) empirical exchange rate equations. Without convincing evidence that a specific model represents the true exchange rate generation process, we employ data-driven criteria to infer in-sample performance. A Bayesian approach is adopted to assess model uncertainties, aggregate information from different specifications, and study in-sample relationships. This approach reduces the chance of working with pre-selected but incorrect models. We describe our empirical framework in the next section.

Our theme is not to assess which of these specifications best explains exchange rates or which combination of explanatory variables yields the highest explanatory power. Instead, the eight specifications listed above are used to facilitate the discussion of the elusive patterns of in-sample relationships between exchange rates and their determinants, and the evolution of the empirical relevance of individual explanatory variables.

In passing, we note that we use the terms "model" and "model specification" loosely to refer to a (reduced-form) empirical exchange rate equation in our exercise.

3. Empirical Framework

The choice of our empirical framework is guided by the characteristics of exchange rate dynamics. We employ an equation-by-equation time-varying Bayesian dynamic linear model (DLM) approach[20] to capture the exchange-rate-specific time-varying behavior and a retrospective approach[21] that considers information in the entire sample to infer in-sample relationships between exchange rates and their explanatory variables. Estimation results from alternative specifications are aggregated and analyzed using a modified dynamic model averaging (DMA) method (Raftery

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19 For example, the output variable $\Delta\tilde{y}_t$ has a positive effect under the monetary model but a negative effect under the Mundell-Fleming model. The interest rate variable $\Delta\tilde{i}_t$ can have different signs under, say, flexible price and stick-price models. A unitary restriction on β may not be appropriate if there are errors in measuring the theoretical price indexes under PPP (Cheung and Lai, 1993).

20. See Beckmann and Schüssler (2016), Byrne *et al.* (2018), Koop and Korobilis (2012) and Raftery *et al.* (2010).

21. See Shmueli (2010).

et al., 2010; West and Harrison, 1997). The DLM-and-DMA framework provides insights into the shifting importance of various empirical specifications and explanatory variables.

We outline the empirical framework in the remainder of this Section and provide in Appendix B a more technical description of the DLM-and-DMA setup for in-sample analysis.

The DLM regression is given by

$$y_t = \boldsymbol{z}_t'\boldsymbol{\theta}_t + \varepsilon_t,\ \varepsilon_t \sim N(0,V), \tag{9}$$

and

$$\boldsymbol{\theta}_t = \boldsymbol{\theta}_{t-1} + \boldsymbol{w}_t,\ \boldsymbol{w}_t \sim N(0,\boldsymbol{W}_t), \tag{10}$$

where $y_t \cong \Delta s_t$, $\boldsymbol{z}_t \cong (1\ \Delta\tilde{p}_t\ \boldsymbol{x}_t')'$, $\boldsymbol{\theta}_t$ contains the time-varying parameters α_t, β_t and $\boldsymbol{\delta}_t$, and $\boldsymbol{W}_t$ is the variance of the error term $\boldsymbol{w}_t$ that defines the degree of parameter variability. The time-varying versions of (1) to (8), for example, are obtained by substituting the corresponding explanatory variables into $\boldsymbol{z}_t$ (via $\boldsymbol{x}_t$). The time-varying parameters reveal the varying strength of the relationships between exchange rates and explanatory variables.

Bayesian methods are used to generate $\boldsymbol{\theta}_t$-estimates and their filtered distributions recursively. Initial parameter values are set to zeros, with the first eight observations comprising the initial period. Inferences are drawn from the retrospective distribution of $\boldsymbol{\theta}_t$ and the retrospective likelihood function of a model specification.

To reiterate, our sample of empirical specifications comprises all models constructed from the 14 explanatory variables and includes the eight specifications in Section 2. In total, we consider K=16,384 (=2^{14}) empirical exchange rate equations. Data-driven retrospective likelihood values are used to evaluate these empirical specifications and conduct the model averaging analysis. Instead of selecting one specific empirical equation, we base our inferences on the retrospective posterior likelihood functions and the retrospective posterior distributions of parameter estimates of all K specifications. The relative importance and relevance of these K specifications are inferred from retrospective model probabilities derived from their retrospective likelihood functions.

The model averaging estimate of $\boldsymbol{\theta}_t$ is the weighted average of $\boldsymbol{\theta}_t$-estimates from all K models, with weights assigned based on retrospective model probabilities. The model averaging procedure addresses model uncertainty and offers a systematic, data-driven approach to aggregate information and generate estimates from multiple models. It also helps reduce overfitting, which is a common concern of in-sample studies.

The retrospective posterior inclusion probability (henceforth PIP for brevity) of an explanatory variable is defined as the sum of the retrospective posterior probabilities of model specifications, that include the explanatory variable. According to the usual Bayesian model averaging approach an explanatory variable is considered to have an acceptable, substantial, strong, or decisive effect if its PIP is between 0.5 and 0.75, 0.75 and 0.95, 0.95 and 0.99, and 0.99 and 1, respectively.[22] An explanatory variable with a PIP less than 0.5 is not deemed "important."

The PIP of a variable is a data-driven indicator of its importance and relevance, and likelihood to be included in an exchange rate model. Since a change in PIP can reflect a shift in market perception of a variable's relevance and importance in explaining exchange rates, it can be an indirect measure of the presence of scapegoat effects or how likely a variable is a scapegoat that represents a market perceived driving force of exchange rate movements.

The β -estimates from (1) and other specifications can be used to assess the empirical PPP relationship in the presence of the other explanatory variables. To this end, we compare the β -estimates from (1) with those from other specifications including the one based on model averaging.

In summary, the DLM-and-DMA framework provides a data-driven mechanism to characterize and quantify model uncertainties, as well as the evolving relevance of models and explanatory variables.

4. Empirical Analyses

Figure 1 illustrates the six quarterly dollar exchange rates, which show a general trend of dollar depreciation before the 2007-2008 GFC and dollar appreciation afterward. From visual inspection, the JPY and GBP exchange rates appear less similar to the other four in the early part of the sample, and the CHF, JPY, and GBP exchange rates are less similar to the other three in the later part. In the rest of this section, we investigate the currency-specific time-varying behaviors.

4.1 Model Relevance

Without a strong prior on which empirical specification is the best, we use the DMA method to analyze currency-specific results from DLM regressions. Data-driven measures are used

22. See Kass and Raftery (1995) and Havranek *et al.* (2015).

to infer the relative importance of individual specifications formed by possible combinations of the 14 explanatory factors introduced in Section 2.

4.1.1 Model Probability

At time t, let "HM_t" be the model specification in the model space that yields the retrospective model probability "$\pi_{t|T,h}$," which is the largest among the set of retrospective model probabilities of the K=16,384 model specifications in the model space.[23] Note that the specification of HM_t can change over time. Similarly, we use $\pi_{t|T,i}$ to label the retrospective model probability of specification i (i = 1, …8) discussed in Section 2 for convenience.

The relative model probability ratio $\pi_{t|T,i}/\pi_{t|T,h}$ which gauges the likelihood and importance of specification i at time t relative to that of HM_t is graphed in Figure 2 for each of the six exchange rates. The relative model probability ratios and their rankings vary over time; indicating the relative importance and the explanatory powers of these eight selected specifications are quite unstable and exchange rate specific.

Figure 2 shows that the model probabilities of these eight specifications are usually less than one-half of the corresponding HM_t. Apart from the CHF series, the aggregate specification (7) tends to display a large relative model probability ratio. The specification (6) that includes the recently popularized explanatory variables can yield a high relative model probability ratio in some historical time periods for some exchange rates (*e.g.* CAD, CHF, and GBP).

The set of smallest relative model probability ratios is typically attributed to the PPP, uncovered interest parity, and bandwagon effect specifications given by (1), (2) and (3). The ratios of these specifications show a declining trend, albeit at different rates across exchange rates.

In general, the in-sample performance of the eight selected specifications is weak relative to the HM_t, and is time-varying and exchange-rate specific.

Table 1 presents the averages of the $\pi_{t|T,i}/\pi_{t|T,h}$ ratio in the full sample, pre-crisis period, and post-crisis period. To isolate the 2007-8 GFC effect, we excluded 2007Q3 to 2008Q4 from the pre- and post-crisis sample periods. These averages of ratios offer an explicit numerical comparison and quantify the observations from Figure 2. Out of 48 cases in each sample period,

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23 See Appendix B for the technical definitions of $\pi_{t|T,h}$ and other DLM-and-DMA related statistics used in the empirical exercise.

there are only three cases in the full sample, eleven cases in the pre-crisis period, and three cases in the post-crisis period that have an average ratio larger than one-half of the corresponding HM_t. The average model probability ratios of the eight selected specifications are in general small.

The aggregate specifications, especially (7), yield the largest average ratios – the only exception is the specification (6) with the recently popularized explanatory variables yields the highest average ratio for the CHF case during the post-crisis period. Indeed, if we consider only the six vintage exchange rate specifications (1) to (6), the most recent vintage specification (6) yields 14 largest average ratios and the extended monetary model specification (5) yields four. The other vintage specifications have quite small average ratios; for example, specifications (1), (2) and (3) that are related to the PPP, uncovered interest parity, and the bandwagon effect garner average ratios that are less than 10% of the corresponding highest model probabilities.

4.1.2 A Modified Adjusted R-2 Measure

In addition to model probabilities, we employ a modified adjusted R-2 measure to assess in-sample performance. In view of the standard adjusted R-2 measure in regression analysis, we construct a modified adjusted R-2 measure

$$R^M = 1 - \frac{\Sigma[(y_t - \hat{y}_t)^2 / (T - \hat{n}_t - 1)]}{\Sigma[(y_t - \bar{y}_t)^2 / (T - 1)]}, \tag{11}$$

where $\hat{y}_t$ is the estimate of y_t generated from the DLM-and-DMA framework, $\hat{n}_t$ is the "effective" number of explanatory variables used to obtain $\hat{y}_t$, and T is the sample size.[24] Similar to the standard adjusted R-2 measure, R^M compares the sum of the squared differences between observed and estimated values and the sum of the squared deviations of observed values from their mean adjusted for the numbers of regressors. A large R^M indicates a good descriptive power of a model.

Table 2 presents the R^M estimates of the specifications (1) to (8), the retrospective model averaging estimate of y_t, and the $\{HM_t\}$ series.

The rows labeled (1) to (8) under column two present the R^M measures of specifications (1) to (8) derived from currency-specific DLM regressions. The R^M measures show that the in-sample

24 For the retrospective model averaging estimate of y_t, $\hat{n}_t = \Sigma_{k=1}^{K} \pi_{t|T,k} n_{t,k}$ is the number from model averaging $n_{t,k}$'s – the numbers of explanatory variables of the K specifications in the model space – with the retrospective model probabilities $\pi_{t|T,k}$'s

performance varies across exchange rates and sample periods. In the full sample, the aggregate specifications (7) and (8) each accounts for the largest R^M measures for three exchange rate series. Their dominance is given up in the pre-crisis sample period.

In the pre-crisis sample, specification (6) garners the highest R^M measure for the CHF, EUR and GBP exchange rates, the monetary model based specification (4) for the AUD and JPY exchange rates, and the carry-trade strategy based specification (2) for CAD. Note that specification (6) includes explanatory variables that are mostly advocated in the post-crisis period, and CAD is not a typical carry trade currency. These eight specifications have difficulty in modeling the AUD exchange rate – even the largest R^M measure is negative.[25]

In the post-crisis period, the aggregate specification (7) regains its good in-sample performance and has the highest R^M measure for the AUD, CAD, EUR and JPY exchange rates, the specifications (8) and (5) deliver similar good in-sample performance for the GBP exchange rate, and the specification (6) yields the largest R^M measure for the CHF exchange rate series. Compared with Table 1, results in Table 2 show a more diverse pattern of good in-sample performance amongst these eight specifications.

The row labeled "MA" gives the R^M measures generated by the retrospective model averaging estimate of y_t

$$\hat{y}_t^{DMA} = \Sigma_{k=1}^{K} \pi_{t|T,k} \boldsymbol{z}'_{t,k} \hat{\boldsymbol{\theta}}_{t|T,k}\,, \qquad (12)$$

where $\pi_{t|T,k}$ is the retrospective model probability, $\mathbf{z}_{t,k}$ is the vector of explanatory variables, and $\hat{\boldsymbol{\theta}}_{t|T,k}$ is the retrospective parameter estimate of model k (k = 1, …, K) from DLM. One salient feature of model averaging is that, given model uncertainty, it uses data-based time-varying weights ($\pi_{t|T,k}$s) that encapsulate model importance to aggregate DLM regression results from individual models. Model averaging with time-varying weights accommodates models displaying time-varying influences on exchange rate dynamics.

Results under the rows labeled "MA" indicate, in our exercise, the implications of using the model averaging estimates. The good performance of model averaging estimates mainly shows up in the post-crisis sample. Specifically, apart from the JPY exchange rate, the model averaging estimate yields an R^M measure larger than (or equal to) those from specifications (1) to (8) in the

25 It is possible to obtain a negative R^M measure from nonlinear estimation processes.

post-crisis sample. The number of cases of relatively good performance drops to three in the pre-crisis sample and one in the full sample. While model averaging can improve in-sample performance, the improvement is not a foregone conclusion. The improvement is time dependent and exchange rate specific, and different variables contribute to the improvement for different exchange rates and in different sample periods.

The R^M measure generated by the $\{HM_t\}$ series is reported under the row labeled "HM." Recall that HM_t is the time-varying model specification with the largest retrospective model probability ($\pi_{t|T,h}$) at time t among the set of K=16,384 model specifications. Among the specifications in Table 2, the $\{HM_t\}$ series gives the largest R^M measures for all the exchange rate series in the three sample periods. That is, the specifications with the largest model probabilities also have the largest R^M measures and explain the most in-sample variations of exchange rates.

4.1.3 Model Specifications with the Largest Model Probabilities

What are the empirical model specifications included in the $\{HM_t\}$ series? It is obvious from Figure 2 that, for the six exchange rates, none of the individual specifications (1) to (8) has attained the largest retrospective model probability ($\pi_{t|T,h}$).

Figure 3 and Table 3 offer some information about the model specifications in the $\{HM_t\}$ series. The histogram plots in Figure 3a affirm that the model specifications in HM_t are different across exchange rates. The mode of the number of explanatory variables (excluding the intercept term) of $\{HM_t\}$, except CAD and CHF, is nine and different from the numbers of explanatory variables in specifications (1) to (8). Apart from the JPY exchange rate, the smallest number of explanatory variables in HM_t is six and is larger than the numbers in specifications (1) to (3). These observations are in accordance with the weak performance of specifications (1) to (8); especially specifications (1) to (3) presented in Figure 2 and Tables 1 and 2.

Table 3a presents, for each exchange rate, the model specification that appears most often in its $\{HM_t\}$ series. The frequency of occurrence is given in column two. The modes in Figure 3a are based on the number of explanatory variables in models, and different models can have the same number of explanatory variables. That is, the mode gives the upper bound of the frequency of the model specification that appears most often in the $\{HM_t\}$ series.

The model specifications that appeared most frequently have different combinations of economic and financial factors. The inter-country productivity differential $\tilde{w}_t$ and the liquidity measure l_t are, respectively, the only economic factor and financial factor that appear in all these six specifications. The fraction of the {HM_t} series accounted by the corresponding specification in the Table is relatively small and ranges from 18.7% (CAD case) to 6.6% (GBP case).

Figure 3b plots the number of explanatory variables in HM_t against time. It shows that the specification of HM_t is quite unstable as the change in the number of explanatory variables can be larger than one, and different exchange rates exhibit dissimilar patterns of changes and numbers of explanatory variables. Note that different model specifications can have the same number of explanatory variables; that is, the Figure indicates a lower bound of the variability of HM_t.

Table 3b presents the frequencies at which HM_t experiences a change in its specification. The frequency of changes is in the range of 44% to 54.9% in the full sample, 46.4% to 65.4% in the pre-crisis period, and 37.3% to 52.5% in the post-crisis period. Excluding the GBP case, the changes are more frequent in the pre-crisis than the post-crisis period. These change frequencies imply that the average duration of a model specification is about 2 periods; that is, model switching is quite pronounced and is a key feature for these exchange rates during the sample period.

It is useful to repeat that our primary goal is to investigate the challenge of explaining exchange rate movements rather than determining which model best explains them.

In sum, our empirical results indicate that the in-sample performance depends on the choices of model probabilities or R^M measures, sample periods, and exchange rates. Individual model specifications (1) to (6) generally perform worse than the aggregate specifications (7) and (8). The DMA approach can enhance in-sample performance, though this enhancement is not consistently observed across all sample periods and exchange rates.

Neither the individual model specifications (1) to (8) nor the model averaging specification yields the highest model probability or R^M measure. Although these selected model specifications (and explanatory variables) are grounded in various economic theories, their explanatory power can be limited compared to the model specification that yields the highest model probability in our sample. Therefore, these selected model specifications are unlikely to be the “true” or “correct” models, making it difficult to rely on them to explain exchange rates.

Additionally, individual exchange rates often exhibit shifts in the model specification that yields the highest model probability. These results further complicate the task of explaining exchange rates. The changing relevance of factors driving exchange rates and the time-varying impacts of these factors likely contribute to the frequent switching of the HM_t structure.

4.2 Individual Explanatory Variables

In this subsection, we examine the estimation results pertaining to the 14 explanatory variables. We analyze the DMA results because we do not have a strong prior on which empirical specification is the "best" among the large set of competing alternatives. Indeed, we anticipate a high level of model uncertainty that prevents unambiguous evidence of a single exchange rate specification that dominates all other competing specifications significantly. To address model uncertainty, we adopt model averaging to incorporate information from all possible model specifications and alleviate the mishap of selecting an inappropriate specification.

4.2.1 Retrospective Posterior Inclusion Probability (PIP)

We use the PIP derived from the DMA procedure to infer how likely a variable should be in the (true) model and the relevance of a variable in explaining exchange rate movements, and the prospect of the variable is a scapegoat (Bacchetta and Van Wincoop, 2004).

The PIP of the *i*-th parameter θ_i is $PIP_t^{DMA}(\theta_i) = \Sigma_{k=1}^{K} \pi_{t|T,k} I_k\left(\theta_i\right)$, where $I_k\left(\theta_i\right)$ is the indicator function that equals 1 if θ_i is included in the *k*-th model.

Figure 4 plots the PIPs of each variable for the six exchange rates. The lines 0.5 and 0.75 are included for references – a PIP value within the range indicates the corresponding variable has an acceptable effect (Kass and Raftery, 1995; Havranek *et al.*, 2015). There are a few observations. First, the dissimilarity of PIP time paths is quite apparent. In addition to marked variability across variables, the PIP time path of an explanatory variable can vary greatly across exchange rates. The likelihood of a variable to be a relevant explanatory factor is widely dispersed across time and exchange rates.

Second, apart from the TED_t variable, the occurrences of PIPs of these variables less than 0.5 outnumber those larger than 0.75; that is, the chance of these explanatory variables to have a substantial effect is less than they are not "important." For instance, the PIP of the lagged exchange rate Δs_{t-1} is below 0.5 for these exchange rates at various periods within the sample period. The $\Delta\tilde{m}_t$, $\Delta\tilde{y}_t$, and $RVar_t$ variables have a relatively high concentration of PIP-below-0.5 cases in the latter part of the sample periods. The CHF and EUR are the two exchange rates that have these cases for the three explanatory variables, while JPY, GBP, AUD and CAD have these cases for some of these three explanatory variables. On the other hand, some variables including $\Delta\tilde{m}_t$, $\Delta\tilde{y}_t$, $\Delta\tilde{i}_t$, $\Delta\tilde{\psi}_t$, TED_t, $RVar_t$, l_t, and q_{t-1} sporadically yield a PIP larger than 0.75; that is, these variables exhibit a substantial effect for these exchange rates at different times.

Third, the PIP of an explanatory variable can experience some large movements, at least, for some exchange rates at some time. Instead of listing all these occurrences, we note a few examples. For instance, the AUD and CAD exchange rates witness the PIPs of the money variable $\Delta\tilde{m}_t$ exhibiting large shifts around, respectively, 2003, 2015, and 2019, and the output variable $\Delta\tilde{y}_t$ displaying jumps around 2007 and 2018. The interest differential variable $\Delta\tilde{i}_t$ of the AUD exchange rate shows a big increase in its PIP beyond the 0.8 level around 2005. Other big PIP shifts include the cases of $\Delta\tilde{\psi}_t$ of EUR, TED_t of CAD and JPY, $RVar_t$ of EUR, and l_t of AUD, CHF and EUR. It is also noted that the swing in the PIP can be uni-directional or bi-directional. Two examples are a) the PIP of Δs_{t-1} for GBP declines steadily from above 0.6 to below 0.5, and b) the PIP of q_{t-1} for CHF springs above 0.75 before dropping below 0.5.

Visually, Figure 4 illustrates the PIPs of these explanatory variables have sizable variability over time and between exchange rates. Based on the information content of the data sample, PIPs indicate the likelihood of a variable to be in a model for describing exchange rate movements. A drastic shift in the market perception of the relevance and importance of a variable in explaining exchange rates can induce a big swing in its PIP. In view of this, PIP can be an indirect measure of the presence of a scapegoat (Bacchetta and Van Wincoop, 2004), or how likely a variable is a scapegoat. Our results indicate that a variable can be a scapegoat for one exchange rate but not for others, or for different exchange rates at different periods. Which variable that plays the role of a scapegoat in all probability is exchange rate specific, and its occurrence and intensity are likely to be non-uniform across exchange rates.

Plausibly, PIP = 0.5 is a relatively weak support for the relevance of a variable. Table 4 summarizes the fractions of individual explanatory variables that have a PIP larger than 0.625 – the mid-point of the 0.5-to-0.75 range in the full sample, the pre-crisis period, and the post-crisis period. In general, Table 4 buttresses the basic observations from Figure 4; the empirical relevance as indicated by PIPs of these selected variables is exchange-rate specific and can vary considerably in different periods. For instance, while the output variable $\Delta\tilde{y}_t$ has a high frequency of PIPs larger than 0.625 for the AUD exchange rate in the three sample periods, it displays a relatively low frequency or even zero frequency for the other five exchange rates.

In the full sample, the percentages of cases in which the financial factors (vix_t, TED_t, $RVar_t$, l_t, q_{t-1}) have PIPs larger than 0.625 are in general larger than the economic factors. The liquidity measure l_t in particular has a PIP larger than 0.625 in all the six exchange rates with frequencies ranging from 0.132 to 0.648. Among the economic factors, $\Delta\tilde{m}_t$, $\Delta\tilde{y}_t$ and $\Delta\tilde{i}_t$ have PIPs larger than 0.625 in four of the six exchange rates – though four economic factors distribute differently between the four exchange rates. The economic factor TB_t receives the weakest empirical support; it has a PIP larger than 0.625 in only one of the six exchange rates.

These explanatory variables – apart from $\tilde{i}_{t-1}$, Δs_{t-1} and TB_t – tend to have a non-zero frequency of PIP above 0.625 across exchange rates more often in the post-crisis than in the pre-crisis period. If the role of a scapegoat is indicated by a PIP above 0.625, then these variables – except $\tilde{i}_{t-1}$, Δs_{t-1} and TB_t – are more likely to be viewed as a scapegoat of an exchange rate in the post-crisis than in the pre-crisis period.

Both the plots and summary statistics of PIP estimates indicate that the relevance and importance of these explanatory variables are unevenly distributed and unstable over time. The PIPs exhibit large variations which are non-synchronized between exchange rates. Our findings suggest a variable can be a scapegoat and deemed relevant for explaining an exchange rate during a specific period. However, the scapegoat role is both exchange rate and time period specific. An example is the trade balance variable TB_t based on the 0.625 PIP threshold – it is "relevant" for the EUR exchange rate during the pre-crisis period but not for the post-crisis period and not for other exchange rates.

In passing, we note that the number of variables displaying a substantial effect (that is, having a PIP in the range of 0.75 to 0.95) is markedly lower than the one displaying an acceptable effect. Appendix C shows that $\Delta\tilde{m}_t$, $\Delta\tilde{y}_t$, $\Delta\tilde{i}_t$, and $\Delta\tilde{\psi}_t$ are the economic factors that have a PIP larger than 0.75 in some time intervals, and vix_t is the only financial factor that does not have a

PIP larger than 0.75. The empirical evidence of the occurrence of a scapegoat (effect) depends on the choice of the PIP threshold – the higher the threshold, the lower the frequency of occurrence. The occurrences of the scapegoat phenomenon implied by a PIP larger than 0.75 are, again, unevenly distributed across periods and exchange rates.

4.2.2 Dynamic Model Averaging Estimates

While the PIP of an explanatory variable is a barometer of its empirical likelihood to be included in the (true) model, the coefficient estimate appraises its marginal impact on the exchange rate. The dynamic model averaging estimate of θ_{it}, the *i*-th parameter at time *t*, is given by

$$\hat{\theta}_{it}^{DMA} = \Sigma_{k=1}^{K} \pi_{t|T,k} \hat{\theta}_{it|T,k} , \qquad (13)$$

where $\hat{\theta}_{it|T,k}$ is the retrospective estimate in model *k* that includes the parameter. Table 5 offers information for each explanatory variable on the average and variability of its dynamic model averaging estimates based on the average and the standard error of $\{\hat{\theta}_{it}^{DMA}\}_{t=1,\cdots,T}$, the time series of the dynamic model averaging estimate of θ_{it}.

Table 5 shows that these averages of dynamic model averaging estimates exhibit sizeable variations across exchange rates and sample periods.[26] Apart from q_{t-1}, the average coefficient estimates of these explanatory factors have different signs for different exchange rates and even in different sample periods of an exchange rate.

Consider the money variable $\Delta\tilde{m}_t$ which has a theoretical positive effect implied by the monetary model of exchange rate determination. It displays opposing effects in the pre- and post-crisis periods on the AUD, CHF and JPY exchange rates, and a negative effect on the GBP exchange rate. Another economic factor $\Delta\tilde{y}_t$ – the output variable – also gives similar bewildering results. While it exerts a positive impact on the AUD exchange rate,[27] $\Delta\tilde{y}_t$ displays opposing effects on the CAD, EUR, GBP and JPY exchange rates in the pre- and post-crisis periods. The other economic factors $\Delta\tilde{p}_t$, $\tilde{i}_{t-1}$, Δs_{t-1}, $\Delta\tilde{i}_t$, $\Delta\tilde{\psi}_t$, TB_t, and $\Delta\tilde{w}_t$ exhibit similar baffling results. The financial factors vix_t, TED_t, $RVar_t$, and l_t also yield non-uniform effects across exchange

26 Appendix D presents the DLM estimation results of specifications (1) to (8).

27 Recall that, for the AUD exchange rate, $\Delta\tilde{y}_t$ has a high frequency of PIPs larger than 0.625.

rates and time periods, albeit with a different level of dispersion. As noted earlier, q_{t-1} is the only explanatory variable that has a negative effect for these exchange rates in the exercise.

The numbers presented in the round parentheses underneath the averages of dynamic model averaging estimates are the standard errors calculated from $\{\hat{\theta}_{it}^{DMA}\}_{t=1,\cdots,T}$, the time series of dynamic model averaging estimates. The "bold" font denotes the ratio of average to standard error is larger than 1.96, and is used to indicate a "significant" marginal effect of the dynamic model averaging estimates. Table 5 shows that the groups of significant dynamic model averaging estimates in different sample periods are quite different. The full sample period typically yields the smallest number of significant estimates, while the pre-crisis period yields the largest count. In the full sample period, the number of significant dynamic model averaging estimates ranges from two for the CAD and GBP exchange rates to six for the CHF exchange rate and, in the pre-crisis sample period, seven for the CAD exchange rate and 11 for the CHF exchange rate.

Individual significant estimates, apart from Δs_{t-1}, $\Delta\tilde{\psi}_t$ and q_{t-1}, have different signs in different exchange rates and/or in different sample periods; these results are hard to reconcile with the effects of these variables implied by standard models. For instance, the significant dynamic model averaging coefficient estimates of $\Delta\tilde{p}_t$ (the change of inter-country price differentials) for the CHF, EUR and JPY exchange rates are negative while the parameter value under PPP is one. Even for Δs_{t-1}, $\Delta\tilde{\psi}_t$ and q_{t-1}, they do not have a ratio of average to standard error larger than 1.96 for all the exchange rates or in all sample periods. For instance, the inflation variable $\Delta\tilde{\psi}_t$ has a ratio larger than 1.96 for the GBP exchange rate only in the post-crisis period, and for the AUD, CHF, and EUR exchange rates in the three sample periods.[28]

Either the averages of dynamic model averaging estimates or estimates with an average-to-standard-error ratio larger than 1.96 reveal the substantial non-uniformity of these averages of dynamic model averaging estimates. It is difficult to construct a common and stable exchange rate specification for these exchange rates since these explanatory variables have different effects on different exchange rates and in different time periods. Each exchange rate tends to have its own

28 Note that the occurrences of the PIP larger than 0.625 (Table 4) do not necessarily match those of the ratio of average to standard error larger than 1.96 (Table 5).

set of explanatory variables which is prone to vary over time. Individual explanatory variables can display dissimilar effects on and levels of relevance for different exchange rates.

Table 5 is based on the average and standard error of $\{\hat{\theta}_{it}^{DMA}\}_{t=1,\cdots,T}$, the time series of dynamic model averaging estimates. If $\hat{\theta}_{it}^{DMA}$ is rather stable over time, its ratio of average to standard error can be larger than 1.96 even $\hat{\theta}_{it}^{DMA}$ is insignificant at each point of time; that is the ratio does not necessarily reflect the estimation uncertainty associated with $\hat{\theta}_{it|T,k}$ given by its variance $\text{var}(\hat{\theta}_{it|T,k})$. Appendix E presents, for each exchange rate, graphs of $\hat{\theta}_{it}^{DMA}$ and its 95% credible interval based on its variance (Hoeting, *et al.*, 1999).

A striking observation is that the 95% credible intervals are consistently wide throughout the sample period and always encompass the zero point for all explanatory variables and exchange rates. These credible intervals suggest that the information content of the data regarding the relationships between exchange rates and these explanatory variables is limited. There is a high level of sampling uncertainty surrounding these coefficient estimates at each point in time, and the data do not provide clear and unambiguous estimates of the effects of these explanatory variables.

The findings on PIPs and dynamic model averaging estimates provide valuable insights into the relevance and impact of explanatory variables on exchange rates. PIPs reveal that the relevance of individual variables can fluctuate greatly over time and is in accordance with the scapegoat hypothesis, which refers to the volatile nature of market sentiments and shifting of perceived determinants of exchange rates. As indicated by dynamic model averaging estimates, the strength of the relationship between exchange rates and their explanatory variables depends on exchange rates and time periods. The uncertainty surrounding coefficient estimates makes it challenging to pinpoint the precise impacts of these explanatory variables on exchange rates.

The heterogeneous effects, particularly when the impact of a variable exhibits different signs for different exchange rates at different times, complicate the development of an exchange rate model for all exchange rates at all times. This variability also poses challenges for interpreting the scapegoat hypothesis using PIPs. For instance, if we consider $RVar_t$ and l_t as potential scapegoats, the differing signs of their coefficient estimates suggest that market participants hold conflicting views on their marginal impacts on different exchange rates. Overall, both PIPs and dynamic model averaging estimates underscore the difficulty of constructing a comprehensive model or assigning a single scapegoat to explain all exchange rates across all time periods.

4.3 PPP

The PPP is the basic element of the eight empirical exchange rate specifications discussed in Section 2. While there is support for its validity as a long-run equilibrium exchange rate condition, PPP typically does not hold perfectly in short-run.[29] The coefficient estimates ($\hat{\beta}_t$s) of the change of inter-country price differentials ($\Delta\tilde{p}_t$) in Table 5 and specification (1) in Appendix D do not provide unequivocal evidence for PPP. Arguably, the use of quarterly data does not reveal the long-run PPP condition because at this data frequency exchange rates are affected by other economic and financial factors.

Does the inclusion of economic and financial variables in specifications (2) to (8) help to improve the empirical evidence for PPP in quarterly data? Table 6 compares the time-varying DLM estimate $\hat{\beta}_t$ – the coefficient estimate of $\Delta\tilde{p}_t$ – from the PPP specification (1) with those from other model specifications. For each model specification, we compute a) the average of the deviations of estimate $\hat{\beta}_t$ from 1: $\{\hat{\beta}_t - 1\}_{t=1,\ldots,T}$, and b) the average of the absolute differences of estimate $\hat{\beta}_t$ and 1: $\{|\hat{\beta}_t - 1|\}_{t=1,\ldots,T}$, where "1" is the parameter value under the long-run PPP condition. Column 1 in the Table lists the model specifications; they are specifications (1) to (8), and the specification obtained via dynamic model averaging (DMA).

Table 6a shows that the average deviation of $\hat{\beta}_t$ from 1 is quite scattered, and can be either positive or negative. For each exchange rate, there is at least one specification that yields an average deviation less than that of the specification (1). Some economic or financial factors can be used to enhance the empirical evidence of PPP. The variables which strengthen the evidence are exchange rate specific. In the current exercise, specification (6) that has gained attention since the 2007-8 GFC yields the smallest average deviation for three exchange rates; namely, AUD, CHF and JPY. Nevertheless, the average deviations under specification (6) in these three cases are still quite large. On the other hand, the DMA specification for CAD, specification (2) for EUR and

29 Ca'Zorzi *et al*. (2016), Ca'Zorzi and Rubaszek (2020), Cheung *et al*. (2019), Froot and Rogoff (1995), Jackson and Magkonis (2024), Taylor and Taylor (2004).

specification (3) for GBP generate average deviations that are quite close to zero. These three specifications provide relatively strong PPP evidence even with quarterly data for these three exchange rates.

The deviations of $\hat{\beta}_t$ from 1 can have different signs over time, and they can offset each other in the process of averaging. Table 6b reports the averages of absolute deviations of $\hat{\beta}_t$ from 1. The results also indicate economic and financial factors can be used to strengthen PPP results. Apart from AUD and GBP, each of the remaining four exchange rates has the same specification that generates the smallest average deviation and smallest average of absolute deviations. Specifically, the DMA specification yields the smallest averages of absolute deviations for AUD, CAD, and GBP, the specification (6) for CHF and JPY, and the specification (2) for EUR. Compared with Table 6a, the extent of improvement is worse in four exchange rates and the same for the remaining two. The difference reflects the offsetting effect building into the process of averaging deviations.

Do the HM_t specifications that yield the highest retrospective model probability provide good support for the PPP hypothesis? Unfortunately, our exercise does not offer a meaningful comparison because not all the specifications in the $\{HM_t\}$ series include the $\Delta\tilde{p}_t$ variable. The number of HM_t specifications that include $\hat{\beta}_t$ ranges from 25 (GBP) to 91 (CAD). For the sake of completeness, the rows labeled "HM" present the two average measures based on the HM_t specifications that include $\hat{\beta}_t$. The HM_t specifications yield neither an average deviation nor an average of absolute deviations smaller than the corresponding best ones in the Table.

Our results highlight the significant roles that economic and financial factors play in explaining parts of PPP violations in quarterly data. However, the set of variables that mitigate PPP deviations depends on exchange rates and measures of deviations. This finding reinforces the exchange rate-specific behavior observed previously.

5. Additional Analyses

We explore the in-sample performance under alternative circumstances. Specifically, we consider the results derived from (a) data on period-average exchange rates, (b) the case in which q_{t-1} is replaced with s_{t-1}, and (c) the first differences of vix_t, $RVar_t$ and l_t.

5.1 Quarterly Averages of Daily Exchange Rates

The serial correlation of quarterly averages of daily exchange rates is larger than that of end-of-quarter exchange rates in our sample – an observation in accordance with common belief. We replicated the DLM-and-DMA estimation exercise using quarterly averages of daily exchange rates and, for brevity, included the results in Appendix F.[30] There are a few main observations.

On the occurrence of the highest model probabilities among the quarterly averages of daily exchange rates, the aggregate specifications (7) and (8) evenly split the top spots: three exchange rates each for each of the three sample periods. Among the individual model specifications (1) to (6), specifications (5) and (6) almost evenly account for the occurrence of the highest model probabilities (Table F1 in Appendix F).

The R^M measures in Table 2 and Table F2 offer a comparative view of the ability to explain quarter-average and end-of-period exchange rates. In the full sample and post-crisis sample periods, apart from JPY-Specification-(2) in the full sample period and AUD-Specification-(6) in the post-crisis sample period, model specifications of changes in quarter-average exchange rates offer better explanatory power than specifications of changes in end-of-period exchange rates. That is, it is relatively easier to describe the variability of changes in quarter-average exchange rates than changes in end-of-period exchange rates. The pre-crisis sample tells a slightly different story – it is in general more challenging to explain, say, the quarter-average CHF movements.

Tables F3a and F3b show that, similar to the case of end-of-quarter exchange rates, the model specification HM_t that gives the highest model probability changes quite frequently over time, and the model specification that appeared most often in the $\{HM_t\}$ series accounts for only a small proportion of the series. Further, the model specification that appeared most often in the $\{HM_t\}$ series is different from and tends to have more explanatory variables than the corresponding end-of-quarter exchange rate specification. The inter-country price differential and the lagged real exchange rate are the only economic and financial factors that appear in the model specifications that appeared most often in the $\{HM_t\}$ series.

In sum, the choice of end-of-quarter or quarter-average exchange rates affects the relative in-sample performance of model specifications.

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30 The quarter-averages of real exchange rates, lagged exchange rate changes, interest rate differentials, changes of interest rate differentials, VIXs, TEDs, and the liquidity measure are used in modeling changes in quarter-average exchange rates. Results are summarized following the layout of Tables 1 to 6 in the text.

Compared with end-of-quarter data, specifications of quarter-average exchange rates tend to yield stronger evidence on the empirical relevance of individual explanatory variables and their empirical linkages with exchange rates. On a net basis, the explanatory variables garner more cases in which the PIP is larger than 0.625; indicating a high level of empirical relevance (Table F4).

Using the ratio of the average and the standard error retrieved from the series $\{\hat{\theta}_{it}^{DMA}\}_{t=1,\cdots,T}$ to indicate the marginal "significance" of the *i*-th explanatory variable, the total number of significant variables under the quarter-average exchange rate specifications is larger than the one under the cases of end-of-quarter exchange rates. These significant variables have different distributions across the three sample periods and six exchange rate series. Similar to the case of end-of-quarter exchange rate data, the average coefficient estimates display different signs for different exchange rates and even in different sample periods of an exchange rate.

Again, if the variance $\{\text{var}(\hat{\theta}_{it|T,k})\}$ of $\hat{\theta}_{it|T,k}$, instead of the standard error of $\{\hat{\theta}_{it}^{DMA}\}_{t=1,\cdots,T}$, is used to assess the sampling uncertainty of $\hat{\theta}_{it}^{DMA}$, then the 95% credible intervals of the coefficient estimates of these explanatory variables always include the zero point for all time periods – indicating that the data are not informative enough to yield unambiguous effects. The weak data information result is similar to that of the changes in the end-of-quarter exchange rates.

These results on PIPs and dynamic model averaging estimates reinforce the qualitative observations from end-of-quarter exchange rates; for these exchange rates, the relevance, importance, and marginal effect of explanatory variables come and go at different times. The ebb and flow of relevance and strength can reflect the fickleness of market sentiments on exchange rates and the subsequent shifting of perceived determinants that underlie the scapegoat hypothesis.

The use of quarter-average data also suggests the potential role of economic and financial factors in explaining (some) PPP violations. The variables that improve the PPP evidence depend on exchange rates and measures of deviations and are usually not the same as those identified for end-of-quarter data. The specification and/or variables that help to explain PPP deviations depend on whether period average or end-of-period data are considered.

In summary, empirical exchange rate specifications tend to better explain quarter-average exchange rates than end-of-quarter exchange rates. However, both data types yield qualitatively similar in-sample performance.

5.2 Replacing Lagged Real Exchange Rate with Lagged Exchange Rate

In this subsection, we explore the implications of replacing the lagged exchange rate q_{t-1} with the lagged exchange rate s_{t-1}. The replacement affects model specifications (6) to (8) and, thus, the formation of dynamic model averaging estimates and the {HM_t} series.[31] Again, for brevity, we included the results of replacing q_{t-1} with s_{t-1} (and skipped those of model specifications (1) to (5) that are not affected by the variable replacement) in Appendix G.

The in-sample performance of these exchange rate model specifications is not materially affected by the choice of s_{t-1} or q_{t-1}. The relative performance of model specifications is essentially the same under either s_{t-1} or q_{t-1} (Tables G1 and G2). For the CAD and EUR exchange rates, the use of q_{t-1} or s_{t-1} yields the same model specifications that appeared most often in the {HM_t} series. The model specification that has the highest model probability (HM_t) also displays frequent changes over time (G3a and G3b).

Despite some variations in the estimates, replacing q_{t-1} with s_{t-1} does not qualitatively change the evidence on the empirical relevance of individual explanatory variables and their impacts on exchange rates. The results related to s_{t-1} are largely comparable to those of q_{t-1}. The relevance and importance of individual explanatory variables, and the strength of their impacts display non-uniform shifts at different times for individual exchange rates. (Tables G4 and G5).

The use of q_{t-1} or s_{t-1} gives similar results of PPP deviations and essentially the same implications for strengthening empirical PPP evidence - the specification and the variables that improve the PPP evidence are exchange-rate and time period specific.

Overall, the in-sample performance of these exchange rate model specifications is largely independent of the choice of the lagged exchange rate q_{t-1} or the lagged exchange rate s_{t-1}.

5.3 First Differences of vix_t, $RVar_t$ and l_t

31 Engel and Wu (2023a), for instance, include s_{t-1} as an explanatory variable.

Some studies used the first differences of vix_t, $RVar_t$ and l_t: the proxies for market uncertainty and liquidity to study exchange rates.[32] In this subsection, we assess the implications of using these first differences for the in-sample performance analysis and present the related results in Appendix H. Since these three variables are not in specifications (1) to (5), we did not include them in Appendix H.

The use of the first differences, instead of the levels, of these three proxy variables tends to bring down the retrospective model probabilities of model specification (6) relative to, say, specification (5) (Table H1) and, apart from a few cases, lowers its modified adjusted R-2 estimates (Table H2). The use of the first differences tends to weaken the in-sample performance.

The results on the model specifications that appeared most often in the $\{HM_t\}$ series (Table H3a), the variables with frequencies of PIPs larger than 0.625 (Table H4), and the DMA coefficient estimates (Table H5) indicate that the relevance and significance of the differences of vix_t and l_t are relatively worse than their level counterparts, while the first difference of $RVar_t$ is relatively better than its level counterpart.

While the use of the first differences of vix_t, $RVar_t$ and l_t improves the empirical PPP evidence, the improvement is weaker than the one associated with the levels of these proxy variables.

Replacing the levels with the first differences of vix_t, $RVar_t$ and l_t has some marginal impacts on the relevance and significance of other explanatory variables. Nevertheless, the impacts on other explanatory variables are exchange rate and time period specific.

In summary, the in-sample performance of proxies for market uncertainty and liquidity (vix_t, $RVar_t$ and l_t) is influenced by whether their levels or first differences are employed. Despite this, the overall conclusions regarding the in-sample performance of exchange rate model specifications remain qualitatively unchanged.

6. Concluding Remarks

Employing a Bayesian dynamic linear model together with a modified dynamic model averaging method, we analyze the in-sample performance of exchange-rate models across 16,384

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32 See, for example, Engel and Wu (2023b, 2024), Fatum and Yamamoto (2016), and Habib and Stracca (2012).

specifications constructed from 14 canonical and newly introduced explanatory variables. The empirical framework allows for inferences on the evolving relevance and significance of these variables.

Our main findings are as follows:

a. The model specification that best describes an exchange rate is specific to each exchange rate and changes frequently over time. Neither some common exchange rate models nor the one based on model averaging estimates is among the "best" model specifications.

b. The relevance of individual explanatory variables is unstable over time and varies across currencies. Variables can have differing and even opposing effects on different exchange rates and in different periods. The magnitude of their interactions with exchange rates, as shown by coefficient estimates and significance levels, also varies over time and across currencies.

c. Combinations of economic and financial variables can strengthen empirical evidence for PPP, but the combination and extent of improvement are exchange rate specific.

These findings highlight the difficulty of identifying a universal exchange rate model that describes all exchange rates at all times. The scapegoat hypothesis, which posits frequent shifts in the relevance and significance of individual explanatory variables, may explain the high instability of the model specification that best describes an exchange rate. Nevertheless, the differential and at times opposing effects of these variables limit the ability of any single canonical model, or the scapegoat hypothesis alone, to account for all exchange rates across all periods.

Modeling period-average rather than period-end exchange rates generally yields better in-sample performance measures and can alter estimated interactions between exchange rates and their determinants. Replacing the lagged real exchange rate with the lagged nominal exchange rate, and using the proxies for uncertainty and liquidity with their first differences, produced some quantitative changes. These modifications do not, however, change the qualitative conclusion that a single exchange rate specification cannot reliably describe all exchange rates across all periods.

Compared with out-of-sample forecasting exercises, which test model usefulness with new data and provide market-relevant guidance, in-sample performance evaluation sheds light on the relevance of theoretical frameworks and the interactions between economic variables and exchange rates. Beyond assessing model soundness and practicality, information on in-sample interactions has implications for exchange-rate risk management and policymaking. Stable and uniform interactions between exchange rates and their determinants facilitate the formulation of exchange rate models, risk management strategies, and economic policy design.

Our empirical findings present substantial challenges for modeling exchange-rate dynamics and for using models in risk management and policymaking. The instability and non-uniformity of relationships across exchange rates undermine the reliability and credibility of traditional empirical models that rely on historical, stable relationships to infer behavior and produce forecasts. Beyond canonical economic factors, exchange-rate movements also depend on contemporaneous market conditions and sentiment.

Although the explanatory variables in our exercise are well-established, they do not exhaust the influences on exchange rates. Nonetheless, expanding the variable set imposes a substantial computational burden. This study does not address why some variables act as scapegoats; investigating that question lies beyond the current scope. Future research should develop flexible and robust modeling techniques capable of accommodating rapid and frequent shifts in the roles of explanatory factors.

References

Bacchetta, Philippe, and Eric Van Wincoop. "A scapegoat model of exchange-rate fluctuations." American Economic Review 94.2 (2004): 114-118.

Bacchetta, Philippe, and Eric Van Wincoop. "Can information heterogeneity explain the exchange rate determination puzzle?." American Economic Review 96.3 (2006): 552-576.

Baillie, Richard T., and Rehim Kilic. "Do asymmetric and nonlinear adjustments explain the forward premium anomaly?" Journal of International Money and Finance 25.1 (2006): 22-47.

Balassa, Bela. "The purchasing-power parity doctrine: a reappraisal." Journal of Political Economy 72.6 (1964): 584-596.

Barndorff-Nielsen, Ole E., and Neil Shephard. "Econometrics of testing for jumps in financial economics using bipower variation." Journal of Financial Econometrics 4.1 (2006): 1-30.

Barndorff-Nielsen, Ole E., Silvia Kinnebrouk, and Neil Shephard. “Measuring Downside Risk: Realised Semivariance.” Volatility and Time Series Econometrics: Essays in Honor of Robert F. Engle, edited by T. Bollerslev et al., Oxford University Press, 2010.

Beckmann, Joscha, and Rainer Schüssler. "Forecasting exchange rates under parameter and model uncertainty." Journal of International Money and Finance 60 (2016): 267-288.

Burnside, Craig, Bing Han, David Hirshleifer, and Tracy Yue Wang. "Investor overconfidence and the forward premium puzzle." The Review of Economic Studies 78 2 (2011): 523-558.

Busch, Thomas, Bent Jesper Christensen, and Morten Ørregaard Nielsen. "The role of implied volatility in forecasting future realized volatility and jumps in foreign exchange, stock, and bond markets." Journal of Econometrics 160.1 (2011): 48-57.

Byrne, Joseph P., Dimitris Korobilis, and Pinho J. Ribeiro. "On the sources of uncertainty in exchange rate predictability." International Economic Review 59.1 (2018): 329-357.

Ca’Zorzi, Michele, and Michał Rubaszek. "Exchange rate forecasting on a napkin." Journal of International Money and Finance 104 (2020): 102168.

Ca’Zorzi, Michele, Jakub Muck, and Michal Rubaszek. "Real exchange rate forecasting and PPP: This time the random walk loses." Open Economies Review 27 (2016): 585-609.

Cheung, Yin-Wong, and Kon S. Lai. "Long-run purchasing power parity during the recent float." Journal of International Economics 34.1-2 (1993): 181-192.

Cheung, Yin-Wong, and Menzie David Chinn. "Currency traders and exchange rate dynamics: a survey of the US market." Journal of International Money and Finance 20.4 (2001): 439-471.

Cheung, Yin-Wong, and Wenhao Wang. "Uncovered interest rate parity redux: Non-uniform effects." Journal of Empirical Finance 67 (2022): 133-151.

Cheung, Yin-Wong, Menzie D. Chinn, and Antonio Garcia Pascual. "Empirical exchange rate models of the nineties: Are any fit to survive?" Journal of International Money and Finance 24.7 (2005): 1150-1175.

Cheung, Yin‐Wong, Menzie D. Chinn, and Ian W. Marsh. "How do UK‐based foreign exchange dealers think their market operates?" International Journal of Finance & Economics 9.4 (2004): 289-306.

Cheung, Yin-Wong, Menzie D. Chinn, Antonio Garcia Pascual, and Yi Zhang. "Exchange rate prediction redux: New models, new data, new currencies." Journal of International Money and Finance 95 (2019): 332-362.

Chinn, Menzie D. "The (partial) rehabilitation of interest rate parity in the floating rate era: Longer horizons, alternative expectations, and emerging markets." Journal of International Money and Finance 25.1 (2006): 7-21.

Chinn, Menzie D., and Guy Meredith. "Monetary policy and long-horizon uncovered interest parity." IMF staff papers 51.3 (2004): 409-430.

Chinn, Menzie D., and Richard A. Meese. "Banking on currency forecasts: how predictable is change in money?" Journal of International Economics 38.1-2 (1995): 161-178.

Chinn, Menzie David. "Paper pushers or paper money? Empirical assessment of fiscal and monetary models of exchange rate determination." Journal of Policy Modeling 19.1 (1997): 51-78.

Clements, Kenneth W., and Jacob A. Frenkel. "Exchange rates, money, and relative prices: the dollar-pound in the 1920s." Journal of International Economics 10.2 (1980): 249-262.

Clements, Michael P., and David F. Hendry. "Evaluating a model by forecast performance." Oxford Bulletin of Economics and Statistics 67 (2005): 931-956.

De Grauwe, Paul, and Hans Dewachter. "A chaotic model of the exchange rate: the role of fundamentalists and chartists." Open Economies Review 4 (1993): 351-379.

Dornbusch, Rudiger. "Expectations and exchange rate dynamics." Journal of Political Economy 84.6 (1976): 1161-1176.

Du, Wenxin, Joanne Im, and Jesse Schreger. "The us treasury premium." Journal of International Economics 112 (2018): 167-181.

Engel, Charles, and Steve Pak Yeung Wu. "Forecasting the US Dollar in the 21st Century." Journal of International Economics 141 (2023a): 103715.

Engel, Charles, and Steve Pak Yeung Wu. "Liquidity and exchange rates: An empirical investigation." The Review of Economic Studies 90.5 (2023b): 2395-2438.

Engel, Charles, and Steve Pak Yeung Wu. Exchange Rate Models are Better than You Think, and Why They Didn't Work in the Old Days. No. w32808. National Bureau of Economic Research, 2024.

Engel, Charles. "Exchange rates and interest parity." Handbook of International Economics 4 (2014): 453-522.

Evans, Martin DD, and Richard K. Lyons. "Order flow and exchange rate dynamics." Journal of Political Economy 110.1 (2002): 170-180.

Fama, Eugene F. "Forward and spot exchange rates." Journal of Monetary Economics 14.3 (1984): 319-338.

Fatum, Rasmus, and Yohei Yamamoto. "Intra-safe haven currency behavior during the global financial crisis." Journal of International Money and Finance 66 (2016): 49-64.

Frankel, Jeffrey A. "On the mark: A theory of floating exchange rates based on real interest differentials." The American Economic Review 69.4 (1979): 610-622.

Frankel, Jeffrey A., and Kenneth A. Froot. "Chartists, fundamentalists, and trading in the foreign exchange market." The American Economic Review 80.2 (1990): 181-185.

Fratzscher, Marcel, Dagfinn Rime, Lucio Sarno, and Gabriele Zinna. "The scapegoat theory of exchange rates: the first tests." Journal of Monetary Economics 70 (2015): 1-21.

Frenkel, Jacob A. "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence." The Scandinavian Journal of Economics (1976): 200-224.

Froot, Kenneth A., and Takatoshi Ito. "On the consistency of short-run and long-run exchange rate expectations." Journal of International Money and Finance 8.4 (1989): 487-510.

Habib, Maurizio M., and Livio Stracca. "Getting beyond carry trade: What makes a safe haven currency?" Journal of International Economics 87.1 (2012): 50-64.

Havranek, Tomas, Roman Horvath, Zuzana Irsova, and Marek Rusnak. "Cross-country heterogeneity in intertemporal substitution." Journal of International Economics 96.1 (2015): 100-118.

Hoeting, Jennifer A., David Madigan, Adrian E. Raftery, and Chris T. Volinsky. "Bayesian Model Averaging: A Tutorial." Statistical Science 14.4 (1999): 382-417.

Hooper, Peter, and John Morton. "Fluctuations in the dollar: A model of nominal and real exchange rate determination." Journal of International Money and Finance 1 (1982): 39-56.

Inoue, Atsushi, and Lutz Kilian. "In-sample or out-of-sample tests of predictability: Which one should we use?" Econometric Reviews 23.4 (2005): 371-402.

Jackson, Karen, and Georgios Magkonis. "Exchange rate predictability: Fact or fiction?" Journal of International Money and Finance 142 (2024): 103026.

Jiang, Zhengyang, Arvind Krishnamurthy, and Hanno Lustig. "Foreign safe asset demand and the dollar exchange rate." The Journal of Finance 76.3 (2021): 1049-1089.

Kass, Robert E., and Adrian E. Raftery. "Bayes factors." Journal of the American Statistical Association 90.430 (1995): 773-795.

Koop, Gary, and Dimitris Korobilis. "Forecasting inflation using dynamic model averaging." International Economic Review 53.3 (2012): 867-886.

Lilley, Andrew, Matteo Maggiori, Brent Neiman, and Jesse Schreger. "Exchange rate reconnect." Review of Economics and Statistics 104.4 (2022): 845-855.

Lucas Jr, Robert E. "Interest rates and currency prices in a two-country world." Journal of Monetary Economics 10.3 (1982): 335-359.

Mark, Nelson C., and Donggyu Sul. "Nominal exchange rates and monetary fundamentals: evidence from a small post-Bretton Woods panel." Journal of International Economics 53.1 (2001): 29-52.

Mark, Nelson. "Exchange Rates and Fundamentals: Evidence on Long-Horizon Predictability." American Economic Review 85.1 (1995): 201-18.

Meese, Richard A., and Kenneth Rogoff. "Empirical exchange rate models of the seventies: Do they fit out of sample?" Journal of International Economics 14.1-2 (1983a): 3-24.

Meese, Richard, and Kenneth Rogoff. "The Out-of-Sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification?" Exchange Rates and International Macroeconomics. University of Chicago Press, (1983b): 67-112.

Meese, Richard A., and Andrew K. Rose. "An empirical assessment of non-linearities in models of exchange rate determination." The Review of Economic Studies 58.3 (1991): 603-619.

Miranda-Agrippino, Silvia, and Hélene Rey. "US monetary policy and the global financial cycle." The Review of Economic Studies 87.6 (2020): 2754-2776.

Officer, Lawrence H. Purchasing Power Parity and Exchange Rates: Theory, Evidence and Relevance. Greenwich, Conn. : JAI Press, 1982.

Raftery, Adrian E., Miroslav Kárný, and Pavel Ettler. "Online prediction under model uncertainty via dynamic model averaging: Application to a cold rolling mill." Technometrics 52.1 (2010): 52-66.

Rapach, David E., and Mark E. Wohar. "Testing the monetary model of exchange rate determination: new evidence from a century of data." Journal of International Economics 58.2 (2002): 359-385.

Rossi, Barbara. "Exchange rate predictability." Journal of Economic Literature 51.4 (2013): 1063-1119.

Samuelson, Paul A. "Theoretical notes on trade problems." The Review of Economics and Statistics (1964): 145-154.

Sarno, Lucio. "Towards a solution to the puzzles in exchange rate economics: Where do we stand?" Canadian Journal of Economics/Revue canadienne d'économique 38.3 (2005): 673-708.

Sarno, Lucio, and Giorgio Valente. "Exchange rates and fundamentals: Footloose or evolving relationship?" Journal of the European Economic Association 7.4 (2009): 786-830.

Shmueli, Galit. "To Explain or to Predict?" Statistical Science 25.3 (2010): 289-310.

Stockman, Alan C. "A theory of exchange rate determination." Journal of Political Economy 88.4 (1980): 673-698.

Taylor, Alan M., and Mark P. Taylor. "The purchasing power parity debate." Journal of Economic Perspectives 18.4 (2002): 135-158.

West, Mike, and Jeff Harrison. “Bayesian Forecasting and Dynamic Models.” New York, Springer series in statistics, 1997.

Working, Holbrook. "Note on the Correlation of First Differences of Averages in a Random Chain." Econometrica 28.4 (1960): 916.

Table 1. Retrospective Model Probabilities

	M	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample Period	(1)	0.017	0.052	0.031	0.037	0.042	0.038
(1999Q1-2023Q3)	(2)	0.029	0.069	0.038	0.062	0.061	0.046
	(3)	0.018	0.057	0.037	0.043	0.039	0.040
	(4)	0.211	0.117	0.098	0.201	0.105	0.143
	(5)	0.252	0.172	0.115	0.219	0.119	0.164
	(6)	0.073	0.198	0.263	0.327	0.276	0.251
	(7)	0.544	0.466	0.308	0.648	0.405	0.605
	(8)	0.416	0.253	0.263	0.499	0.307	0.456
Pre-crisis Period	(1)	0.026	0.148	0.018	0.019	0.089	0.026
(1999Q1-2007Q2)	(2)	0.056	0.195	0.027	0.042	0.111	0.040
	(3)	0.026	0.162	0.027	0.026	0.080	0.025
	(4)	0.213	0.269	0.058	0.134	0.140	0.155
	(5)	0.232	0.318	0.076	0.130	0.136	0.157
	(6)	0.062	0.258	0.456	0.348	0.537	0.322
	(7)	0.591	0.476	0.597	0.711	0.587	0.704
	(8)	0.649	0.550	0.563	0.692	0.486	0.562
Post-crisis Period	(1)	0.010	0.012	0.039	0.046	0.020	0.044
(2009Q1-2023Q3)	(2)	0.011	0.017	0.045	0.070	0.033	0.050
	(3)	0.012	0.013	0.044	0.051	0.019	0.049
	(4)	0.205	0.056	0.116	0.230	0.094	0.143
	(5)	0.256	0.105	0.131	0.261	0.117	0.175
	(6)	0.077	0.181	0.174	0.320	0.157	0.215
	(7)	0.509	0.473	0.151	0.618	0.307	0.551
	(8)	0.302	0.117	0.104	0.411	0.218	0.394

Notes: The Table presents the averages of the $\pi_{t|T,i}/\pi_{t|T,h}$ ratio, which measures the retrospective model probability of the *i*-th model specification relative to that of HM_t in the full-period sample, pre-crisis period, and post-crisis period. The model specifications (1) to (8) presented in Section 2 are listed under the column labeled "M." In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included. The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY).

Table 2. Modified Adjusted R-2 Estimates

	M	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample Period (1999Q1-2023Q3)	(1)	0.066	0.157	0.062	0.049	0.161	0.099
	(2)	0.096	0.181	0.084	0.120	0.229	0.120
	(3)	0.084	0.167	0.067	0.055	0.166	0.106
	(4)	0.360	0.284	0.160	0.235	0.315	0.243
	(5)	0.377	0.329	0.188	0.246	0.332	0.272
	(6)	0.250	0.351	0.238	0.284	0.352	0.244
	(7)	0.453	0.458	0.300	0.380	0.455	0.372
	(8)	0.451	0.444	0.301	0.375	0.471	0.378
	MA	0.433	0.442	0.313	0.341	0.452	0.328
	HM	0.537	0.565	0.439	0.490	0.560	0.441
Pre-crisis Period (1999Q1-2007Q2)	(1)	-0.104	0.072	0.055	-0.052	-0.059	-0.013
	(2)	-0.010	0.096	0.086	0.085	-0.040	0.048
	(3)	-0.129	0.045	0.029	-0.081	-0.093	-0.054
	(4)	-0.001	0.061	0.017	0.051	-0.159	0.184
	(5)	-0.035	0.040	0.042	0.011	-0.216	0.155
	(6)	-0.208	-0.024	0.301	0.223	0.144	0.097
	(7)	-0.118	-0.183	0.201	0.125	0.011	0.158
	(8)	-0.275	-0.248	0.099	0.000	-0.109	0.058
	MA	0.084	0.061	0.274	0.243	0.108	0.204
	HM	0.165	0.260	0.369	0.386	0.357	0.317
Post-crisis Period (2009Q1-2023Q3)	(1)	0.067	0.079	-0.013	0.039	0.025	0.010
	(2)	0.050	0.098	-0.025	0.052	0.021	0.012
	(3)	0.092	0.088	0.004	0.045	0.009	0.019
	(4)	0.306	0.157	-0.014	0.159	0.120	0.100
	(5)	0.323	0.175	0.003	0.175	0.149	0.140
	(6)	0.291	0.244	0.036	0.241	0.083	0.049
	(7)	0.352	0.332	-0.025	0.265	0.136	0.164
	(8)	0.341	0.243	-0.030	0.249	0.149	0.146
	MA	0.373	0.335	0.167	0.265	0.210	0.157
	HM	0.485	0.454	0.257	0.404	0.320	0.253

Notes: The modified adjusted R-2 estimates, R^{M}'s, of the specifications (1) to (8), the retrospective model averaging estimate of y_t, and the $\{HM_t\}$ series are given in rows labeled (1) to (8), "MA" and "HM," respectively, under column "M" in the full-period sample, pre-crisis period, and post-crisis period. In the full sample and pre-crisis subsample, the first eight quarters (initial period, 1999Q1-2000Q4) are not included in calculating these ratios. The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY).

Table 3a. The Model Specification with Most Frequent Presence in the {HM$_t$} series

FX Codes	#	Model Specification
AUD	11	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_6\Delta\tilde{w}_t + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
CAD	17	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_{72} TED_t + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
CHF	11	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_{73} RVar_t + \delta_8 l_t + \varepsilon_t$
EUR	13	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi} + \delta_6\Delta\tilde{w}_t + \delta_{72} TED_t + \delta_{73} RVar + \delta_8 l_t + \delta_9 q_{t-1} + \varepsilon_t$
GBP	6	$\Delta s_t = \alpha + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_{72} TED_t + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
JPY	15	$\Delta s_t = \alpha + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_{72} TED_t + \delta_{73} RVar_t + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$

Notes: The model specification appears the most often in the {HM$_t$} series is listed for each exchange rate. Column one gives the exchange rate codes and Column two is the number of times the model specification appeared in the {HM$_t$} series. The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY). The explanatory variables are intercountry inflation differential ($\Delta\tilde{p}_t$), changes in intercountry money supply differential ($\Delta\tilde{m}_t$), intercountry GDP growth differential ($\Delta\tilde{y}_t$), changes in intercountry interest rate differential ($\Delta\tilde{i}_t$), changes in intercountry inflation differential changes ($\Delta\tilde{\psi}_t$), the US trade balance (TB_t), changes in intercountry productivity differential ($\Delta\tilde{w}_t$), VIX index (vix_t), TED (TED_t), realized variance ($RVar_t$), liquidity (l_t), lagged real exchange rate (q_{t-1}), intercountry interest rate differential ($\tilde{i}_{t-1}$) and lagged exchange rate changes (Δs_{t-1}).

Table 3b. Change Frequency of HM$_t$ Model Specifications

	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample	54.9%	48.4%	44.0%	46.2%	51.6%	46.2%
Pre-Crisis	65.4%	65.4%	53.8%	61.5%	46.2%	61.5%
Post-Crisis	50.8%	45.8%	37.3%	37.3%	52.5%	37.3%

Notes: The Table lists the frequency of changes in the model specification of the {HM$_t$} series for each exchange rate and each sample period. The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY).

Table 4. Frequencies of PIP Larger than 0.625

	$\Delta\tilde{p}_t$	$\Delta\tilde{m}_t$	$\Delta\tilde{y}_t$	$\Delta\tilde{i}_t$	$\Delta\tilde{\psi}_t$	TB_t	$\Delta\tilde{w}_t$	vix_t	TED_t	$RVar_t$	l_t	q_{t-1}	$\tilde{i}_{t-1}$	Δs_{t-1}
Full Sample Period (1999Q1-2023Q3)														
AUD	0	0.220	0.923	0.242	0	0	0	0.319	0	0	0.132	0.231	0.165	0
CAD	0.165	0.319	0.209	0	0	0	0.385	0.264	0.593	0.033	0.220	0	0.187	0
CHF	0.088	0	0.066	0	0.099	0	0	0.066	0.121	0.022	0.648	0.505	0	0.022
EUR	0	0.011	0.121	0.044	0.407	0.011	0	0	0	0	0.176	0.835	0	0.044
GBP	0	0.011	0	0.088	0.593	0	0.011	0.022	0.033	0.165	0.242	0.429	0	0
JPY	0	0	0	0.473	0	0	0.066	0.022	0.297	0.165	0.429	0.132	0	0
Pre-crisis Period (1999Q1-2007Q2)														
AUD	0	0.308	0.808	0	0	0	0	0	0	0	0	0.231	0.577	0
CAD	0	0	0	0	0	0	0	0	0	0.115	0	0	0.538	0
CHF	0	0	0	0	0	0	0	0.231	0.423	0	0.731	0.923	0	0.077
EUR	0	0	0	0	0.385	0.038	0	0	0	0	0.346	0.923	0	0.154
GBP	0	0	0	0	0	0	0	0	0	0	0.808	0	0	0
JPY	0	0	0	0.577	0	0	0	0.077	0	0	0.923	0	0	0
Post-crisis Period (2009Q1-2023Q3)														
AUD	0	0.203	1.000	0.322	0	0	0	0.492	0	0	0.169	0.254	0	0
CAD	0.254	0.492	0.322	0	0	0	0.492	0.407	0.881	0	0.339	0	0	0
CHF	0.102	0	0.068	0	0.119	0	0	0	0	0	0.644	0.271	0	0
EUR	0	0.017	0.186	0.068	0.458	0	0	0	0	0	0.119	0.814	0	0
GBP	0	0.017	0	0.102	0.915	0	0.017	0	0.034	0.186	0	0.627	0	0
JPY	0	0	0	0.475	0	0	0.102	0	0.390	0.203	0.186	0.203	0	0

Notes: The table presents for each exchange rate the frequencies that the PIP of a variable is larger than 0.625 in the full-period sample, pre-crisis subsample and post-crisis subsample. The exchange rate codes are listed in the first column. In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included. The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY). The explanatory variables are intercountry inflation differential ($\Delta\tilde{p}_t$), changes in intercountry money supply differential ($\Delta\tilde{m}_t$), intercountry GDP growth differential ($\Delta\tilde{y}_t$), changes in intercountry interest rate differential ($\Delta\tilde{i}_t$), changes in intercountry inflation differential changes ($\Delta\tilde{\psi}_t$), the US trade balance (TB_t), changes in intercountry productivity differential ($\Delta\tilde{w}_t$), VIX index (vix_t), TED (TED_t), realized variance ($RVar_t$), liquidity (l_t), lagged real exchange rate (q_{t-1}), intercountry interest rate differential ($\tilde{i}_{t-1}$) and lagged exchange rate changes (Δs_{t-1}).

Table 5 Summary of DMA Coefficient Estimates

	AUD			CAD			CHF			EUR			GBP			JPY		
	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post
$\Delta\tilde{p}_t$	0.017	0.048	-0.005	1.024	0.376	1.280	-1.507	-2.167	-1.080	-0.147	-0.744	0.187	0.131	-0.355	0.314	-0.669	-1.223	-0.371
	(0.588)	(0.074)	(0.730)	(0.708)	(0.542)	**(0.622)**	**(0.720)**	**(0.120)**	**(0.459)**	(0.542)	**(0.330)**	(0.288)	(0.401)	(0.255)	(0.266)	(0.583)	**(0.514)**	(0.390)
$\Delta\tilde{m}_t$	0.048	-0.337	0.239	0.420	0.283	0.489	-0.011	-0.082	0.018	0.099	0.047	0.136	-0.232	-0.392	-0.138	0.008	-0.292	0.165
	(0.340)	**(0.074)**	(0.263)	(0.242)	**(0.105)**	**(0.268)**	(0.056)	(0.062)	(0.013)	(0.117)	(0.084)	(0.117)	(0.188)	**(0.045)**	(0.165)	(0.264)	**(0.043)**	(0.189)
$\Delta\tilde{y}_t$	1.344	1.655	1.167	-0.241	0.104	-0.412	-0.354	-0.496	-0.237	-0.258	0.069	-0.362	0.016	-0.085	0.063	-0.051	0.176	-0.144
	(0.665)	**(0.248)**	(0.746)	(0.307)	(0.067)	(0.239)	(0.321)	**(0.111)**	(0.315)	(0.315)	(0.253)	(0.222)	(0.138)	**(0.040)**	(0.147)	(0.157)	(0.109)	**(0.019)**
$\Delta\tilde{i}_t$	-4.675	-1.900	-5.520	0.765	1.118	0.789	-1.596	-1.871	-1.244	-2.326	0.606	-3.668	-4.822	-2.090	-5.993	5.766	7.352	5.218
	(2.665)	(1.933)	**(1.773)**	(1.331)	(1.047)	(1.375)	(1.110)	**(0.928)**	(0.918)	(3.541)	(1.688)	(3.535)	(2.762)	(1.235)	**(2.525)**	**(2.320)**	**(1.449)**	**(2.398)**
$\Delta\tilde{\psi}_t$	0.863	0.902	0.859	0.284	-0.004	0.404	1.006	1.114	0.945	1.316	1.928	1.050	1.014	0.152	1.412	0.440	0.500	0.413
	(0.100)	**(0.101)**	**(0.089)**	(0.303)	(0.259)	(0.249)	**(0.183)**	**(0.102)**	**(0.176)**	**(0.602)**	**(0.426)**	**(0.488)**	(0.734)	(0.382)	**(0.523)**	(0.242)	(0.282)	(0.233)
TB_t	0.273	-0.267	0.519	0.257	0.300	0.237	0.221	0.416	0.126	0.445	0.621	0.368	0.278	0.224	0.305	-0.423	-0.706	-0.279
	(0.397)	(0.245)	**(0.159)**	**(0.076)**	**(0.089)**	**(0.064)**	(0.151)	**(0.085)**	(0.071)	**(0.183)**	**(0.076)**	**(0.171)**	(0.168)	**(0.047)**	(0.202)	(0.259)	**(0.044)**	(0.206)
$\Delta\tilde{w}_t$	-0.168	0.261	-0.388	-0.974	-1.010	-0.868	-0.146	-0.057	-0.206	0.068	0.043	0.093	0.289	-0.078	0.516	0.838	0.033	1.190
	(0.437)	**(0.108)**	(0.387)	**(0.488)**	**(0.171)**	(0.511)	(0.256)	(0.268)	(0.240)	(0.214)	(0.105)	(0.252)	(0.599)	(0.094)	(0.629)	(0.664)	(0.134)	**(0.504)**
vix_t	-0.018	-0.007	-0.024	-0.007	0.005	-0.013	0.002	0.020	-0.007	0.002	0.007	0.000	0.001	0.012	-0.004	0.002	0.010	-0.002
	(0.009)	**(0.001)**	**(0.005)**	(0.009)	**(0.003)**	**(0.003)**	(0.013)	**(0.009)**	**(0.003)**	(0.005)	**(0.004)**	(0.003)	(0.010)	**(0.005)**	(0.008)	(0.009)	(0.011)	(0.005)
TED_t	0.006	0.016	0.002	0.008	0.004	0.009	0.003	0.022	-0.006	-0.001	0.015	-0.008	0.015	0.018	0.013	-0.018	-0.013	-0.019
	(0.008)	**(0.003)**	(0.005)	(0.009)	(0.005)	(0.010)	(0.014)	**(0.010)**	**(0.002)**	(0.011)	**(0.007)**	**(0.002)**	**(0.005)**	**(0.002)**	**(0.006)**	**(0.005)**	**(0.004)**	**(0.003)**
$RVar_t$	0.205	0.803	-0.077	0.536	4.467	-1.163	-0.354	0.080	-0.492	0.151	3.740	-1.772	0.382	4.541	-1.353	1.059	2.450	0.154
	(0.430)	**(0.247)**	(0.120)	(2.661)	**(1.516)**	**(0.214)**	(0.653)	(0.490)	(0.646)	(3.154)	**(0.357)**	(2.158)	(2.869)	**(1.546)**	(0.862)	(1.670)	**(0.464)**	(1.292)
l_t	0.732	0.183	0.938	-0.838	-0.241	-1.171	-1.230	-1.495	-1.167	-1.753	-1.557	-1.896	-0.844	-1.573	-0.576	-0.579	-1.543	-0.246
	(0.444)	(0.215)	**(0.271)**	(0.685)	(0.174)	(0.627)	**(0.330)**	**(0.405)**	**(0.186)**	**(0.604)**	**(0.330)**	**(0.668)**	(0.557)	**(0.526)**	**(0.146)**	(0.972)	(0.964)	(0.673)
q_{t-1}	-0.052	-0.044	-0.059	-0.032	-0.008	-0.044	-0.101	-0.126	-0.090	-0.079	-0.097	-0.073	-0.058	-0.056	-0.057	-0.022	-0.020	-0.022
	(0.023)	**(0.011)**	**(0.024)**	(0.019)	**(0.004)**	**(0.012)**	**(0.026)**	**(0.012)**	**(0.024)**	**(0.016)**	**(0.017)**	**(0.006)**	**(0.017)**	**(0.011)**	**(0.019)**	**(0.010)**	**(0.004)**	(0.012)
$\tilde{i}_{t-1}$	-1.793	-2.692	-1.504	1.260	-2.281	2.951	-1.461	-1.754	-1.255	-0.218	-1.345	0.297	0.623	0.503	0.602	-0.362	-1.022	0.003
	(1.005)	**(1.091)**	**(0.702)**	(2.559)	**(0.806)**	**(1.079)**	**(0.523)**	**(0.194)**	**(0.511)**	(0.800)	**(0.505)**	(0.197)	(0.550)	(0.359)	(0.592)	(0.714)	**(0.114)**	(0.632)
Δs_{t-1}	-0.025	-0.012	-0.033	-0.028	-0.018	-0.036	-0.067	-0.085	-0.061	-0.034	-0.078	-0.017	0.037	0.018	0.045	-0.008	-0.031	0.005
	(0.017)	**(0.004)**	(0.017)	(0.021)	(0.026)	**(0.015)**	**(0.025)**	**(0.036)**	**(0.013)**	(0.038)	**(0.047)**	(0.010)	(0.021)	(0.021)	**(0.016)**	(0.021)	**(0.006)**	(0.014)

Notes: The first element of an exchange-rate-explanatory-factor cell is the average of the series of dynamic model averaging estimates, and the second element presented in the round parentheses is the standard error of the series of dynamic model averaging estimates. The "Full," "Pre," and "Post" columns present results from the full sample period (1999Q1-2023Q3), pre-crisis subsample period (1999Q1-2007Q2), and post-crisis subsample period (2009Q1-2023Q3). In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included. The numbers in bold denote the corresponding average-to-standard-error ratio is larger than 1.96. The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY). The explanatory variables are intercountry inflation differential ($\Delta\tilde{p}_t$), changes in intercountry money supply differential ($\Delta\tilde{m}_t$), intercountry GDP growth differential ($\Delta\tilde{y}_t$), changes in intercountry interest rate differential ($\Delta\tilde{i}_t$), changes in intercountry inflation differential changes ($\Delta\tilde{\psi}_t$), the US trade balance (TB_t), changes in intercountry productivity differential ($\Delta\tilde{w}_t$), VIX index (vix_t), TED (TED_t), realized variance ($RVar_t$), liquidity (l_t), lagged real exchange rate (q_{t-1}), intercountry interest rate differential ($\tilde{i}_{t-1}$) and lagged exchange rate changes (Δs_{t-1}).

Table 6a Average Deviations of the PPP Coefficient Estimates from Unity

	AUD	CAD	CHF	EUR	GBP	JPY
(1)	1.019	1.115	-2.549	-0.433	0.085	-2.369
(2)	0.973	1.057	-2.288	-0.005	0.382	-2.126
(3)	1.209	1.246	-2.335	-0.271	0.051	-2.315
(4)	-3.094	-0.507	-5.688	-3.101	-1.984	-3.167
(5)	-3.235	-0.917	-5.924	-3.386	-2.138	-3.910
(6)	0.713	1.433	-2.097	0.368	0.193	-1.281
(7)	-2.830	1.042	-5.409	-2.400	-1.658	-2.906
(8)	-2.129	0.902	-5.534	-2.424	-1.704	-2.593
DMA	-0.983	0.024	-2.507	-1.147	-0.869	-1.669
HM	-1.888	0.757	-4.565	-1.653	-0.989	-2.964

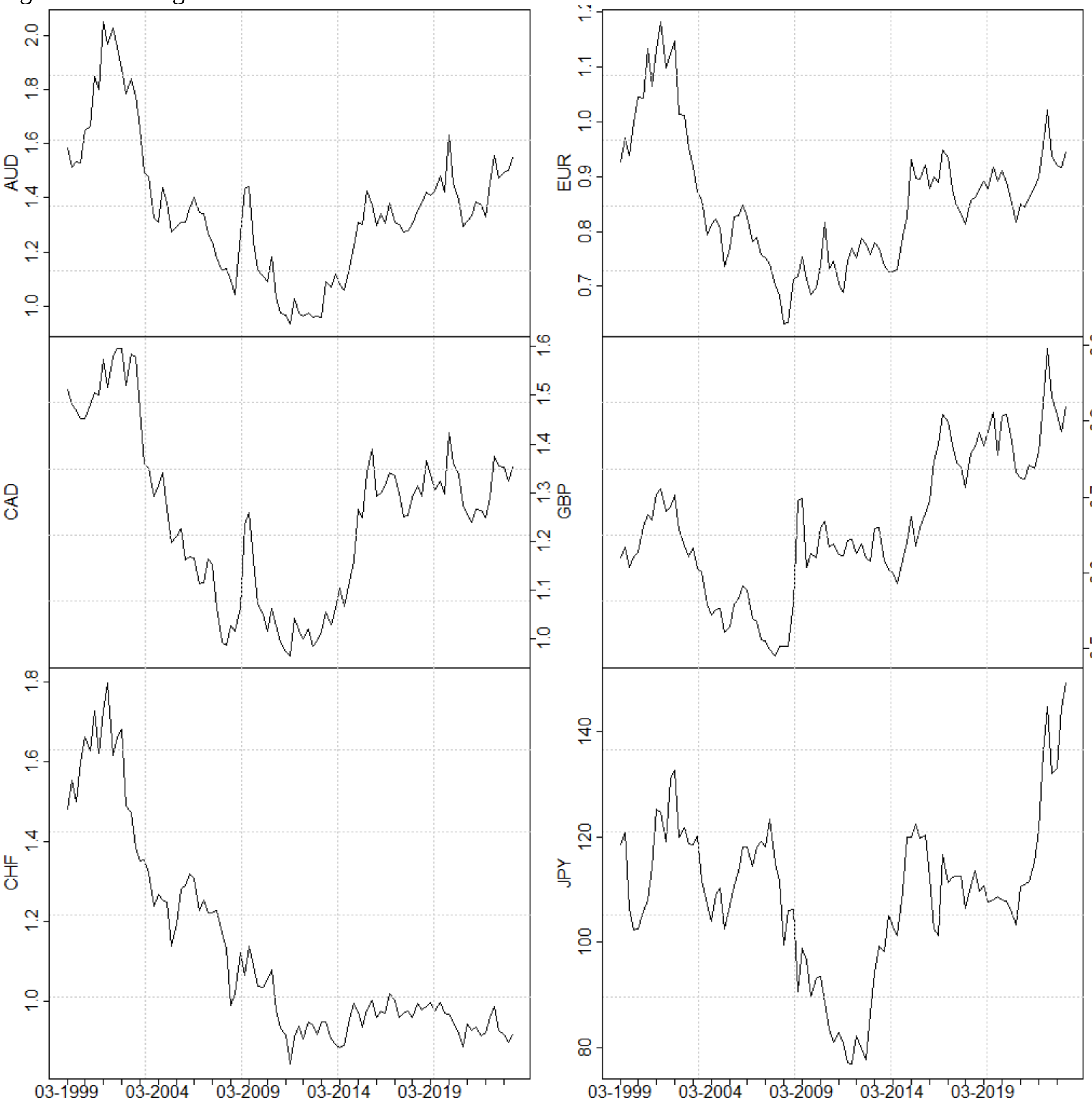
Notes: The Table presents the averages of the series $\{\beta_{i,t} - 1\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled (1) to (8), "MA" and "HM." The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY).

Table 6b Average Absolute Deviations of PPP Coefficient Estimates from Unity

	AUD	CAD	CHF	EUR	GBP	JPY
(1)	1.282	1.513	2.549	0.931	1.075	2.369
(2)	1.226	1.394	2.288	0.529	1.125	2.126
(3)	1.392	1.638	2.335	1.011	1.112	2.315
(4)	3.094	1.101	5.688	3.101	1.984	3.167
(5)	3.235	1.008	5.924	3.386	2.138	3.910
(6)	1.384	1.750	2.097	0.648	1.063	1.281
(7)	2.830	1.196	5.409	2.400	1.658	2.906
(8)	2.129	1.154	5.534	2.424	1.704	2.593
DMA	0.983	0.627	2.507	1.147	0.869	1.669
HM	2.060	1.313	4.565	1.687	1.179	2.964

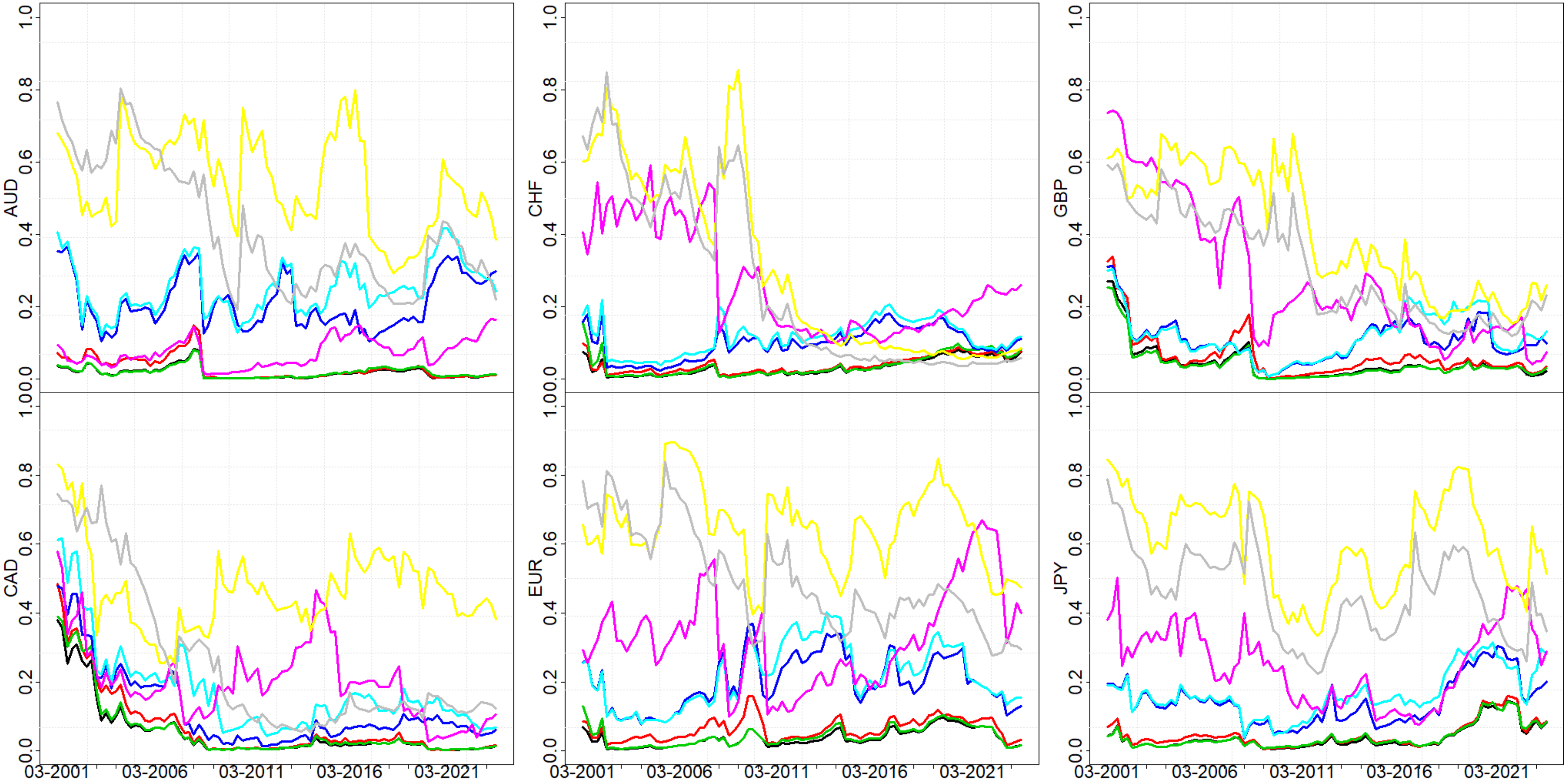
Notes: The Table presents the averages of the series $\{|\beta_{i,t} - 1|\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled (1) to (8), "MA" and "HM." The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY).

Figure 1. Exchange Rates



Notes: The Figure presents the US dollar exchange rates of the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY) for the period 1999Q1 to 2023Q3.

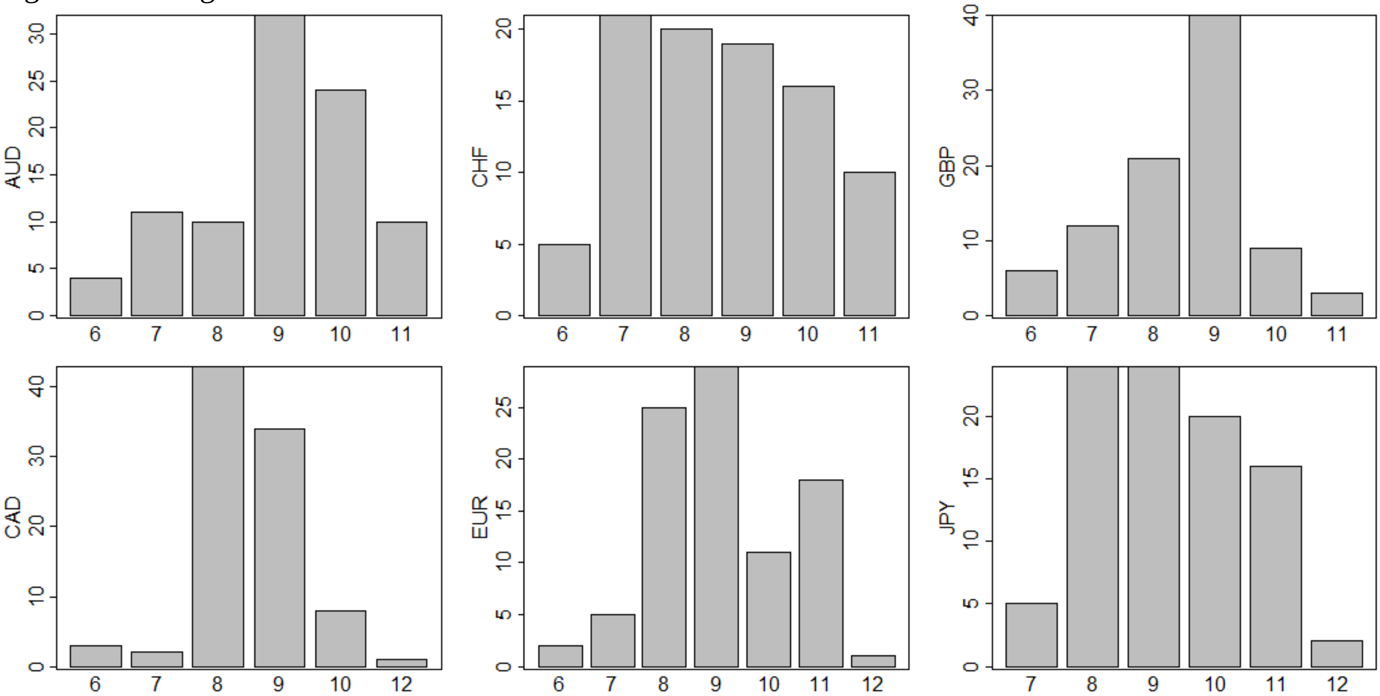
Figure 2. The Model Probability Ratios



Notes: The Figure graphs the ratio $\pi_{t|T,i}/\pi_{t|T,h}$ given by the retrospective model probability of the *i*-th model specification at time *t* relative to that of HM_t. The lines in the figure represent the following model specifications: Black line, model specification (1), Red line, model specification (2); Green line, model specification (3); Blue line, model specification (4); Cyan line, model specification (5); Magenta line, model specification (6); Yellow line, model specification (7); and Grey line, model specification (8). The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY).

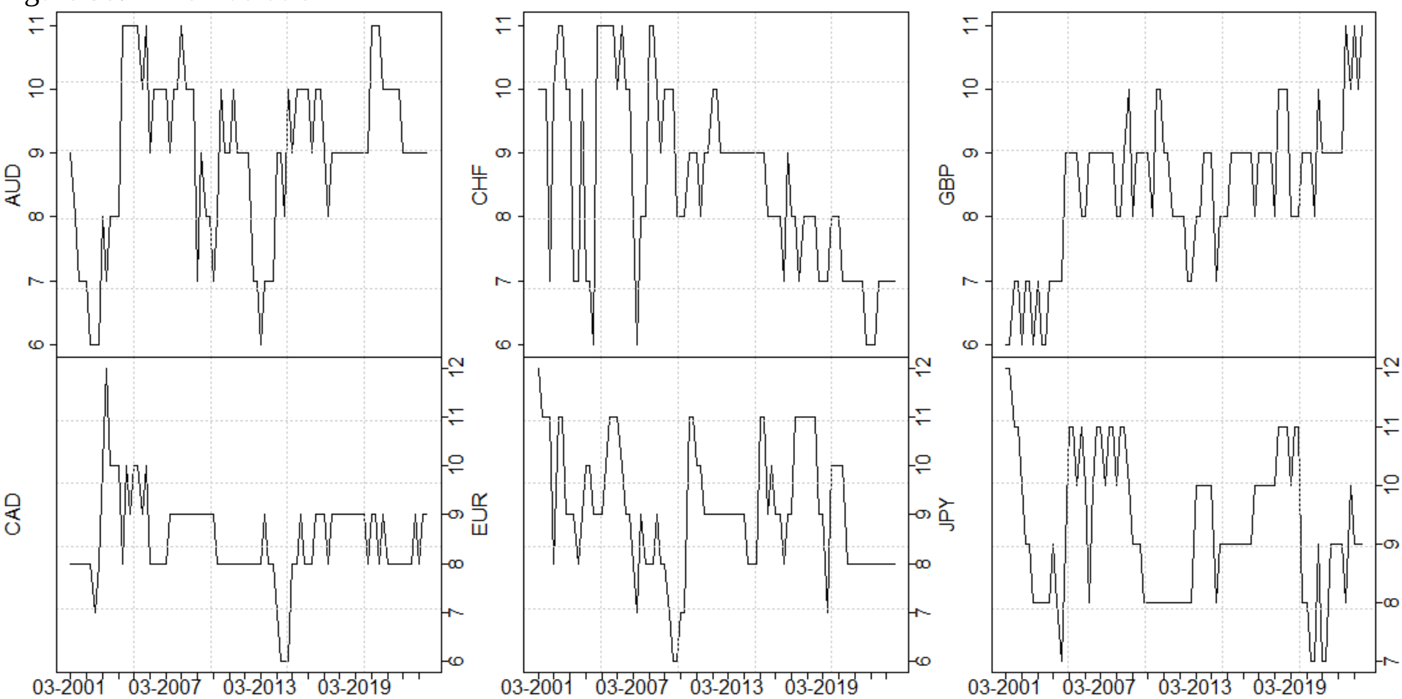
Figure 3. The Explanatory Variables in the $\{HM_t\}$ Series

Figure 3a. Histograms



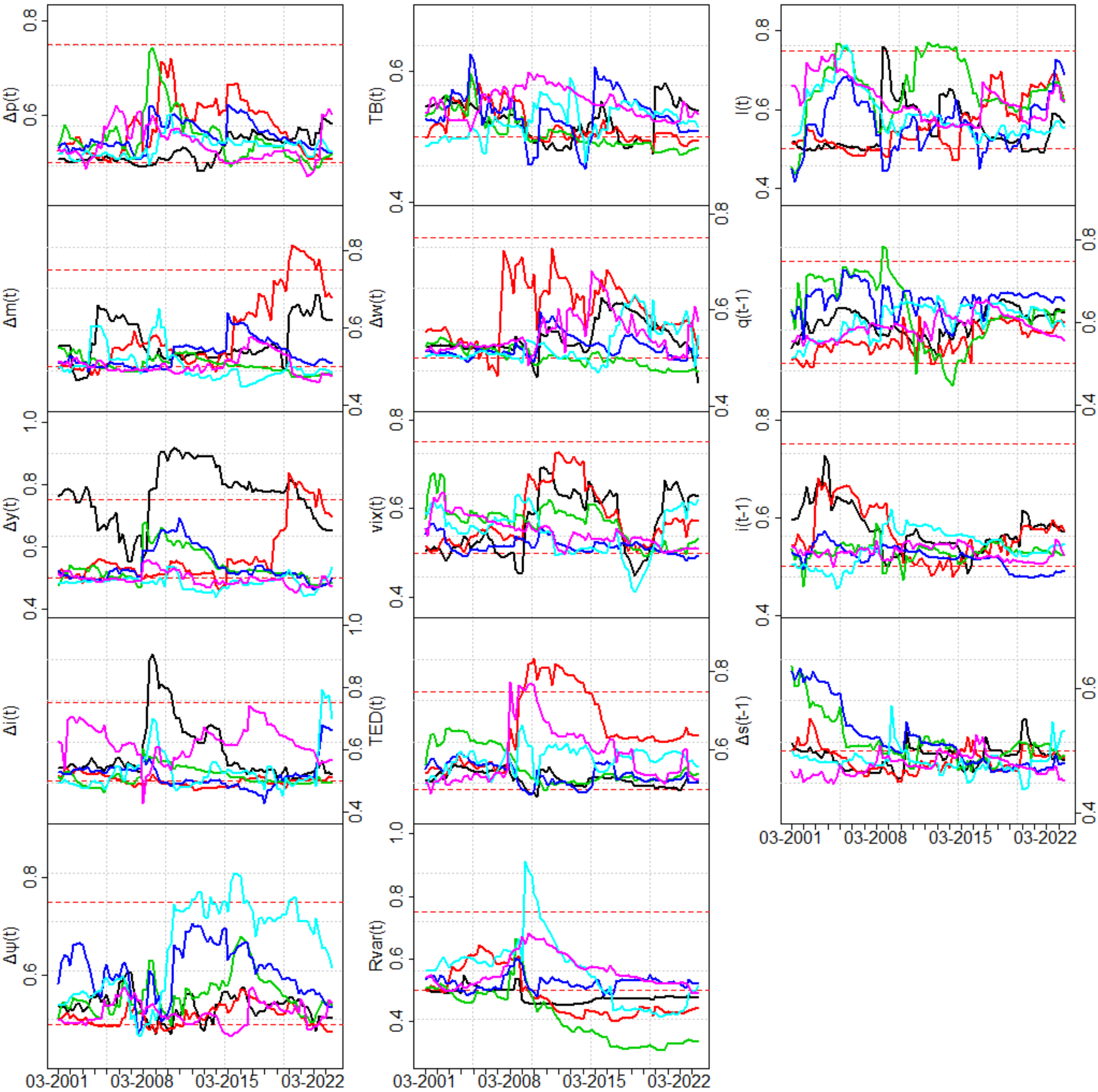
Notes: The vertical axis gives the number of occurrences and the horizon axis the number of variables in the HM_t specification. The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY).

Figure 3b. Time Evolution



Notes: The Figure traces, for each exchange rate, the evolution of the number of variables in the HM_t specification. The exchange rates against the US dollar are the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound GBP), and Japanese yen (JPY).

Figure 4 Posterior Inclusion Probabilities



Notes: The Figure plots the retrospective PIPs of the variables in modeling each exchange rate. The Black line is the PIP of the variable in AUD model, the Red line is the PIP of the variable in CAD model, the Green line is the PIP of the variable in CHF model, the Blue line is the PIP of the variable in EUR model, the Cyan line is the PIP of the variable in GBP model and the Magenta line is the PIP of the variable in JPY model. The variables labeled along the *y*-axis are intercountry inflation differential ($\Delta\tilde{p}_t$), changes in intercountry money supply differential ($\Delta\tilde{m}_t$), intercountry GDP growth differential ($\Delta\tilde{y}_t$), changes in intercountry interest rate differential ($\Delta\tilde{i}_t$), changes in intercountry inflation differential changes ($\Delta\tilde{\psi}_t$), the US trade balance (TB_t), changes in intercountry productivity differential ($\Delta\tilde{w}_t$), VIX index (vix_t), TED (TED_t), realized variance ($RVar_t$), liquidity (l_t), lagged real exchange rate (q_{t-1}), intercountry interest rate differential ($\tilde{i}_{t-1}$) and lagged exchange rate changes (Δs_{t-1}).

Appendix

Appendix A: Data

0. The sample period covers from the first quarter of 1999 to the third quarter of 2023.

1. The end-of-quarter US dollar exchange rates of Australian dollar, Canadian dollar, Swiss franc, the euro, British pound and Japanese yen are collected from the DataStream.

   The quarter-average exchange rate is the average of daily rates during the quarter.

2. The change of inter-country price differentials and the change of the inter-country inflation differentials are derived from data on the seasonally adjusted consumer price index from the IMF IFS database.

3. The 3-month inter-country interest rate differentials and the change of interest rate differentials are derived from the 3-month euro dollar and other G7 euro currency deposit rates from the Datastream.

4. The change of the inter-country differentials of money supply is based on the seasonally adjusted M2 data of the US, GB, JP, CH, and CA from the DataStream and the seasonally adjusted M3 data of AU and EU from the OECD database.

5. The change of the inter-country GDP differential is calculated using the quarterly nominal GDP data in local currencies from the IMF IFS database.

6. The trade balance variable is given by the US trade balance from the FRED normalized by the US GDP from the IMF IFS database.

7. The inter-country differential of GDP per capita is calculated using quarterly data interpolated from annual GDP per capita from the World Bank.

8. VIX_t is the logarithm of the end-of-quarter VIX observation from CBOE.

9. TED_t is the level of TED spread, which is the end-of-quarter TED data from FRED before January 21, 2022, and is constructed using the secured overnight financing rate and 3-month treasury bill rate after.

10. The realized variance is calculated using daily exchange rate changes from Datastream.

11. The liquidity measure is derived from data on forward and government bond rates from the Datastream.

12. The real exchange rate in log, q_{t-1}, is given by $q_{t-1} = s_{t-1} + \ln(P^*_{t-1}) - \ln(P_{t-1})$.

Appendix B. A Dynamic Model Averaging Framework for In Sample Analysis

We adopt a modified dynamic model averaging framework to conduct the empirical analysis. Specifically, we employ the dynamic linear model (DLM) to estimate the time-varying retrospective coefficient estimates, and the dynamic model averaging (DMA) procedure to conduct the model averaging analysis (Raftery *et al*., 2010; West and Harrison, 1997).

B.1 Dynamic Linear Model (DLM)

For clarity, we add the subscript "*k*" to the DLM regression given by (9) and (10) in the text to indicate the *k*-th model in the model space:

$$y_t = \boldsymbol{z}'_{t,k}\boldsymbol{\theta}_{t,k} + \varepsilon_{t,k}\,,\ \ \varepsilon_{t,k} \sim N\left(0, V_k\right), \tag{B.1.1}$$

$$\boldsymbol{\theta}_{t,k} = \boldsymbol{\theta}_{t-1,k} + \boldsymbol{w}_{t,k}\,,\ \ \boldsymbol{w}_{t,k} \sim N\left(0, \boldsymbol{W}_{t,k}\right). \tag{B.1.2}$$

Bayesian methods are used to recursively estimate the parameter vector θ. Let $Y_t = \{y_1, y_2, ..., y_t\}$, T be the number of observations, K is the number of models in the model space, and $\boldsymbol{\theta}_{t\text{-}1,k} \mid Y_{t-1} \sim N(\hat{\boldsymbol{\theta}}_{t-1|t-1,k}, \Sigma_{t-1|t-1,k})$ is the θ-estimate at time *t*-1 derived from information up to *t*-1. Then, given B.1.2,

$$\boldsymbol{\theta}_{t,k} \mid Y_{t-1} \sim N(\hat{\boldsymbol{\theta}}_{t-1|t-1,k}, \boldsymbol{R}_{t,k}), \tag{B.1.3}$$

where $\boldsymbol{R}_{t,k} \equiv \Sigma_{t-1|t-1,k} + \boldsymbol{W}_{t,k}$. Following Raftery *et al.* (2010), we set $\boldsymbol{W}_{t,k} = (1-\lambda)\lambda^{-1}\Sigma_{t-1|t-1,k}$, where the hyperparameter λ is also known as the "forgetting" factor, and obtain $\boldsymbol{R}_{t,k} = \lambda^{-1}\Sigma_{t-1|t-1,k}$. We set $\lambda = 0.95$ in our exercise following Cheung and Wang (2022) and Koop and Korobilis (2012).[33]

From B.1.3 and B.1.1, we have the distribution of the predicted y_t,

$$y_{t,k} \mid Y_{t-1} \sim N(\boldsymbol{z}'_{t,k}\hat{\boldsymbol{\theta}}_{t-1|t-1,k}, \hat{V}_{t-1|t-1,k} + \boldsymbol{z}'_{t,k}\boldsymbol{R}_{t,k}\boldsymbol{z}_{t,k}). \tag{B.1.4}$$

The estimate $\hat{V}_{.,k}$ is obtained via the exponentially weighted moving average (EWMA) setup; $\hat{V}_{t|t,k} = \kappa\hat{V}_{t-1|t-1,k} + (1-\kappa)(e_{t,k})^2$, where $e_{t,k} = y_t - \boldsymbol{z}'_{t,k}\hat{\boldsymbol{\theta}}_{t-1|t-1,k}$ (Koop and Korobilis, 2012).

Given the distributions of $y_{t,k} \mid Y_{t-1}$ and $\theta_{t,k} \mid Y_{t-1}$ (B.1.4 and B.1.3), the Bayes' theorem implies

$$\boldsymbol{\theta}_{t,k} \mid Y_t \sim N(\hat{\boldsymbol{\theta}}_{t|t,k}, \Sigma_{t|t,k}), \tag{B.1.5}$$

where $\hat{\boldsymbol{\theta}}_{t|t,k} = \hat{\boldsymbol{\theta}}_{t-1|t-1,k} + \boldsymbol{R}_{t,k}\boldsymbol{z}_{t,k}(\hat{V}_{t|t,k} + \boldsymbol{z}'_{t,k}\boldsymbol{R}_{t,k}\boldsymbol{z}_{t,k})^{-1}e_{t,k}$ and $\hat{\boldsymbol{\theta}}_{t|t,k} = \hat{\boldsymbol{\theta}}_{t-1|t-1,k} + \boldsymbol{R}_{t,k}\boldsymbol{z}_{t,k}(\hat{V}_{t|t,k} + \boldsymbol{z}'_{t,k}\boldsymbol{R}_{t,k}\boldsymbol{z}_{t,k})^{-1}e_{t,k}$.

By repeating the procedure, we recursively estimate the parameter vector θ, and obtain the distribution of $\theta_{t,k} \mid Y_t$; $t = 1, 2, ..., T$.

The retrospective distributions of $\theta_{t,k}$ and $y_{t,k}$ that incorporate information from the entire sample Y_T are given by (West and Harrison, 1997; chapter 4, p.112-115)

$$\boldsymbol{\theta}_{t,k} \mid Y_T \sim N(\hat{\boldsymbol{\theta}}_{t|T,k}, \Sigma_{t|T,k}), \tag{B.1.6}$$

$$y_{t,k} \mid Y_T \sim N(\boldsymbol{z}'_{t,k}\hat{\boldsymbol{\theta}}_{t|T,k}, \hat{V}_k + \boldsymbol{z}'_{t,k}\Sigma_{t|T,k}\boldsymbol{z}_{t,k}). \tag{B.1.7}$$

where $\hat{\boldsymbol{\theta}}_{t|T,k} = \hat{\boldsymbol{\theta}}_{t|t,k} + \lambda(\hat{\boldsymbol{\theta}}_{t+1|T,k} - \hat{\boldsymbol{\theta}}_{t|t,k})$, $\Sigma_{t+1|T,k} = \Sigma_{t|t,k} + \lambda^2(\Sigma_{t+1|T,k} - \lambda^{-1}\Sigma_{t|t,k})$, and $\hat{V}_k = T^{-1}\Sigma_{t=1}^{T}(y_t - \boldsymbol{z}'_{t,k}\hat{\boldsymbol{\theta}}_{t|T,k})^2$.

---

33 We also conducted the exercise with λ = 0.90 and λ = 0.975. The results are qualitatively similar to those reported in the text. For instance, (a) the "best models" that describe exchange rates are exchange-rate-specific, time-varying and do not include specifications (1) and (8) given in the text, (b) the coefficient estimates are period specific, vary across exchange rates, and can be different from their theoretically predicted values, and (c) the variables and specifications that help to alleviate PPP deviations are exchange-rate and time-period specific.

B.2 Model Probabilities

Model probabilities that indicate the relative importance of models in each period are used to conduct dynamic model averaging. The model probability in the current exercise is derived from the retrospective distributions of $\theta_{t,k}$ and $y_{t,k}$ for $t=1,2,...,T$, $k=1,2,...,K$, and a given λ value. Let $L_t = k$ be the event that the *k*-th model is the true model at time *t*.

Let $\pi_{t-1|t-1,k} = P(L_{t-1} = k \mid \boldsymbol{F}_{t-1})$ be the model probability of model *k* at time *t*-1 based on sample information available from time 1 to *t*-1; where $P(\cdot)$ is the probability operator, and $\boldsymbol{F}_{t-1}$ includes the retrospective likelihoods of all *K* models at time *t*-1. Assume the time *t* predicted model probability $\pi_{t|t-1,k} = P(L_t = k \mid \boldsymbol{F}_{t-1})$ follows a Markov process given by the $K \times K$ transition matrix $\Phi_{t-1} = [\varphi_{t-1,\ell k}]$, where $\varphi_{t-1,\ell k} = P(L_t = k \mid \boldsymbol{F}_{t-1}, L_{t-1} = \ell)$. Thus,

$$\pi_{t|t-1,k} = P(L_t = k \mid \boldsymbol{F}_{t-1}) = \Sigma_{\ell=1}^{K} \pi_{t-1|t-1,\ell}\varphi_{t-1,\ell k}. \tag{B.2.1}$$

Defining a forgetting factor τ, (B.2.1) could be simplified and re-written as

$$\pi_{t|t-1,k} = [(\pi_{t-1|t-1,k})^{\tau} + c][\Sigma_{\ell=1}^{K}(\pi_{t-1|t-1,\ell})^{\tau} + c]^{-1}, \tag{B.2.2}$$

where *c* is a small positive number to avoid a zero model probability caused by aberrant observations. Following Drachal (2020), we set $c = 10^{-3} \times 2^{-n} = 10^{-3} \times 2^{-14} = 6.103516 \times 10^{-8}$, where *n* = 14 is the number of explanatory variables in our exercise. Also, we set τ = 0.95 in our exercise (Cheung and Wang, 2022; Koop and Korobilis, 2012).

Given (B.2.2) and (B.1.7),

$$\pi_{t|t,k} = P(L_t = k \mid \boldsymbol{F}_t) = \pi_{t|t-1,k} f_k(y_t \mid Y_T)[\Sigma_{\ell=1}^{K} \pi_{t|t-1,\ell} f_{\ell}(y_t \mid Y_T)]^{-1}, \tag{B.2.3}$$

where $f_{\ell}(y_t \mid Y_T)$ is the retrospective likelihood value of the ℓ-th model at time *t*.[34]

The model probability $\pi_{t|t,k}$ is recursively estimated for $t=1,2,...,T$ and $k=1,2,...,K$. Then, the retrospective model probability is given by (see Appendix B.4)

$$\pi_{t|T,k} = P(L_t = k \mid \boldsymbol{F}_T) = \pi_{t|t,k}\Sigma_{\ell=1}^{K}\varphi_{t,k\ell}(\pi_{t+1|T,\ell})(\pi_{t+1|t,\ell})^{-1}, \tag{B.2.4}$$

where $t=1,2,...,T-1$, $k=1,2,...,K$. Assuming $\varphi_{t,k\ell}$'s are the same for $k=1,2,...,K$, then $\pi_{t|T,k} = \pi_{t|t,k}$.

B.3 Parameter Averaging

The retrospective model averaging estimates of y_t and parameters are given by $\hat{y}_t^{DMA} = \Sigma_{k=1}^{K}\pi_{t|T,k}\boldsymbol{z}'_{t,k}\hat{\boldsymbol{\theta}}_{t|T,k}$, and $\hat{\theta}_t^{DMA} = \Sigma_{k=1}^{K}\pi_{t|T,k}\hat{\boldsymbol{\theta}}_{t|T,k}$, where $\pi_{t|T,k}$ is the retrospective model probability (B.2.4). The retrospective posterior inclusion probability (PIP) of the *i*-th parameter, θ_i, is $PIP_t^{DMA}(\theta_i) = \Sigma_{k=1}^{K}\pi_{t|T,k}\boldsymbol{I}_k(\theta_i)$ for all *i*, where $I_k(\theta_i)$ is the indicator function that equals 1 if θ_i is included in the *k*-th model. The variance of $\hat{\theta}_{i,t}^{DMA}$, the retrospective model averaging estimate of the *i*-th parameter, is $\mathrm{var}(\hat{\theta}_{i,t}^{DMA}) = \Sigma_{k=1}^{K}\pi_{t|T,k}[\mathrm{var}(\hat{\theta}_{it|T,k}) + \hat{\theta}_{it|T,k}^2] - (\hat{\theta}_{i,t}^{DMA})^2$.

B.4 Derivation of (B.2.4).

The retrospective model probability of the *k*-th model is

$$\pi_{t|T,k} = P(L_t = k \mid \boldsymbol{F}_T) = \Sigma_{\ell=1}^{K} P(L_t = k \mid \boldsymbol{F}_T, L_{t+1} = \ell)P(L_{t+1} = \ell \mid \boldsymbol{F}_T). \tag{B.4.1}$$

The Bayes' theorem implies,

34 As discussed, (B.2.3) is based on retrospective distributions. For the typical DMA based on "forecasts," (B.2.3) is modified to $\pi_{t|t,k} = P(L_t = k \mid \boldsymbol{F}_t) = \pi_{t|t-1,k} f_k(y_t \mid Y_{t-1})[\Sigma_{\ell=1}^{K}\pi_{t|t-1,\ell} f_{\ell}(y_t \mid Y_{t-1})]^{-1}$, where the likelihood value is based on (B.1.4).

$$
\begin{aligned}
&P(L_t = k \mid \boldsymbol{F}_T, L_{t+1} = \ell) \\
&= P(L_t = k \mid \boldsymbol{F}_t, L_{t+1} = \ell) P(\boldsymbol{F}_{t+1|T} \mid \boldsymbol{F}_t, L_t = k, L_{t+1} = \ell)[P(\boldsymbol{F}_{t+1|T} \mid \boldsymbol{F}_t, L_{t+1} = \ell)]^{-1} \\
&= P(L_t = k \mid \boldsymbol{F}_t, L_{t+1} = \ell) && \text{(B.4.2)} \\
&= P(L_t = k \mid \boldsymbol{F}_t) P(L_{t+1} = \ell \mid \boldsymbol{F}_t, L_t = k)[P(L_{t+1} = \ell \mid \boldsymbol{F}_t)]^{-1} && \text{(B.4.3)} \\
&= \pi_{t|t,k} \varphi_{t,k\ell} (\pi_{t+1|t,\ell})^{-1}. && \text{(B.4.4)}
\end{aligned}
$$

where (B.4.2) follows from $\boldsymbol{F}_{t+1|T} = \{\boldsymbol{F}_{t+1}, ..., \boldsymbol{F}_T\}$, $\boldsymbol{F}_t$ and $\boldsymbol{F}_{t+1|T}$ are independent of the state of L_t and, thus, the two terms $P(\boldsymbol{F}_{t+1|T} \mid \cdot)$ cancel out, and (B.4.3) follows from the Bayes' theorem.

Substituting (B.4.4) into (B.4.1), we obtain (B.2.4):

$$\pi_{t|T,k} = P(L_t = k \mid \boldsymbol{F}_T) = \pi_{t|t,k} \Sigma_{\ell=1}^{K} \varphi_{t,k\ell} (\pi_{t+1|T,\ell})(\pi_{t+1|t,\ell})^{-1}.$$

The retrospective model probability depends on the transition matrix $\Phi_t = [\varphi_{t,k\ell}]$. The data do not provide enough information about the transition matrix. Without any restrictions, there are infinite ways to define the transition matrix. For computational simplicity, we assume all $\varphi_{t,k\ell}$ s are the same for $k = 1, 2, ..., K$, and then, $\varphi_{t,k\ell} = \pi_{t+1|t,\ell}$, and $\pi_{t|T,k} = \pi_{t|t,k}$. This assumption implies all the states are the same and with the same probability to transit to the same state in the next period.

In estimating the DLM-and-DMA specification, we set the initial values of the coefficients to zero, the variances to their sample counterparts, and model probabilities to $2^{-14} = 6.103516 \times 10^{-5}$.

Appendix C Frequencies of PIPs Larger than 0.75

	$\Delta\tilde{p}_t$	$\Delta\tilde{m}_t$	$\Delta\tilde{y}_t$	$\Delta\tilde{i}_t$	$\Delta\tilde{\psi}_t$	TB_t	$\Delta\tilde{w}_t$	vix_t	TED_t	$RVar_t$	l_t	q_{t-1}	$\tilde{i}_{t-1}$	Δs_{t-1}
Full Sample Period (1999Q1-2023Q3)														
AUD	0	0	0.670	0.088	0	0	0	0	0	0	0.022	0	0	0
CAD	0	0.110	0.110	0	0	0	0	0	0.220	0	0	0	0	0
CHF	0	0	0	0	0	0	0	0	0	0	0.165	0.022	0	0
EUR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBP	0	0	0	0.033	0.154	0	0	0	0	0.055	0.022	0	0	0
JPY	0	0	0	0	0	0	0	0	0.077	0	0	0	0	0
Pre-crisis Period (1999Q1-2007Q2)														
AUD	0	0	0.346	0	0	0	0	0	0	0	0	0	0	0
CAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHF	0	0	0	0	0	0	0	0	0	0	0.154	0	0	0
EUR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBP	0	0	0	0	0	0	0	0	0	0	0.077	0	0	0
JPY	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Post-crisis Period (2009Q1-2023Q3)														
AUD	0	0	0.847	0.102	0	0	0	0	0	0	0	0	0	0
CAD	0	0.169	0.169	0	0	0	0	0	0.339	0	0	0	0	0
CHF	0	0	0	0	0	0	0	0	0	0	0.186	0	0	0
EUR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBP	0	0	0	0.051	0.237	0	0	0	0	0.085	0	0	0	0
JPY	0	0	0	0	0	0	0	0	0.085	0	0	0	0	0

Notes: The table presents the frequencies that the posterior inclusion probability (PIP) of a variable is larger than 0.75 in the full-period sample, pre-crisis subsample and post-crisis subsample. In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included.

Appendix D. DLM Coefficient Estimates of Model Specifications (1) to (8)

	AUD			CAD			CHF			EUR			GBP			JPY		
	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post
(1)																		
$\Delta\tilde{p}_t$	**2.019**	**2.226**	1.863	2.115	0.995	**2.488**	-1.549	**-3.152**	**-0.820**	0.567	**-1.176**	**1.355**	1.085	-0.365	**1.620**	-1.369	**-2.312**	-0.821
	(0.920)	**(0.141)**	(1.103)	(1.409)	(1.274)	**(1.236)**	(1.162)	**(0.887)**	**(0.233)**	(1.207)	**(0.563)**	**(0.340)**	(1.244)	(0.925)	**(0.825)**	(0.938)	**(0.199)**	(0.686)
(2)																		
$\Delta\tilde{p}_t$	**1.973**	**1.955**	1.918	2.057	1.069	**2.374**	-1.288	**-2.424**	**-0.735**	0.995	0.277	**1.390**	1.382	0.046	**1.862**	-1.126	-1.452	-0.829
	(0.902)	**(0.198)**	(1.094)	(1.288)	(1.207)	**(1.122)**	(0.813)	**(0.377)**	**(0.211)**	(0.647)	(0.530)	**(0.267)**	(1.214)	(0.802)	**(0.920)**	(0.867)	(0.873)	(0.681)
$\tilde{i}_{t-1}$	-0.608	-2.366	0.001	2.029	-1.635	**3.752**	-0.277	-2.140	**0.468**	0.967	-2.286	**2.343**	2.532	0.586	**3.252**	-0.202	**-1.800**	0.528
	(1.617)	(1.896)	(0.682)	(2.632)	(1.208)	**(0.979)**	(1.347)	(1.182)	**(0.183)**	(2.360)	(1.852)	**(0.673)**	(1.570)	(1.487)	**(0.668)**	(1.162)	**(0.741)**	(0.408)
(3)																		
$\Delta\tilde{p}_t$	**2.209**	**2.197**	2.174	2.246	0.850	**2.771**	-1.335	**-2.861**	**-0.639**	0.729	**-1.025**	**1.530**	1.051	-0.364	1.568	-1.315	**-2.219**	-0.793
	(0.914)	**(0.129)**	(1.126)	(1.486)	(1.264)	**(1.223)**	(1.100)	**(0.750)**	**(0.301)**	(1.239)	**(0.511)**	**(0.473)**	(1.283)	(0.935)	(0.939)	(0.891)	**(0.186)**	(0.648)
Δs_{t-1}	-0.106	-0.013	**-0.156**	-0.054	-0.009	**-0.083**	**-0.121**	**-0.106**	**-0.132**	-0.034	-0.044	-0.033	**0.070**	**0.079**	0.064	0.004	**-0.051**	0.036
	(0.084)	(0.024)	**(0.058)**	(0.056)	(0.040)	**(0.041)**	**(0.032)**	**(0.027)**	**(0.029)**	(0.036)	(0.047)	(0.029)	**(0.030)**	**(0.018)**	(0.034)	(0.059)	**(0.008)**	(0.049)
(4)																		
$\Delta\tilde{p}_t$	-2.094	**-1.148**	-2.577	0.493	-0.146	0.606	-4.688	**-8.572**	**-2.901**	-2.101	**-5.786**	-0.428	-0.984	**-2.365**	-0.436	-2.167	**-4.148**	-1.195
	(1.437)	**(0.263)**	(1.578)	(1.177)	(0.944)	(1.133)	(2.702)	**(1.491)**	**(0.537)**	(2.511)	**(1.107)**	(0.530)	(0.988)	**(0.694)**	(0.325)	(1.507)	**(0.318)**	(0.810)
$\Delta\tilde{m}_t$	0.163	**-0.781**	0.615	**0.849**	**0.828**	**0.847**	0.126	-0.024	**0.186**	0.121	-0.023	0.221	-0.459	**-0.965**	-0.183	0.285	-0.534	**0.683**
	(0.792)	**(0.195)**	(0.580)	**(0.219)**	**(0.195)**	**(0.238)**	(0.113)	(0.073)	**(0.058)**	(0.203)	(0.155)	(0.144)	(0.483)	**(0.089)**	(0.371)	(0.618)	(0.289)	**(0.282)**
$\Delta\tilde{y}_t$	**1.964**	**2.710**	1.517	-0.390	0.291	**-0.713**	-0.480	**-0.671**	-0.337	-0.826	-0.059	**-1.096**	0.051	-0.351	0.218	0.026	0.497	**-0.152**
	(0.888)	**(0.073)**	(0.794)	(0.484)	(0.159)	**(0.181)**	(0.422)	**(0.171)**	(0.437)	(0.635)	(0.507)	**(0.356)**	(0.382)	(0.207)	(0.325)	(0.348)	(0.310)	**(0.071)**
$\Delta\tilde{i}_t$	**-7.744**	**-7.762**	**-7.419**	1.484	3.719	0.924	-0.152	**-3.763**	1.588	-3.330	-0.565	-4.879	-6.422	**-2.426**	**-8.413**	**9.133**	**10.634**	**8.527**
	(1.432)	**(1.122)**	**(1.232)**	(3.609)	(2.745)	(3.545)	(2.572)	**(0.622)**	(0.947)	(5.766)	(1.149)	(6.634)	(3.946)	**(1.200)**	**(3.437)**	**(3.330)**	**(1.848)**	**(3.770)**
$\Delta\tilde{\psi}_t$	**2.290**	**1.605**	**2.683**	**1.154**	**0.720**	**1.385**	**2.433**	**3.605**	**1.941**	2.948	**5.555**	1.787	**2.180**	**1.921**	**2.272**	**1.341**	**1.553**	**1.253**
	(0.694)	**(0.127)**	**(0.537)**	**(0.457)**	**(0.245)**	**(0.378)**	**(0.826)**	**(0.420)**	**(0.334)**	(1.949)	**(1.155)**	(0.947)	**(0.621)**	**(0.253)**	**(0.725)**	**(0.559)**	**(0.684)**	**(0.504)**
TB_t	1.472	**0.411**	**2.017**	0.272	**0.457**	0.203	0.781	**1.282**	**0.586**	0.483	**0.990**	0.243	-0.056	0.152	-0.134	0.139	0.082	0.172
	(1.003)	**(0.183)**	**(0.825)**	(0.173)	**(0.117)**	(0.136)	(0.402)	**(0.340)**	**(0.206)**	(0.470)	**(0.133)**	(0.398)	(0.216)	(0.153)	(0.186)	(0.152)	(0.193)	(0.129)
(5)																		
$\Delta\tilde{p}_t$	-2.235	**-1.592**	-2.569	0.083	-0.685	0.309	-4.924	**-8.765**	**-3.099**	-2.386	**-5.798**	-0.860	-1.138	**-2.328**	-0.687	**-2.910**	**-4.298**	**-2.239**
	(1.425)	**(0.243)**	(1.673)	(0.852)	(0.766)	(0.653)	(2.730)	**(1.312)**	**(0.798)**	(2.340)	**(1.109)**	(0.601)	(0.968)	**(0.660)**	(0.605)	**(1.162)**	**(0.316)**	**(0.832)**
$\Delta\tilde{m}_t$	0.234	**-0.756**	0.710	**0.877**	**0.793**	**0.918**	0.172	0.064	**0.208**	0.004	-0.047	0.053	-0.459	**-0.899**	-0.216	0.162	**-0.566**	0.513
	(0.773)	**(0.187)**	(0.474)	**(0.227)**	**(0.175)**	**(0.247)**	(0.107)	(0.109)	**(0.068)**	(0.201)	(0.152)	(0.206)	(0.420)	**(0.082)**	(0.315)	(0.582)	**(0.280)**	(0.344)
$\Delta\tilde{y}_t$	**2.119**	**2.630**	**1.797**	-0.252	**0.424**	**-0.580**	-0.821	**-1.336**	-0.473	-0.767	-0.103	**-0.978**	-0.029	-0.377	0.103	-0.079	0.472	**-0.292**
	(0.822)	**(0.080)**	**(0.855)**	(0.517)	**(0.132)**	**(0.288)**	(0.819)	**(0.430)**	(0.758)	(0.629)	(0.515)	**(0.430)**	(0.348)	(0.223)	(0.298)	(0.402)	(0.339)	**(0.089)**
$\Delta\tilde{i}_t$	**-8.363**	**-9.294**	**-7.583**	2.349	**4.127**	1.942	0.629	**-2.540**	**2.151**	-4.618	-0.527	-6.827	-6.394	**-2.423**	**-8.430**	**9.292**	**10.577**	**8.807**
	(1.793)	**(1.024)**	**(1.468)**	(3.107)	**(2.002)**	(3.191)	(2.257)	**(0.579)**	**(0.836)**	(7.225)	(1.463)	(8.119)	(4.312)	**(1.103)**	**(4.028)**	**(3.072)**	**(1.874)**	**(3.463)**
$\Delta\tilde{\psi}_t$	**2.314**	**1.807**	**2.623**	**1.319**	**0.826**	**1.562**	**2.541**	**3.744**	**2.012**	3.036	**5.508**	**1.948**	**2.319**	**1.891**	**2.494**	**1.638**	**1.612**	**1.671**
	(0.698)	**(0.132)**	**(0.681)**	**(0.533)**	**(0.329)**	**(0.469)**	**(0.832)**	**(0.344)**	**(0.294)**	(1.814)	**(1.145)**	**(0.774)**	**(0.504)**	**(0.282)**	**(0.492)**	**(0.561)**	**(0.702)**	**(0.520)**
TB_t	-0.203	**1.017**	-0.788	-1.543	**-2.122**	-1.168	0.847	**1.708**	0.318	0.382	0.145	0.484	0.682	0.232	1.028	1.764	0.386	**2.387**
	(1.019)	**(0.237)**	(0.740)	(0.988)	**(0.323)**	(1.016)	(1.161)	**(0.808)**	(0.984)	(0.364)	(0.182)	(0.394)	(0.911)	(0.274)	(0.907)	(1.149)	(0.464)	**(0.838)**
$\Delta\tilde{w}_t$	1.334	**0.482**	**1.768**	0.364	**0.698**	0.216	**0.853**	**1.448**	**0.596**	0.399	**0.988**	0.114	0.112	0.149	0.118	-0.156	0.009	**-0.222**
	(0.930)	**(0.181)**	**(0.882)**	(0.245)	**(0.127)**	(0.114)	**(0.421)**	**(0.296)**	**(0.103)**	(0.576)	**(0.139)**	(0.511)	(0.165)	(0.126)	(0.171)	(0.190)	(0.256)	**(0.103)**

Appendix D (Continued)

	AUD			CAD			CHF			EUR			GBP			JPY		
	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post
(6)																		
$\Delta\tilde{p}_t$	**-0.046**	**-0.037**	**-0.053**	**-0.065**	**-0.029**	**-0.083**	**-0.145**	**-0.188**	**-0.129**	**-0.120**	**-0.125**	**-0.120**	**-0.051**	**-0.050**	**-0.050**	-0.033	**-0.022**	**-0.037**
	(0.014)	**(0.009)**	**(0.010)**	**(0.028)**	**(0.010)**	**(0.013)**	**(0.041)**	**(0.022)**	**(0.036)**	**(0.019)**	**(0.027)**	**(0.013)**	**(0.011)**	**(0.013)**	**(0.010)**	(0.017)	**(0.007)**	**(0.019)**
vix_t	1.713	**2.297**	1.381	2.433	0.960	**3.014**	-1.097	**-1.199**	**-0.933**	**1.368**	0.895	**1.675**	1.193	-0.471	**1.874**	-0.281	-0.890	0.070
	(1.298)	**(0.140)**	(1.512)	(1.473)	(1.294)	**(1.132)**	(0.570)	**(0.497)**	**(0.474)**	**(0.641)**	(0.658)	**(0.390)**	(1.231)	(0.863)	**(0.531)**	(0.777)	(0.830)	(0.529)
TED_t	**-0.040**	**-0.020**	**-0.049**	-0.016	0.000	**-0.024**	0.008	**0.033**	-0.003	0.008	**0.019**	0.002	0.005	**0.019**	-0.003	-0.001	0.014	-0.006
	(0.014)	**(0.003)**	**(0.004)**	(0.012)	(0.006)	**(0.003)**	(0.017)	**(0.011)**	(0.003)	(0.009)	**(0.006)**	(0.005)	(0.014)	**(0.005)**	(0.011)	(0.021)	(0.027)	(0.014)
$RVar_t$	0.014	**0.040**	0.002	0.014	0.018	0.010	0.004	**0.038**	-0.010	-0.010	0.027	**-0.026**	0.018	**0.022**	0.015	**-0.030**	**-0.025**	**-0.032**
	(0.023)	**(0.006)**	(0.018)	(0.014)	(0.010)	(0.015)	(0.023)	**(0.015)**	(0.006)	(0.025)	(0.015)	**(0.006)**	(0.012)	**(0.005)**	(0.013)	**(0.005)**	**(0.002)**	**(0.004)**
l_t	0.035	0.501	-0.156	0.018	**2.683**	**-1.209**	**-3.828**	**-2.577**	**-4.281**	-1.058	**5.425**	-4.441	1.089	**7.507**	-1.610	2.388	2.796	1.736
	[4.666]	[7.357]	[3.498]	[7.716]	**[12.501]**	**[5.771]**	**[12.230]**	**[15.657]**	**[11.018]**	[10.623]	**[14.306]**	[9.179]	[7.646]	**[10.981]**	[6.251]	[6.434]	[6.421]	[6.479]
q_{t-1}	0.990	-0.394	**1.565**	-1.064	-0.489	**-1.394**	**-1.891**	**-2.306**	**-1.793**	**-3.346**	**-2.887**	**-3.620**	-1.074	**-2.380**	**-0.549**	-1.423	**-3.245**	-0.736
	(1.051)	(0.855)	**(0.430)**	(0.675)	(0.364)	**(0.577)**	**(0.502)**	**(0.512)**	**(0.345)**	**(0.855)**	**(0.378)**	**(0.920)**	(0.943)	**(0.814)**	**(0.150)**	(1.595)	**(1.473)**	(0.951)
(7)																		
$\Delta\tilde{p}_t$	-0.042	-0.073	-0.034	-0.067	-0.003	**-0.097**	**-0.133**	**-0.174**	-0.120	**-0.152**	**-0.179**	**-0.144**	**-0.079**	**-0.077**	-0.077	**-0.048**	**-0.044**	**-0.050**
	(0.036)	(0.044)	(0.021)	(0.050)	(0.025)	**(0.027)**	**(0.061)**	**(0.042)**	(0.061)	**(0.029)**	**(0.035)**	**(0.016)**	**(0.035)**	**(0.017)**	(0.040)	**(0.010)**	**(0.005)**	**(0.011)**
$\Delta\tilde{m}_t$	-1.830	**-1.107**	-2.164	**2.042**	1.028	**2.408**	**-4.409**	**-5.694**	**-3.564**	-1.400	**-2.111**	-0.884	**-0.658**	**-0.764**	**-0.613**	-1.906	**-2.932**	-1.354
	(1.460)	**(0.467)**	(1.692)	**(0.874)**	(0.726)	**(0.542)**	**(1.713)**	**(0.758)**	**(1.434)**	(1.167)	**(1.029)**	(0.865)	**(0.186)**	**(0.098)**	**(0.206)**	(1.228)	**(1.199)**	(0.910)
$\Delta\tilde{y}_t$	0.035	**-0.752**	0.410	**0.760**	**0.728**	**0.799**	-0.112	-0.228	**-0.063**	0.328	**0.309**	0.329	-0.413	**-0.550**	-0.318	0.037	-0.339	0.279
	(0.614)	**(0.141)**	(0.383)	**(0.279)**	**(0.092)**	**(0.329)**	(0.107)	(0.143)	**(0.018)**	(0.376)	**(0.123)**	(0.461)	(0.211)	**(0.063)**	(0.193)	(0.519)	(0.247)	(0.460)
$\Delta\tilde{i}_t$	**1.781**	**2.051**	**1.571**	-0.272	**0.502**	-0.648	-0.765	**-1.000**	-0.559	0.067	0.595	-0.103	-0.024	**-0.305**	0.118	0.044	**0.382**	-0.128
	(0.683)	**(0.144)**	**(0.744)**	(0.622)	**(0.160)**	(0.404)	(0.627)	**(0.429)**	(0.598)	(0.497)	(0.447)	(0.318)	(0.305)	**(0.046)**	(0.289)	(0.258)	**(0.057)**	(0.116)
$\Delta\tilde{\pi}_t$	-4.630	2.470	**-6.967**	3.656	**7.615**	2.029	-2.514	**-3.025**	-1.942	-3.014	3.447	-5.960	**-10.335**	-5.204	**-12.625**	**10.917**	**14.822**	**9.386**
	(6.085)	(6.625)	**(2.010)**	(2.875)	**(1.436)**	(1.435)	(1.656)	**(1.354)**	(1.344)	(7.266)	(4.399)	(6.768)	**(4.685)**	(2.796)	**(3.678)**	**(3.654)**	**(1.441)**	**(3.196)**
TB_t	**2.195**	**1.876**	**2.382**	-0.303	-0.524	-0.184	**2.706**	**3.043**	**2.466**	**2.417**	**3.255**	1.935	1.078	-0.501	**1.782**	**1.536**	**1.905**	**1.347**
	(0.580)	**(0.218)**	**(0.631)**	(0.359)	(0.349)	(0.326)	**(0.644)**	**(0.512)**	**(0.582)**	**(1.152)**	**(0.216)**	(1.167)	(1.169)	(0.748)	**(0.505)**	**(0.544)**	**(0.493)**	**(0.499)**
$\Delta\tilde{w}_t$	-0.049	**1.054**	-0.587	-1.371	**-2.165**	-0.904	0.559	-0.367	0.859	0.122	0.256	0.058	0.216	-0.544	0.692	**1.938**	0.904	**2.307**
	(0.940)	**(0.260)**	(0.690)	(0.968)	**(0.217)**	(0.890)	(1.165)	(1.645)	(0.586)	(0.645)	(0.171)	(0.785)	(1.370)	(0.281)	(1.477)	**(0.947)**	(0.652)	**(0.716)**
vix_t	**-0.028**	-0.010	**-0.036**	**-0.014**	**-0.008**	**-0.016**	0.003	0.025	**-0.007**	0.006	0.008	0.006	0.003	**0.025**	-0.009	0.007	0.022	0.002
	(0.013)	(0.008)	**(0.005)**	**(0.006)**	**(0.003)**	**(0.006)**	(0.016)	(0.014)	**(0.003)**	(0.009)	(0.008)	(0.010)	(0.020)	**(0.007)**	(0.014)	(0.016)	(0.018)	(0.010)
TED_t	0.023	**0.049**	0.012	0.012	0.014	0.008	0.009	**0.041**	-0.005	-0.003	0.024	**-0.016**	**0.028**	**0.025**	**0.030**	**-0.022**	-0.011	**-0.025**
	(0.020)	**(0.015)**	(0.009)	(0.014)	(0.010)	(0.015)	(0.022)	**(0.012)**	(0.006)	(0.019)	(0.013)	**(0.004)**	**(0.005)**	**(0.004)**	**(0.004)**	**(0.010)**	(0.010)	**(0.006)**
$RVar_t$	1.093	**1.843**	0.740	-1.031	**4.317**	**-3.278**	-0.768	-0.759	-0.826	1.518	**6.583**	-1.595	0.667	**8.679**	**-2.787**	3.334	**7.982**	0.690
	(0.648)	**(0.160)**	(0.500)	(3.605)	**(2.112)**	**(0.339)**	(1.988)	(1.516)	(2.239)	(6.473)	**(3.103)**	(5.620)	(5.388)	**(2.436)**	**(1.104)**	(4.190)	**(1.387)**	(2.454)
l_t	1.112	0.049	**1.588**	0.611	**0.957**	0.448	**0.695**	**1.015**	**0.514**	**1.203**	**1.498**	**1.058**	**0.687**	**0.438**	**0.807**	-1.137	**-2.301**	-0.562
	(0.840)	(0.551)	**(0.475)**	(0.322)	**(0.168)**	(0.257)	**(0.305)**	**(0.096)**	**(0.214)**	**(0.406)**	**(0.067)**	**(0.437)**	**(0.350)**	**(0.147)**	**(0.370)**	(0.888)	**(0.122)**	(0.481)
q_{t-1}	1.237	0.505	**1.489**	**-2.043**	**-1.678**	**-2.316**	**-1.779**	**-2.323**	**-1.619**	**-2.870**	**-2.211**	**-3.252**	**-1.630**	**-2.572**	**-1.301**	-1.003	-1.841	-0.736
	(0.652)	(0.469)	**(0.451)**	**(0.937)**	**(0.565)**	**(0.981)**	**(0.551)**	**(0.566)**	**(0.333)**	**(0.830)**	**(0.192)**	**(0.790)**	**(0.825)**	**(0.827)**	**(0.422)**	(1.125)	(1.124)	(0.963)

Appendix D (Continued)

	AUD			CAD			CHF			EUR			GBP			JPY		
	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post
(8)																		
$\Delta\tilde{p}_t$	**-0.076**	**-0.093**	**-0.074**	-0.032	0.026	**-0.058**	**-0.169**	**-0.178**	**-0.170**	**-0.147**	**-0.153**	**-0.149**	**-0.082**	**-0.069**	**-0.086**	**-0.050**	**-0.051**	**-0.049**
	(0.037)	**(0.036)**	**(0.032)**	(0.041)	(0.021)	**(0.014)**	**(0.053)**	**(0.026)**	**(0.061)**	**(0.024)**	**(0.021)**	**(0.022)**	**(0.033)**	**(0.022)**	**(0.036)**	**(0.014)**	**(0.007)**	**(0.016)**
$\Delta\tilde{m}_t$	**-3.882**	**-5.822**	**-3.136**	2.184	**-4.899**	5.617	**-3.182**	-1.600	**-3.754**	-0.794	-0.056	**-1.080**	1.001	**1.812**	0.546	-0.935	**-2.574**	-0.031
	(1.660)	**(1.503)**	**(0.960)**	(5.465)	**(1.375)**	(3.170)	**(1.286)**	(1.115)	**(0.643)**	(0.642)	(0.495)	**(0.429)**	(1.181)	**(0.551)**	(1.197)	(1.611)	**(0.527)**	(1.235)
$\Delta\tilde{y}_t$	0.056	**-0.705**	0.427	**0.836**	**0.628**	**0.952**	-0.099	-0.246	-0.038	0.318	**0.421**	0.262	-0.418	**-0.599**	-0.301	0.185	-0.070	0.347
	(0.623)	**(0.122)**	(0.426)	**(0.313)**	**(0.132)**	**(0.324)**	(0.130)	(0.168)	(0.023)	(0.386)	**(0.122)**	(0.465)	(0.244)	**(0.060)**	(0.219)	(0.411)	(0.166)	(0.412)
$\Delta\tilde{i}_t$	**1.674**	**1.821**	**1.528**	-0.260	**0.328**	-0.558	-0.801	**-1.144**	-0.555	0.028	0.386	-0.065	-0.029	**-0.305**	0.111	0.048	**0.417**	-0.134
	(0.628)	**(0.139)**	**(0.710)**	(0.544)	**(0.093)**	(0.442)	(0.614)	**(0.306)**	(0.585)	(0.418)	(0.336)	(0.336)	(0.314)	**(0.061)**	(0.305)	(0.270)	**(0.048)**	(0.114)
$\Delta\tilde{\pi}_t$	-6.526	-0.657	**-8.334**	3.580	**1.764**	4.681	**-5.361**	**-4.953**	**-5.166**	-3.779	2.462	-6.707	-9.151	-3.943	**-11.503**	**9.404**	**12.526**	**8.356**
	(5.164)	(5.253)	**(2.138)**	(3.080)	**(0.785)**	(3.289)	**(1.890)**	**(1.596)**	**(1.711)**	(7.415)	(3.286)	(7.355)	(4.755)	(2.837)	**(3.712)**	**(2.982)**	**(1.905)**	**(2.377)**
TB_t	**1.919**	**1.878**	**1.962**	**-0.663**	**-0.737**	**-0.609**	**2.989**	**3.506**	**2.678**	**2.642**	**3.792**	2.034	1.078	-0.417	**1.748**	**1.462**	**1.723**	**1.329**
	(0.501)	**(0.231)**	**(0.597)**	**(0.225)**	**(0.228)**	**(0.214)**	**(0.638)**	**(0.351)**	**(0.537)**	**(1.260)**	**(0.179)**	(1.173)	(1.105)	(0.629)	**(0.510)**	**(0.508)**	**(0.480)**	**(0.500)**
$\Delta\tilde{w}_t$	-0.300	**0.518**	-0.730	-1.704	**-2.338**	-1.300	-0.272	-0.600	-0.176	-0.021	0.251	-0.129	0.765	0.005	1.186	1.685	-0.395	**2.575**
	(0.827)	**(0.177)**	(0.714)	(0.975)	**(0.180)**	(0.979)	(0.789)	(1.181)	(0.529)	(0.698)	(0.177)	(0.833)	(1.069)	(0.321)	(1.101)	(1.465)	(0.449)	**(0.684)**
vix_t	-0.016	0.011	**-0.028**	-0.004	**0.012**	**-0.011**	0.009	**0.027**	0.001	0.004	0.000	0.007	-0.002	**0.020**	-0.013	0.014	**0.036**	0.005
	(0.019)	(0.008)	**(0.005)**	(0.011)	**(0.005)**	**(0.003)**	(0.013)	**(0.011)**	(0.004)	(0.010)	(0.005)	(0.011)	(0.019)	**(0.008)**	(0.012)	(0.017)	**(0.014)**	(0.008)
TED_t	**0.016**	**0.015**	**0.017**	0.012	-0.003	0.018	0.009	**0.042**	-0.005	-0.003	**0.030**	**-0.017**	**0.030**	**0.029**	**0.030**	**-0.027**	-0.025	**-0.025**
	(0.005)	**(0.003)**	**(0.005)**	(0.014)	(0.012)	(0.010)	(0.022)	**(0.014)**	(0.003)	(0.023)	**(0.012)**	**(0.005)**	**(0.004)**	**(0.002)**	**(0.004)**	**(0.010)**	(0.013)	**(0.006)**
$RVar_t$	1.622	**2.672**	1.121	0.037	**9.421**	**-4.082**	-0.308	0.147	-0.567	2.075	**7.356**	-1.136	0.809	**8.790**	**-2.615**	3.251	**7.255**	0.916
	(0.928)	**(0.596)**	(0.626)	(6.231)	**(2.590)**	**(0.542)**	(1.827)	(1.239)	(2.069)	(6.480)	**(2.618)**	(5.588)	(5.398)	**(2.607)**	**(1.195)**	(3.858)	**(1.123)**	(2.558)
l_t	0.485	-1.108	**1.188**	**0.576**	**0.769**	0.468	0.685	**1.147**	0.437	**1.189**	**1.546**	**1.016**	**0.793**	**0.554**	**0.905**	-1.203	**-2.572**	-0.513
	(1.146)	(0.717)	**(0.416)**	**(0.293)**	**(0.131)**	(0.303)	(0.412)	**(0.097)**	(0.286)	**(0.461)**	**(0.150)**	**(0.480)**	**(0.347)**	**(0.139)**	**(0.374)**	(1.024)	**(0.142)**	(0.467)
q_{t-1}	**1.596**	**0.958**	**1.834**	-2.083	**-1.080**	**-2.650**	**-1.724**	**-2.179**	**-1.608**	**-2.858**	**-2.169**	**-3.269**	**-1.845**	**-2.849**	**-1.480**	-0.812	-1.413	-0.660
	(0.581)	**(0.367)**	**(0.448)**	(1.192)	**(0.404)**	**(1.097)**	**(0.540)**	**(0.544)**	**(0.385)**	**(0.856)**	**(0.233)**	**(0.784)**	**(0.842)**	**(0.872)**	**(0.353)**	(1.052)	(1.155)	(0.910)
$\tilde{i}_{t-1}$	-1.129	**-0.915**	-1.203	**1.902**	0.779	**2.338**	**-4.534**	**-5.762**	**-3.737**	-1.424	**-2.389**	-0.809	**-0.704**	**-0.899**	**-0.640**	-1.593	**-2.327**	-1.213
	(1.323)	**(0.421)**	(1.616)	**(0.881)**	(0.741)	**(0.418)**	**(1.522)**	**(0.763)**	**(1.167)**	(1.257)	**(1.084)**	(0.884)	**(0.279)**	**(0.301)**	**(0.237)**	(1.071)	**(1.048)**	(0.939)
Δs_{t-1}	**-0.080**	**-0.065**	**-0.087**	**-0.111**	**-0.113**	**-0.113**	**-0.118**	**-0.124**	**-0.114**	-0.056	**-0.108**	-0.033	0.062	0.025	**0.079**	-0.030	**-0.067**	-0.008
	(0.026)	**(0.012)**	**(0.029)**	**(0.032)**	**(0.051)**	**(0.018)**	**(0.018)**	**(0.020)**	**(0.017)**	(0.051)	**(0.053)**	(0.033)	(0.043)	(0.028)	**(0.039)**	(0.039)	**(0.024)**	(0.027)

Notes: The first element of an exchange-rate-explanatory-factor cell is the average of the series of DML coefficient estimates, and the second element presented in the round parentheses is the standard error of the series of DML coefficient estimates. The "Full," "Pre," and "Post" columns present results from the full sample period (1999Q1-2023Q3), pre-crisis subsample period (1999Q1-2007Q2), and post-crisis subsample period (2009Q1-2023Q3). In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included. The numbers in bold denote the corresponding average-to-standard-error ratio is larger than 1.96.

Appendix E. Dynamic Model Averaging Estimates

Figure E1: The AUD case

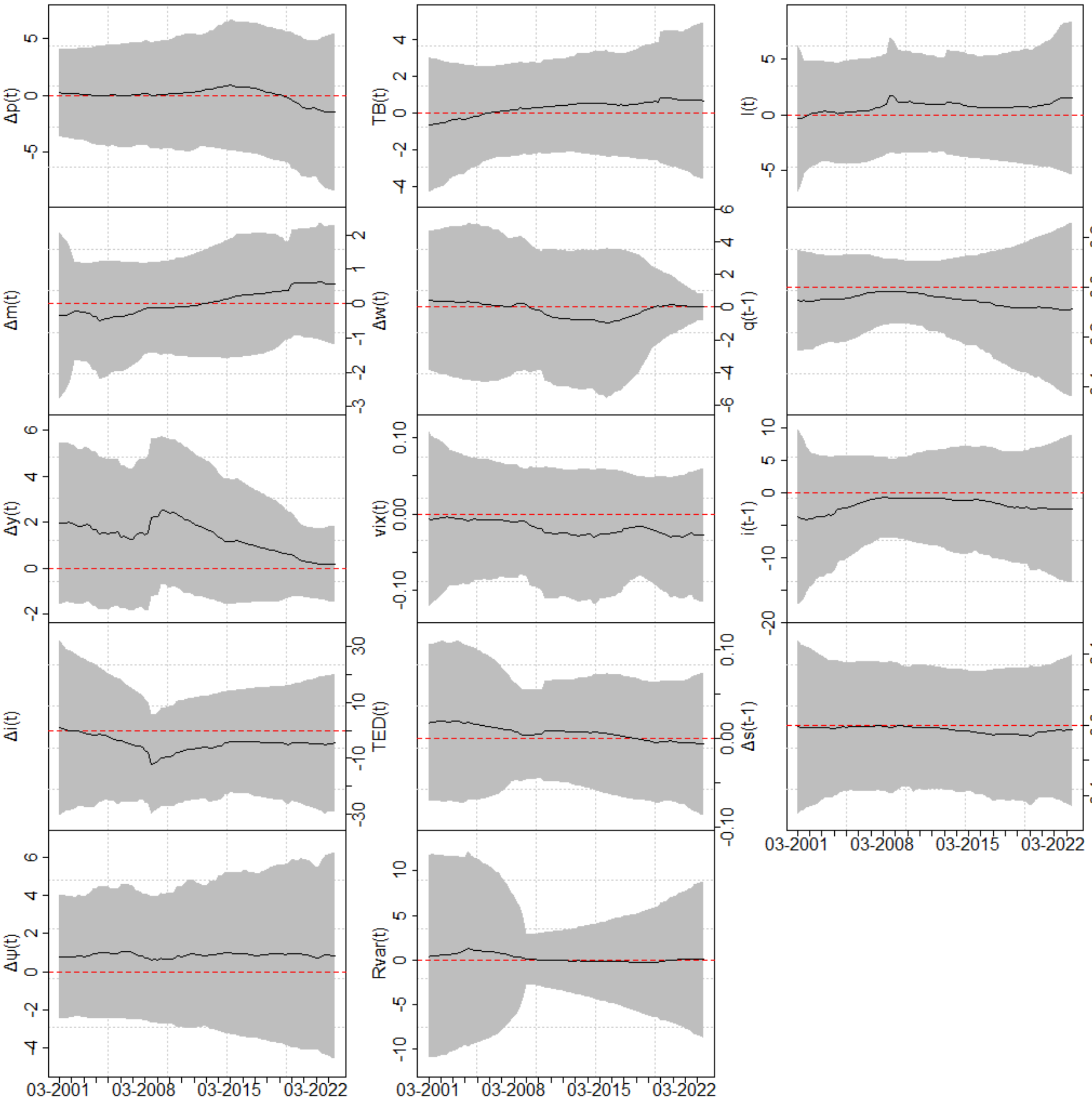


Figure E2: The CAD Case

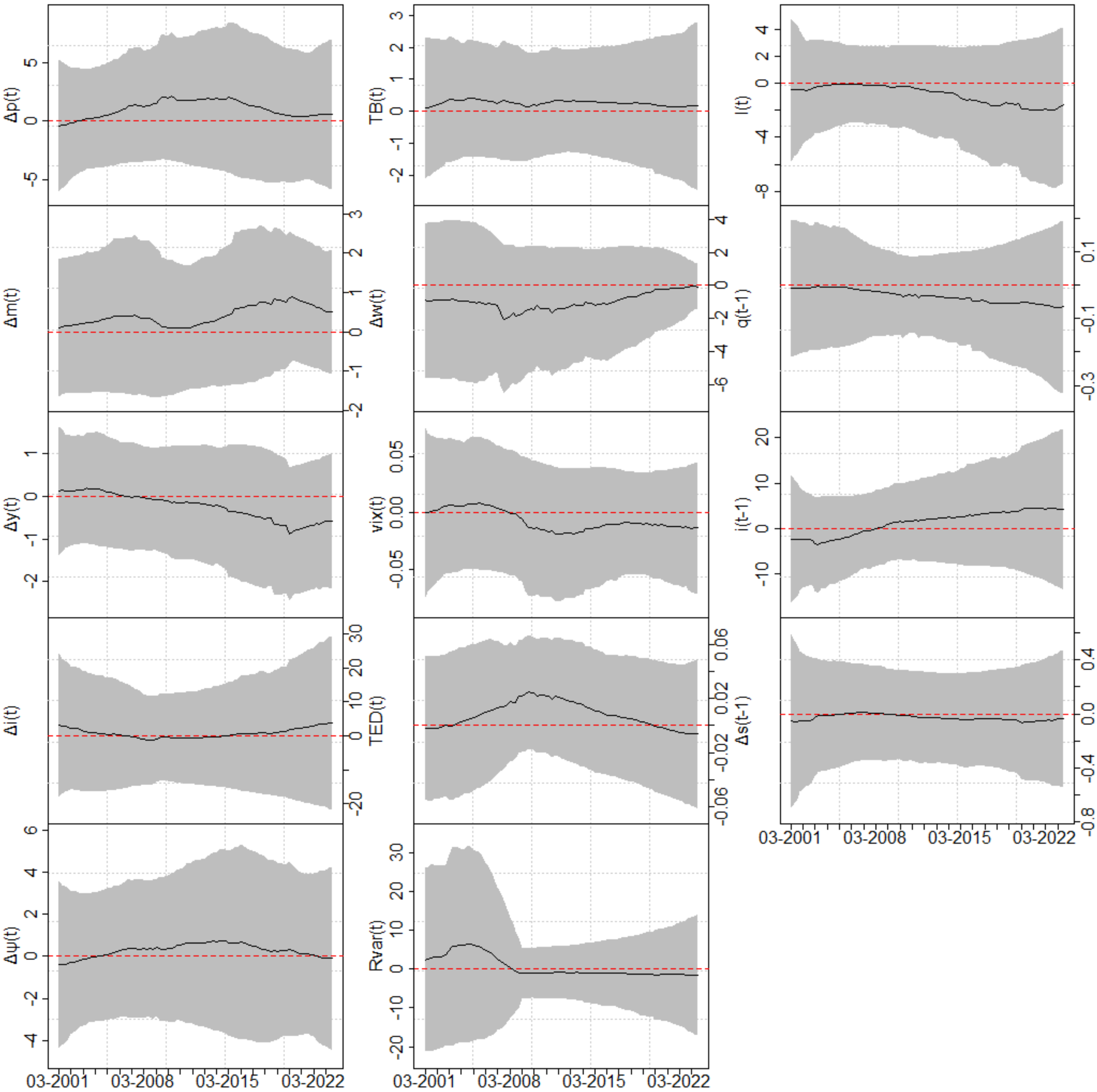


Figure E3: The CHF Case

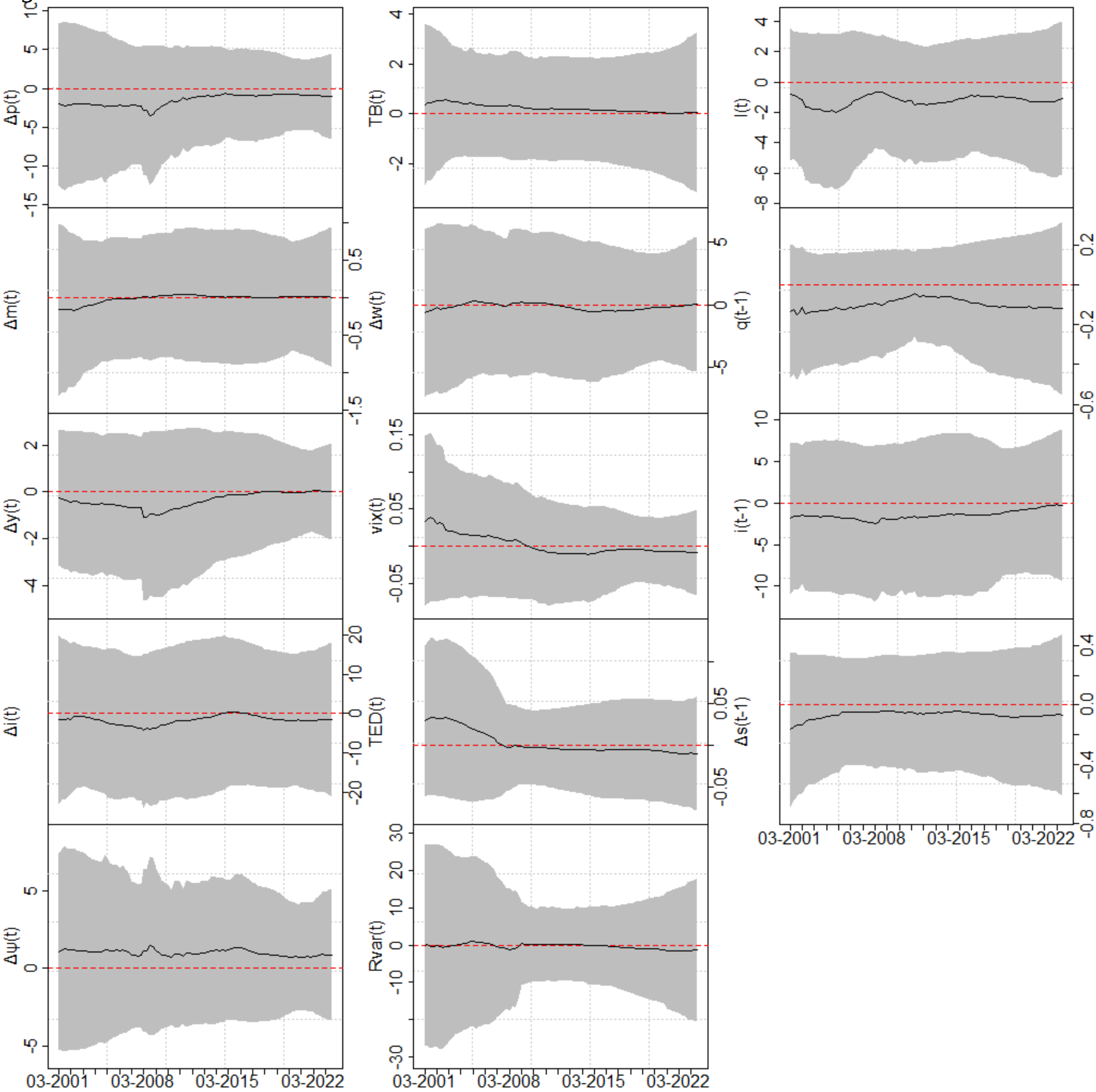


Figure E4: The EUR Case

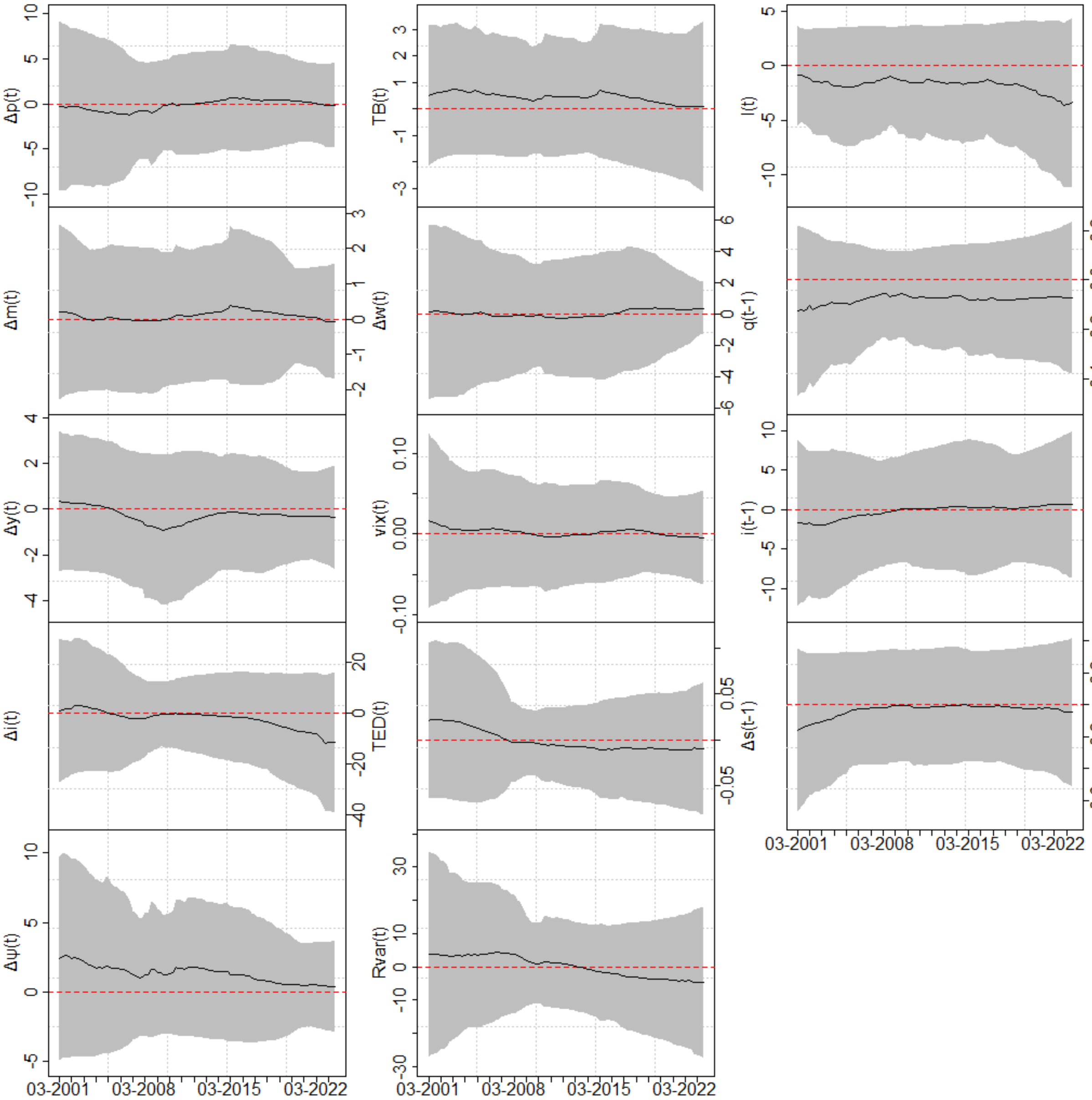


Figure E5: The GBP Case

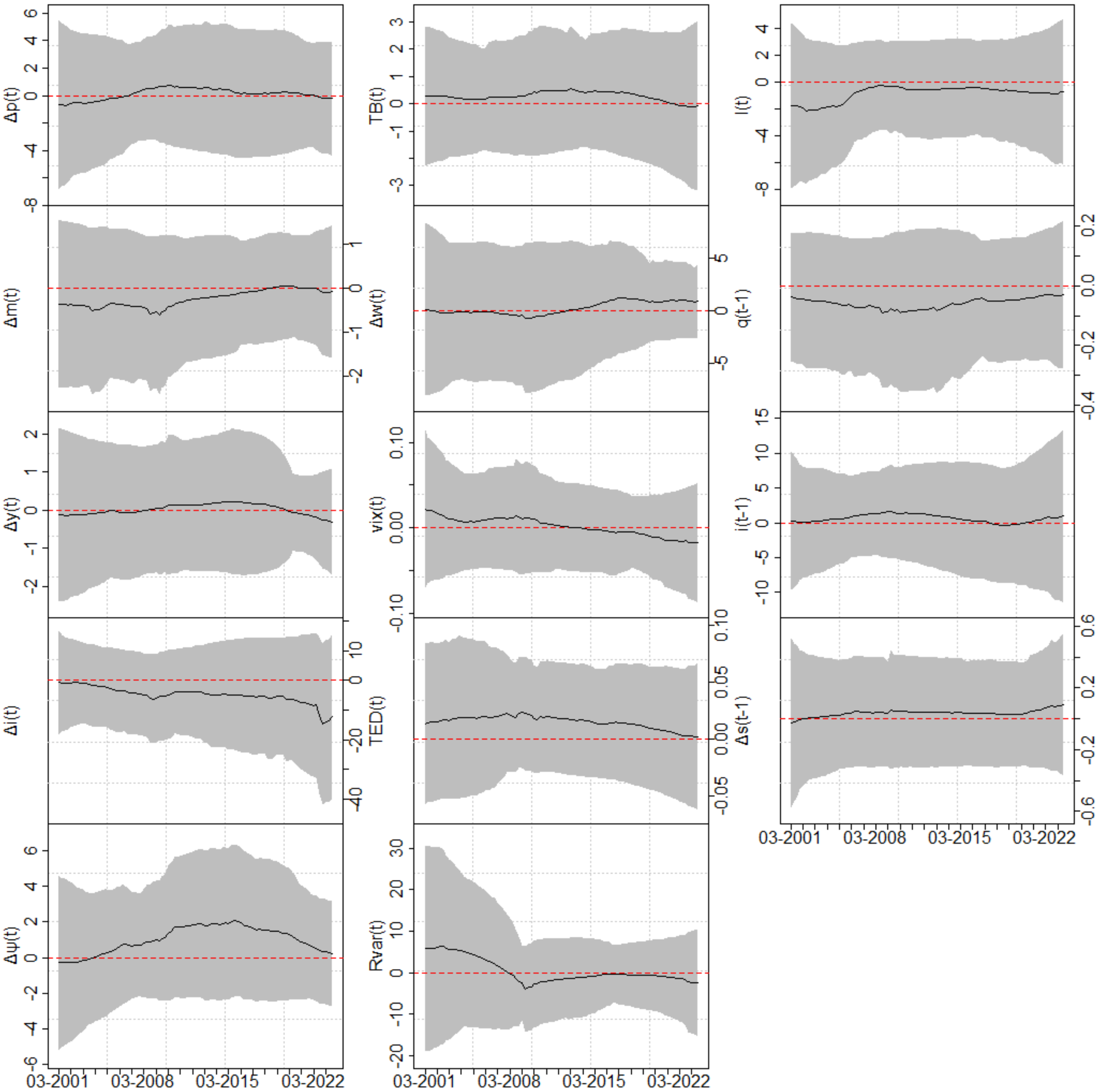
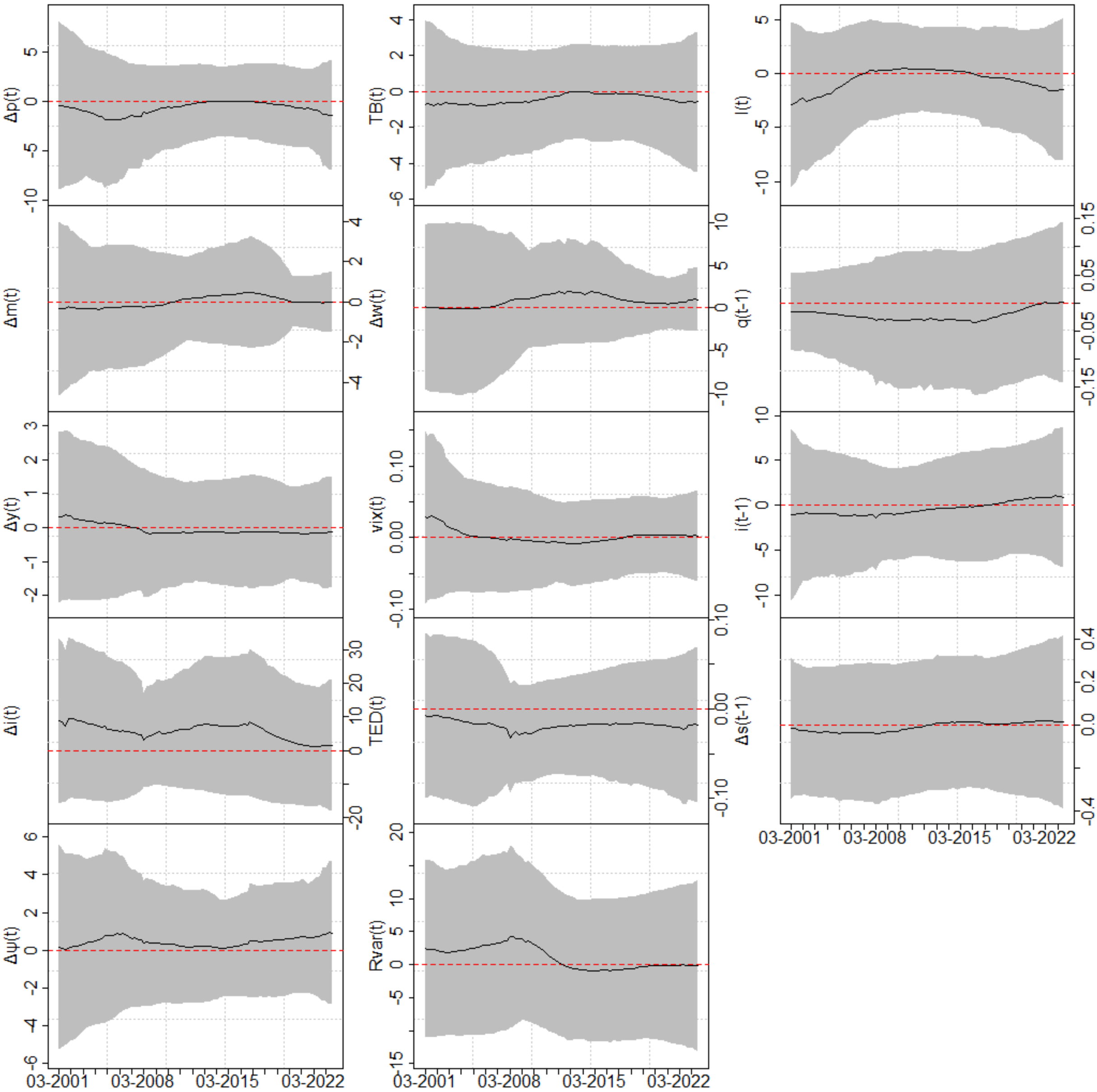


Figure E6: The JPY Case



Notes: The line traces the dynamic model averaging estimates of the explanatory variables; namely (1) intercountry differential of inflation ($\Delta\tilde{p}_t$), (2) intercountry differential of money supply changes ($\Delta\tilde{m}_t$), (3) intercountry differential of GDP growth ($\Delta\tilde{y}_t$), (4) changes of interest rates ($\Delta\tilde{i}_t$), (5) intercountry differential of inflation changes ($\Delta\tilde{\psi}_t$), (6) the US trade balance (TB_t), (7) productivity ($\Delta\tilde{w}_t$), (8) VIX (vix_t), (9) TED (TED_t), (10) realized variance ($RVar_t$), (11) liquidity (l_t), (12) lagged real exchange rate (q_{t-1}), (13) interest rate differential ($\tilde{i}_{t-1}$), and (14) lagged exchange rate changes (Δs_{t-1}). The grey area is the 95% credible interval.

Appendix F. Modeling Quarterly Averages of Daily Exchange Rates

Table F1: Relative Model Probabilities

	M	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample Period	(1)	0.009	0.035	0.025	0.011	0.022	0.020
(1999Q1-2023Q3)	(2)	0.017	0.049	0.072	0.044	0.043	0.024
	(3)	0.013	0.035	0.027	0.013	0.036	0.034
	(4)	0.062	0.107	0.174	0.074	0.050	0.140
	(5)	0.137	0.212	0.235	0.117	0.056	0.173
	(6)	0.044	0.137	0.120	0.262	0.312	0.153
	(7)	0.357	0.548	0.293	0.434	0.287	0.607
	(8)	0.218	0.200	0.465	0.485	0.516	0.513
Pre-crisis Period	(1)	0.018	0.089	0.030	0.010	0.051	0.029
(1999Q1-2007Q2)	(2)	0.044	0.121	0.165	0.114	0.099	0.036
	(3)	0.032	0.088	0.032	0.010	0.081	0.035
	(4)	0.079	0.134	0.221	0.119	0.111	0.265
	(5)	0.192	0.191	0.404	0.194	0.124	0.296
	(6)	0.089	0.227	0.203	0.381	0.616	0.091
	(7)	0.517	0.516	0.507	0.630	0.562	0.879
	(8)	0.471	0.459	0.669	0.636	0.761	0.677
Post-crisis Period	(1)	0.005	0.014	0.024	0.012	0.011	0.018
(2009Q1-2023Q3)	(2)	0.005	0.021	0.033	0.017	0.020	0.020
	(3)	0.005	0.014	0.026	0.015	0.016	0.035
	(4)	0.053	0.099	0.136	0.059	0.025	0.080
	(5)	0.110	0.225	0.140	0.090	0.029	0.112
	(6)	0.027	0.100	0.079	0.202	0.189	0.185
	(7)	0.271	0.565	0.188	0.340	0.166	0.477
	(8)	0.086	0.051	0.367	0.424	0.400	0.448

Notes: The Table presents the averages of the $\pi_{t|T,i}/\pi_{t|T,h}$ ratio, which measures the retrospective model probability of the *i*-th model specification relative to that of HM_t in the full-period sample, pre-crisis period, and post-crisis period. The model specifications (1) to (8) presented in Section 2 are listed under the column labeled "M." In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included.

Table F2: Modified Adjusted R-2 Estimates

	M	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample Period (1999Q1-2023Q3)	(1)	0.241	0.330	0.121	0.286	0.300	0.101
	(2)	0.263	0.361	0.177	0.360	0.358	0.119
	(3)	0.264	0.338	0.131	0.319	0.352	0.173
	(4)	0.514	0.473	0.307	0.462	0.407	0.293
	(5)	0.561	0.519	0.329	0.486	0.421	0.339
	(6)	0.428	0.481	0.253	0.528	0.499	0.336
	(7)	0.633	0.596	0.376	0.601	0.538	0.476
	(8)	0.636	0.537	0.423	0.632	0.616	0.482
	MA	0.634	0.585	0.401	0.605	0.584	0.427
	HM	0.712	0.660	0.494	0.687	0.698	0.545
Pre-crisis Period (1999Q1-2007Q2)	(1)	-0.123	0.037	-0.101	-0.121	-0.195	0.002
	(2)	0.008	0.063	0.083	0.167	-0.103	0.020
	(3)	-0.089	0.009	-0.118	-0.114	-0.111	0.021
	(4)	-0.124	0.177	0.043	-0.019	-0.173	0.188
	(5)	0.001	0.136	0.131	0.033	-0.240	0.160
	(6)	-0.025	0.132	0.081	0.316	0.151	-0.088
	(7)	-0.016	0.130	-0.015	0.185	0.109	0.154
	(8)	-0.094	0.159	-0.141	0.065	0.084	0.013
	MA	0.147	0.237	0.158	0.298	0.249	0.173
	HM	0.290	0.406	0.262	0.412	0.393	0.389
Post-crisis Period (2009Q1-2023Q3)	(1)	0.149	0.271	0.129	0.264	0.157	0.044
	(2)	0.138	0.311	0.140	0.272	0.180	0.047
	(3)	0.145	0.283	0.120	0.299	0.195	0.123
	(4)	0.316	0.360	0.166	0.379	0.204	0.160
	(5)	0.353	0.394	0.159	0.393	0.229	0.216
	(6)	0.239	0.291	0.114	0.376	0.271	0.272
	(7)	0.378	0.420	0.165	0.432	0.258	0.345
	(8)	0.353	0.210	0.229	0.483	0.381	0.350
	MA	0.430	0.444	0.278	0.496	0.389	0.340
	HM	0.527	0.503	0.344	0.583	0.534	0.442

Notes: The modified adjusted R-2 estimates ($R^{M'}$s) of the specifications (1) to (8), the retrospective model averaging estimate of y_t, and the {HM_t} series are given in rows labeled (1) to (8), "MA" and "HM," respectively, under column "M" in the full-period sample, pre-crisis period, and post-crisis period. In the full sample and pre-crisis subsample, the first eight quarters (initial period, 1999Q1-2000Q4) are not included in calculating these ratios.

Table F3a: The Model Specification with Most Frequent Presence in the {HM$_t$} series

ID	#	Specification
AUD	16	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
CAD	11	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_5 TB_t + \delta_{71} vix_t + \delta_{72} TED_t + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
CHF	13	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
EUR	10	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_3\Delta\tilde{i}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{72} TED_t + \delta_8 l_t + \delta_9 q_{t-1} + \varepsilon_t$
GBP	8	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_2\Delta\tilde{y}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_{72} TED_t + \delta_{73} RVar_t + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \delta_{11}\Delta s_{t-1} + \varepsilon_t$
JPY	12	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_{73} RVar_t + \delta_9 q_{t-1} + \varepsilon_t$

Notes: The model specification appears the most often in the {HM$_t$} series is listed for each exchange rate. Column one gives the exchange rate codes and Column two is the number of times the model specification appeared in the {HM$_t$} series.

Table F3b: Change Frequency of HM$_t$ model specifications

	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample	36.3%	36.3%	47.3%	46.7%	59.3%	46.2%
Pre-Crisis	42.3%	34.6%	53.8%	44.0%	69.2%	50.0%
Post-Crisis	30.5%	39.0%	44.1%	47.5%	55.9%	42.4%

Notes: The Table lists the frequency of changes in the model specification of the {HM$_t$} series for each exchange rate and each sample period.

Table F4: Frequencies of PIPs larger than 0.625

	$\Delta\tilde{p}_t$	$\Delta\tilde{m}_t$	$\Delta\tilde{y}_t$	$\Delta\tilde{i}_t$	$\Delta\tilde{\psi}_t$	TB_t	$\Delta\tilde{w}_t$	vix_t	TED_t	$RVar_t$	l_t	q_{t-1}	$\tilde{i}_{t-1}$	Δs_{t-1}
Full Sample Period (1999Q1-2023Q3)														
AUD	0.451	0.352	0.538	0.945	0	0	0.143	0.242	0.198	0.077	0	0.527	0.066	0.011
CAD	0.747	0	0.011	0.758	0	0	0.242	0.341	0	0	0	0.319	0.209	0
CHF	0.253	0	0	0.516	0.473	0.011	0	0	0	0	0	0.527	0.242	0.011
EUR	0.578	0.067	0	0.300	0.200	0	0	0	0.267	0.200	0.822	0.489	0	0.444
GBP	0.615	0	0	0	0.198	0	0	0	0	0.484	0.220	0.648	0.033	0.615
JPY	0.033	0.286	0.209	0.264	0	0	0.143	0.736	0.099	0.033	0	0.341	0	0.088
Pre-crisis Period (1999Q1-2007Q2)														
AUD	0	0.462	0	0.808	0	0	0	0	0	0.269	0	0	0.115	0
CAD	0.115	0	0	0.731	0	0	0	0.692	0	0	0	0.038	0.538	0
CHF	0	0	0	0	0.615	0.038	0	0	0	0	0	0	0	0
EUR	0.360	0.240	0	0	0	0	0	0	0	0.520	0.520	0	0	0
GBP	0	0	0	0	0	0	0	0	0	0.538	0.462	0.038	0	0.154
JPY	0.115	0.577	0.731	0.385	0	0	0	0.385	0.115	0	0	0	0	0
Post-crisis Period (2009Q1-2023Q3)														
AUD	0.695	0.237	0.797	1.000	0	0	0.220	0.356	0.288	0	0	0.814	0.051	0.017
CAD	1.000	0	0.017	0.746	0	0	0.271	0.119	0	0	0	0.458	0	0
CHF	0.390	0	0	0.729	0.441	0	0	0	0	0	0	0.814	0.373	0.017
EUR	0.729	0	0	0.441	0.305	0	0	0	0.322	0.068	0.932	0.746	0	0.678
GBP	0.932	0	0	0	0.305	0	0	0	0	0.407	0.102	0.949	0.051	0.797
JPY	0	0.186	0	0.169	0	0	0.220	0.881	0.102	0.051	0	0.525	0	0.136

Notes: The table presents for each exchange rate the frequencies that the PIP of a variable is larger than 0.625 in the full-period sample, pre-crisis subsample and post-crisis subsample. The exchange rate codes are listed in the first column. In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included.

Table F5: Summary of DMA coefficient estimates

	AUD			CAD			CHF			EUR			GBP			JPY		
	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post
$\Delta\tilde{p}_t$	0.902	**0.594**	1.022	**2.405**	**1.209**	**2.904**	0.367	0.365	0.374	**1.288**	**1.658**	1.123	**1.296**	**0.873**	**1.483**	-0.612	**-1.335**	**-0.273**
	(0.683)	**(0.105)**	(0.811)	**(1.114)**	**(0.603)**	**(0.929)**	(0.654)	(0.441)	(0.760)	**(0.643)**	**(0.442)**	(0.682)	**(0.416)**	**(0.082)**	**(0.383)**	(0.495)	**(0.138)**	**(0.129)**
$\Delta\tilde{m}_t$	-0.249	**-0.429**	-0.134	0.093	-0.035	**0.142**	-0.042	**-0.058**	-0.035	-0.083	**-0.440**	0.091	**-0.236**	**-0.330**	**-0.190**	-0.007	**-0.601**	0.265
	(0.230)	**(0.140)**	(0.184)	(0.105)	(0.089)	**(0.057)**	(0.026)	**(0.021)**	(0.026)	(0.260)	**(0.099)**	(0.096)	**(0.083)**	**(0.044)**	**(0.060)**	(0.450)	**(0.152)**	(0.263)
$\Delta\tilde{y}_t$	0.492	0.251	0.567	0.019	0.126	-0.046	-0.056	**-0.388**	0.100	-0.015	-0.249	0.072	0.221	0.070	0.262	0.216	**0.640**	0.036
	(0.343)	(0.207)	(0.348)	(0.172)	(0.076)	(0.176)	(0.242)	**(0.095)**	(0.108)	(0.272)	(0.255)	(0.232)	(0.205)	(0.174)	(0.183)	(0.300)	**(0.181)**	(0.107)
$\Delta\tilde{i}_t$	**-11.485**	**-10.998**	-11.200	**-11.435**	**-12.484**	**-11.037**	**-5.909**	**-3.684**	**-6.614**	**-5.985**	**-3.743**	**-6.931**	**-3.679**	**-3.431**	**-3.788**	-1.284	2.779	-2.886
	(5.266)	**(2.854)**	(6.039)	**(2.822)**	**(2.940)**	**(2.801)**	**(2.486)**	**(1.281)**	**(2.267)**	**(1.847)**	**(1.106)**	**(1.277)**	**(0.993)**	**(0.547)**	**(1.164)**	(3.136)	(2.455)	(1.507)
$\Delta\tilde{\psi}_t$	0.354	-0.023	**0.524**	0.397	**0.315**	0.442	**1.264**	**1.503**	**1.177**	**1.027**	**0.895**	**1.077**	**0.741**	**0.394**	**0.908**	0.193	**0.333**	0.117
	(0.310)	(0.142)	**(0.217)**	(0.231)	**(0.065)**	(0.273)	**(0.277)**	**(0.201)**	**(0.254)**	**(0.145)**	**(0.159)**	**(0.098)**	**(0.275)**	**(0.114)**	**(0.165)**	(0.145)	**(0.150)**	(0.077)
TB_t	0.057	**-0.154**	0.168	**0.224**	**0.176**	**0.253**	0.177	**0.464**	0.034	0.150	**0.279**	0.103	**0.255**	**0.237**	**0.261**	-0.089	-0.058	-0.115
	(0.211)	**(0.071)**	(0.177)	**(0.094)**	**(0.062)**	**(0.097)**	(0.218)	**(0.092)**	(0.098)	(0.120)	**(0.069)**	(0.098)	**(0.103)**	**(0.073)**	**(0.118)**	(0.129)	(0.038)	(0.150)
$\Delta\tilde{w}_t$	0.229	**0.949**	-0.107	**-0.811**	**-1.018**	-0.665	-0.147	0.334	**-0.349**	0.164	**0.385**	0.079	0.149	0.215	0.187	0.735	0.127	**0.989**
	(0.558)	**(0.179)**	(0.345)	**(0.357)**	**(0.105)**	(0.350)	(0.359)	(0.295)	**(0.129)**	(0.189)	**(0.103)**	(0.144)	(0.394)	(0.223)	(0.412)	(0.503)	(0.176)	**(0.378)**
vix_t	**0.019**	**0.023**	**0.016**	0.016	**0.032**	**0.009**	-0.006	**-0.011**	**-0.003**	-0.001	**-0.008**	0.002	0.006	-0.001	**0.009**	**-0.022**	**-0.025**	-0.020
	(0.006)	**(0.003)**	**(0.006)**	(0.011)	**(0.007)**	**(0.003)**	(0.004)	**(0.002)**	**(0.001)**	(0.005)	**(0.001)**	(0.003)	(0.006)	(0.007)	**(0.003)**	**(0.009)**	**(0.004)**	(0.011)
TED_t	**0.020**	**0.021**	**0.019**	-0.002	**-0.011**	0.003	**0.006**	**0.008**	**0.006**	-0.010	-0.003	**-0.013**	0.002	**0.005**	0.000	**-0.017**	**-0.022**	-0.015
	(0.005)	**(0.001)**	**(0.006)**	(0.007)	**(0.003)**	(0.003)	**(0.003)**	**(0.003)**	**(0.001)**	(0.006)	(0.005)	**(0.004)**	(0.007)	**(0.001)**	(0.007)	**(0.008)**	**(0.005)**	(0.008)
$RVar_t$	-0.112	**1.684**	**-0.859**	0.164	**2.675**	**-0.987**	0.013	**1.637**	-0.663	-0.663	**4.707**	**-3.021**	2.220	**5.935**	0.640	-0.546	**1.240**	-1.523
	(1.205)	**(0.672)**	**(0.139)**	(1.762)	**(1.061)**	**(0.329)**	(1.163)	**(0.789)**	(0.409)	(3.567)	**(1.270)**	**(0.810)**	(2.576)	**(1.369)**	(0.805)	(1.992)	**(0.129)**	(1.841)
l_t	1.111	**-0.677**	2.025	**-1.870**	**-2.013**	**-1.782**	-0.865	**-1.671**	-0.466	**-5.467**	**-5.906**	**-4.936**	**-3.131**	**-4.024**	**-2.724**	-0.531	**-1.684**	-0.017
	(1.598)	**(0.197)**	(1.215)	**(0.404)**	**(0.120)**	**(0.471)**	(0.604)	**(0.115)**	(0.297)	**(2.146)**	**(1.350)**	**(2.178)**	**(0.704)**	**(0.436)**	**(0.388)**	(0.967)	**(0.376)**	(0.725)
q_{t-1}	-0.054	**-0.025**	**-0.070**	**-0.037**	**-0.023**	**-0.043**	**-0.056**	**-0.032**	**-0.069**	**-0.053**	**-0.037**	**-0.062**	**-0.068**	**-0.045**	**-0.078**	-0.023	**-0.012**	**-0.028**
	(0.029)	**(0.004)**	**(0.024)**	**(0.014)**	**(0.010)**	**(0.010)**	**(0.022)**	**(0.004)**	**(0.016)**	**(0.016)**	**(0.003)**	**(0.014)**	**(0.016)**	**(0.008)**	**(0.006)**	(0.012)	**(0.002)**	**(0.011)**
$\tilde{i}_{t-1}$	**-1.859**	**-2.060**	**-1.826**	-0.257	**-2.766**	**0.968**	-1.693	**-2.445**	-1.329	-0.518	**-1.613**	-0.093	-0.212	0.147	-0.487	-0.139	**-0.935**	0.243
	(0.328)	**(0.386)**	**(0.226)**	(1.759)	**(0.621)**	**(0.374)**	(0.957)	**(0.304)**	(0.990)	(0.835)	**(0.796)**	(0.298)	(0.927)	(0.629)	(0.943)	(0.627)	**(0.262)**	(0.373)
Δs_{t-1}	**0.083**	**0.076**	**0.087**	0.016	**0.028**	0.009	0.056	0.008	**0.074**	0.172	0.037	**0.237**	**0.196**	**0.130**	**0.223**	**0.093**	**0.066**	**0.108**
	(0.014)	**(0.016)**	**(0.013)**	(0.018)	**(0.009)**	(0.018)	(0.042)	(0.050)	**(0.014)**	(0.105)	(0.031)	**(0.063)**	**(0.051)**	**(0.040)**	**(0.026)**	**(0.034)**	**(0.005)**	**(0.034)**

Notes: The first element of an exchange-rate-explanatory-factor cell is the average of the series of the dynamic model averaging estimates (the retrospective coefficient estimates of the explanatory factor obtained via dynamic model averaging), and the second element presented in the round parentheses is the standard error of the dynamic model averaging estimates. The "Full," "Pre," and "Post" columns present results from the full sample period (1999Q1-2023Q3), pre-crisis subsample period (1999Q1-2007Q2), and post-crisis subsample period (2009Q1-2023Q3). In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included. The numbers in bold denote the corresponding average-to-standard-error ratio is larger than 1.96.

Table F6a: Average Deviation of PPP Coefficient Estimates from Unity

	AUD	CAD	CHF	EUR	GBP	JPY
(1)	1.304	2.976	0.443	2.076	1.364	-1.768
(2)	1.202	2.940	0.894	2.539	1.608	-1.668
(3)	1.000	2.877	0.329	1.565	1.234	-2.159
(4)	0.722	2.230	-1.557	0.206	0.260	-2.380
(5)	0.196	1.886	-1.217	0.321	0.337	-3.014
(6)	0.511	2.691	0.321	2.514	1.702	-1.100
(7)	0.152	2.020	-1.419	1.459	0.731	-2.512
(8)	0.085	1.299	-1.298	-0.050	0.167	-2.480
DMA	-0.098	1.405	-0.633	0.288	0.296	-1.612
HM	0.759	1.914	-0.962	0.824	0.845	-3.010

Notes: The Table presents the averages of the series $\{\beta_{i,t} - 1\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled (1) to (8), "MA" and "HM."

Table F6b: Average Absolute Deviation of PPP Coefficient Estimates from Unity

	AUD	CAD	CHF	EUR	GBP	JPY
(1)	1.383	2.976	1.018	2.076	1.456	1.768
(2)	1.343	2.940	1.241	2.539	1.608	1.668
(3)	1.289	2.877	0.868	1.620	1.284	2.159
(4)	1.445	2.230	1.952	1.683	0.995	2.380
(5)	1.139	1.886	1.530	1.460	1.045	3.014
(6)	0.996	2.691	1.072	2.514	1.702	1.100
(7)	1.299	2.020	1.548	1.479	0.733	2.512
(8)	0.991	1.314	1.462	1.306	0.502	2.480
DMA	0.575	1.467	0.738	0.602	0.413	1.612
HM	1.552	1.929	1.705	2.228	0.973	3.010

Notes: The Table presents the averages of the series $\{|\beta_{i,t} - 1|\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled (1) to (8), "MA" and "HM."

Appendix G. Replacing q(t-1) with s(t-1)

Table G1: Relative Model Probabilities

	M	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample Period	(1)	0.016	0.052	0.046	0.034	0.041	0.026
(1999Q1-2023Q3)	(2)	0.028	0.069	0.055	0.058	0.059	0.032
	(3)	0.018	0.057	0.054	0.039	0.038	0.027
	(4)	0.206	0.118	0.133	0.187	0.100	0.098
	(5)	0.246	0.173	0.154	0.203	0.112	0.112
	(6)	0.071	0.198	0.406	0.324	0.266	0.197
	(7)	0.544	0.461	0.431	0.646	0.393	0.478
	(8)	0.410	0.251	0.323	0.489	0.292	0.494
Pre-crisis Period	(1)	0.026	0.149	0.022	0.018	0.087	0.021
(1999Q1-2007Q2)	(2)	0.056	0.195	0.034	0.041	0.109	0.032
	(3)	0.025	0.163	0.032	0.026	0.079	0.020
	(4)	0.211	0.269	0.069	0.130	0.137	0.122
	(5)	0.229	0.319	0.093	0.127	0.133	0.125
	(6)	0.062	0.259	0.540	0.358	0.529	0.264
	(7)	0.610	0.470	0.662	0.709	0.584	0.591
	(8)	0.645	0.544	0.626	0.679	0.488	0.564
Post-crisis Period	(1)	0.009	0.012	0.058	0.042	0.019	0.029
(2009Q1-2023Q3)	(2)	0.011	0.017	0.067	0.064	0.031	0.033
	(3)	0.012	0.014	0.067	0.047	0.018	0.032
	(4)	0.198	0.057	0.159	0.211	0.087	0.091
	(5)	0.248	0.106	0.178	0.239	0.108	0.111
	(6)	0.074	0.181	0.352	0.308	0.145	0.164
	(7)	0.498	0.469	0.301	0.617	0.287	0.424
	(8)	0.294	0.117	0.159	0.402	0.193	0.454

Notes: The Table presents the averages of the $\pi_{t|T,i}/\pi_{t|T,h}$ ratio, which measures the retrospective model probability of the *i*-th model specification relative to that of HM_t in the full-period sample, pre-crisis period, and post-crisis period. The model specifications (1) to (8) presented in Section 2 are listed under the column labeled "M." In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included.

Table G2: Modified Adjusted R-2 Estimates

	M	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample Period	(6)	0.250	0.352	0.268	0.290	0.354	0.255
(1999Q1-2023Q3)	(7)	0.454	0.457	0.335	0.387	0.456	0.390
	(8)	0.453	0.443	0.313	0.381	0.473	0.420
	MA	0.435	0.442	0.301	0.348	0.455	0.359
	HM	0.549	0.565	0.440	0.500	0.581	0.475
Pre-crisis Period	(6)	-0.207	-0.022	0.307	0.229	0.141	0.100
(1999Q1-2007Q2)	(7)	-0.107	-0.188	0.182	0.123	0.013	0.171
	(8)	-0.273	-0.255	0.053	-0.003	-0.100	0.110
	MA	0.090	0.061	0.244	0.244	0.108	0.232
	HM	0.161	0.272	0.338	0.390	0.336	0.313
Post-crisis Period	(6)	0.291	0.243	0.154	0.248	0.088	0.063
(2009Q1-2023Q3)	(7)	0.352	0.330	0.109	0.279	0.132	0.191
	(8)	0.345	0.242	0.039	0.261	0.147	0.211
	MA	0.376	0.334	0.178	0.277	0.214	0.199
	HM	0.494	0.453	0.287	0.418	0.357	0.305

Notes: The modified adjusted R-2 estimates, R^{M}'s, of the specifications (1) to (8), the retrospective model averaging estimate of y_t, and the {HM_t} series are given in rows labeled (1) to (8), "MA" and "HM," respectively, under column "M" in the full-period sample, pre-crisis period, and post-crisis period. In the full sample and pre-crisis subsample, the first eight quarters (initial period, 1999Q1-2000Q4) are not included in calculating these ratios.

Table G3a: The Model Specification with Most Frequent Presence in the {HM$_t$} Series

ID	#	Specification
AUD	7	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_6\Delta\tilde{w}_t + \delta_8 l_t + \delta_9 s_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
CAD	17	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_{72} TED_t + \delta_8 l_t + \delta_9 s_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
CHF	14	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_4\Delta\tilde{\psi}_t + \delta_{71} vix_t + \delta_{72} TED_t + \delta_8 l_t + \delta_9 s_{t-1} + \varepsilon_t$
EUR	10	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_6\Delta\tilde{w}_t + \delta_{72} TED_t + \delta_{73} RVar_t + \delta_8 l_t + \delta_9 s_{t-1} + \varepsilon_t$
GBP	7	$\Delta s_t = \alpha + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_{73} RVar_t + \delta_8 l_t + \delta_9 s_{t-1} + \delta_{11}\Delta s_{t-1} + \varepsilon_t$
JPY	15	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{71} vix_t + \delta_{72} TED_t + \delta_{73} RVar_t + \delta_8 l_t + \delta_9 s_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$

Notes: The model specification appears the most often in the {HM$_t$} series is listed for each exchange rate. Column one gives the exchange rate codes and Column two is the number of times the model specification appeared in the {HM$_t$} series.

Table G3b. Change Frequency of HM$_t$ Model Specifications

	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample	51.6%	51.6%	60.4%	49.5%	54.9%	31.9%
Pre-Crisis	46.2%	61.5%	50.0%	57.7%	50.0%	23.1%
Post-Crisis	50.8%	52.5%	61.0%	47.5%	57.6%	33.9%

Notes: The Table lists the frequency of changes in the model specification of the {HM$_t$} series for each exchange rate and each sample period.

Table G4: Frequencies of PIPs Larger than 0.625

	$\Delta\tilde{p}_t$	$\Delta\tilde{m}_t$	$\Delta\tilde{y}_t$	$\Delta\tilde{i}_t$	$\Delta\tilde{\psi}_t$	TB_t	$\Delta\tilde{w}_t$	vix_t	TED_t	$RVar_t$	l_t	s_{t-1}	$\tilde{i}_{t-1}$	Δs_{t-1}
Full Sample Period (1999Q1-2023Q3)														
AUD	0	0.198	0.923	0.253	0	0	0.011	0.341	0	0	0.132	0.341	0.121	0
CAD	0.165	0.319	0.209	0	0	0	0.374	0.264	0.593	0.033	0.220	0	0.165	0
CHF	0.132	0	0.077	0	0.099	0	0	0.055	0.220	0	0.747	0.341	0	0.044
EUR	0.011	0.011	0.121	0.044	0.374	0.011	0	0	0	0	0.176	0.857	0	0.033
GBP	0	0.011	0	0.088	0.593	0	0.011	0.033	0.022	0.198	0.242	0.462	0	0
JPY	0	0	0	0.396	0	0	0.066	0.022	0.286	0.099	0.429	0.769	0.044	0
Pre-crisis Period (1999Q1-2007Q2)														
AUD	0	0.346	0.808	0	0	0	0	0	0	0	0	0.385	0.423	0
CAD	0	0	0	0	0	0	0	0	0	0.115	0	0	0.5	0
CHF	0	0	0	0	0	0	0	0.192	0.769	0	0.808	0.846	0	0.154
EUR	0	0	0	0	0.269	0.038	0	0	0	0	0.346	0.923	0	0.115
GBP	0	0	0	0	0	0	0	0	0	0	0.808	0	0	0
JPY	0	0	0	0.577	0	0	0	0.077	0	0	0.923	0.385	0	0
Post-crisis Period (2009Q1-2023Q3)														
AUD	0	0.153	1.000	0.339	0	0	0.017	0.525	0	0	0.169	0.356	0	0
CAD	0.254	0.492	0.322	0	0	0	0.475	0.407	0.881	0	0.339	0	0	0
CHF	0.153	0	0.068	0	0.119	0	0	0	0	0	0.763	0.068	0	0
EUR	0.017	0.017	0.186	0.068	0.458	0	0	0	0	0	0.119	0.847	0	0
GBP	0	0.017	0	0.102	0.915	0	0.017	0.017	0.017	0.220	0	0.678	0	0
JPY	0	0	0	0.356	0	0	0.102	0	0.373	0.153	0.203	0.915	0.068	0

Notes: The table presents for each exchange rate the frequencies that the PIP of a variable is larger than 0.625 in the full-period sample, pre-crisis subsample and post-crisis subsample. The exchange rate codes are listed in the first column. In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included.

Table G5: Summary of DMA coefficient estimates based on Quarter-Average Observations

	AUD			CAD			CHF			EUR			GBP			JPY		
	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post
$\Delta\tilde{p}_t$	0.028	0.069	0.001	1.023	0.375	**1.280**	*-1.538*	**-2.298**	*-1.049*	-0.130	**-0.755**	0.219	0.100	-0.381	0.282	-0.577	**-1.139**	-0.284
	(0.577)	(0.069)	(0.715)	(0.698)	(0.537)	**(0.607)**	*(0.840)*	**(0.133)**	*(0.570)*	(0.562)	**(0.327)**	(0.297)	(0.384)	(0.244)	(0.238)	(0.587)	**(0.471)**	(0.431)
$\Delta\tilde{m}_t$	0.035	**-0.349**	0.224	0.419	**0.281**	0.487	0.016	-0.063	**0.050**	0.104	0.047	0.143	-0.231	**-0.388**	-0.139	0.063	**-0.285**	0.243
	(0.335)	**(0.078)**	(0.255)	(0.241)	**(0.106)**	(0.268)	(0.060)	(0.055)	**(0.018)**	(0.118)	(0.082)	(0.116)	(0.184)	**(0.045)**	(0.161)	(0.308)	**(0.049)**	(0.227)
$\Delta\tilde{y}_t$	**1.343**	**1.662**	1.162	-0.241	0.104	-0.412	-0.357	**-0.562**	-0.207	-0.249	0.065	-0.346	0.015	**-0.086**	0.063	-0.030	0.183	**-0.116**
	(0.665)	**(0.254)**	(0.743)	(0.307)	(0.067)	(0.238)	(0.353)	**(0.103)**	(0.332)	(0.313)	(0.254)	(0.227)	(0.137)	**(0.039)**	(0.147)	(0.149)	(0.105)	**(0.032)**
$\Delta\tilde{i}_t$	-4.704	-1.790	**-5.609**	0.776	1.118	0.806	-1.509	**-2.472**	-0.843	-2.331	0.517	-3.632	-4.935	-2.161	**-6.112**	**5.244**	**7.322**	*4.462*
	(2.714)	(1.971)	**(1.742)**	(1.339)	(1.049)	(1.387)	(1.301)	**(0.745)**	(0.965)	(3.474)	(1.662)	(3.484)	(2.750)	(1.270)	**(2.468)**	**(2.465)**	**(1.581)**	*(2.364)*
$\Delta\tilde{\psi}_t$	**0.841**	**0.875**	**0.838**	0.273	-0.004	0.387	**0.990**	**1.148**	**0.900**	**1.278**	**1.897**	**1.007**	0.996	0.139	**1.391**	0.422	0.497	0.388
	(0.098)	**(0.103)**	**(0.087)**	(0.304)	(0.258)	(0.257)	**(0.242)**	**(0.099)**	**(0.235)**	**(0.608)**	**(0.427)**	**(0.493)**	(0.731)	(0.381)	**(0.525)**	(0.248)	(0.272)	(0.244)
TB_t	0.318	-0.247	**0.579**	**0.252**	**0.291**	**0.234**	0.235	**0.471**	0.121	**0.449**	**0.609**	**0.381**	**0.358**	**0.300**	0.386	-0.422	**-0.652**	-0.306
	(0.420)	(0.240)	**(0.188)**	**(0.071)**	**(0.088)**	**(0.057)**	(0.176)	**(0.110)**	(0.062)	**(0.157)**	**(0.078)**	**(0.139)**	**(0.182)**	**(0.039)**	(0.220)	(0.232)	**(0.044)**	(0.208)
$\Delta\tilde{w}_t$	-0.171	**0.285**	-0.402	*-0.959*	**-0.997**	-0.851	-0.133	-0.139	-0.148	0.037	-0.037	0.084	0.292	-0.058	0.513	0.719	-0.138	**1.112**
	(0.451)	**(0.120)**	(0.390)	*(0.492)*	**(0.172)**	(0.515)	(0.230)	(0.252)	(0.222)	(0.238)	(0.093)	(0.278)	(0.601)	(0.097)	(0.638)	(0.666)	(0.127)	**(0.436)**
vix_t	**-0.018**	**-0.006**	**-0.024**	-0.007	**0.005**	**-0.013**	0.000	**0.018**	**-0.008**	0.003	**0.008**	0.000	0.002	**0.012**	-0.004	0.003	0.011	-0.001
	(0.009)	**(0.001)**	**(0.005)**	(0.009)	**(0.003)**	**(0.003)**	(0.013)	**(0.009)**	**(0.003)**	(0.005)	**(0.004)**	(0.003)	(0.010)	**(0.004)**	(0.008)	(0.009)	(0.011)	(0.004)
TED_t	0.006	**0.015**	0.002	0.008	0.004	0.009	0.005	**0.025**	**-0.003**	-0.001	**0.016**	**-0.008**	**0.015**	**0.018**	**0.013**	**-0.020**	**-0.015**	**-0.021**
	(0.007)	**(0.003)**	(0.005)	(0.009)	(0.005)	(0.010)	(0.014)	**(0.010)**	**(0.001)**	(0.012)	**(0.007)**	**(0.002)**	**(0.006)**	**(0.002)**	**(0.006)**	**(0.006)**	**(0.005)**	**(0.004)**
$RVar_t$	0.196	**0.787**	-0.083	0.518	**4.418**	**-1.170**	0.120	**1.211**	-0.364	0.322	**3.686**	-1.488	0.339	**4.494**	-1.390	1.130	**2.432**	0.290
	(0.424)	**(0.241)**	(0.119)	(2.641)	**(1.500)**	**(0.222)**	(1.001)	**(0.516)**	(0.812)	(2.948)	**(0.388)**	(1.977)	(2.876)	**(1.543)**	(0.913)	(1.558)	**(0.424)**	(1.223)
l_t	0.724	0.179	**0.928**	-0.827	-0.238	-1.156	**-1.282**	**-1.542**	**-1.216**	**-1.768**	**-1.581**	**-1.907**	-0.855	**-1.580**	**-0.588**	-0.494	-1.362	-0.216
	(0.438)	(0.213)	**(0.264)**	(0.672)	(0.173)	(0.613)	**(0.333)**	**(0.421)**	**(0.190)**	**(0.598)**	**(0.335)**	**(0.660)**	(0.553)	**(0.519)**	**(0.145)**	(0.990)	(0.989)	(0.758)
s_{t-1}	**-0.059**	**-0.051**	**-0.066**	-0.033	**-0.009**	**-0.045**	**-0.050**	**-0.071**	**-0.042**	**-0.092**	**-0.096**	**-0.093**	**-0.061**	**-0.058**	**-0.061**	**-0.068**	**-0.058**	**-0.070**
	(0.026)	**(0.011)**	**(0.028)**	(0.020)	**(0.003)**	**(0.014)**	**(0.018)**	**(0.012)**	**(0.014)**	**(0.019)**	**(0.018)**	**(0.018)**	**(0.014)**	**(0.010)**	**(0.015)**	**(0.016)**	**(0.015)**	**(0.015)**
$\tilde{i}_{t-1}$	-1.876	**-2.628**	**-1.656**	1.241	**-2.282**	**2.922**	-0.923	**-1.824**	-0.436	-0.294	**-1.366**	0.192	0.562	0.493	0.510	-1.191	**-1.548**	-0.932
	(0.993)	**(1.033)**	**(0.802)**	(2.537)	**(0.802)**	**(1.047)**	(0.879)	**(0.138)**	(0.708)	(0.757)	**(0.511)**	(0.128)	(0.604)	(0.379)	(0.657)	(0.926)	**(0.340)**	(1.024)
Δs_{t-1}	-0.024	**-0.009**	-0.032	-0.029	-0.018	**-0.037**	**-0.079**	**-0.100**	**-0.071**	-0.032	**-0.078**	-0.014	0.037	0.019	**0.045**	0.002	**-0.024**	0.015
	(0.018)	**(0.003)**	(0.017)	(0.021)	(0.026)	**(0.015)**	**(0.027)**	**(0.039)**	**(0.014)**	(0.038)	**(0.046)**	(0.008)	(0.021)	(0.021)	**(0.016)**	(0.022)	**(0.005)**	(0.014)

Notes: The first element of an exchange-rate-explanatory-factor cell is the average of the series of dynamic model averaging estimates, and the second element presented in the round parentheses is the standard error of the series of dynamic model averaging estimates. The "Full," "Pre," and "Post" columns present results from the full sample period (1999Q1-2023Q3), pre-crisis subsample period (1999Q1-2007Q2), and post-crisis subsample period (2009Q1-2023Q3). In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included. The numbers in bold denote the corresponding average-to-standard-error ratio is larger than 1.96.

Table G6a: Average Deviation of PPP Coefficient Estimates from Unity

	AUD	CAD	CHF	EUR	GBP	JPY
(6)	0.718	1.385	-2.092	0.337	0.129	-1.343
(7)	-2.804	1.104	-5.541	-2.338	-1.718	-2.866
(8)	-2.079	0.942	-5.564	-2.377	-1.775	-2.063
DMA	-0.972	0.023	-2.538	-1.130	-0.900	-1.577
HM	-1.669	0.738	-4.693	-1.578	-1.065	-2.157

Notes: The Table presents the averages of the series $\{\beta_{i,t} - 1\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled (1) to (8), "MA" and "HM."

Table G6b: Average Absolute Deviation of PPP Coefficient Estimates from Unity

	AUD	CAD	CHF	EUR	GBP	JPY
(6)	1.390	1.694	2.092	0.655	1.034	1.343
(7)	2.804	1.253	5.541	2.338	1.718	2.866
(8)	2.079	1.203	5.564	2.377	1.775	2.063
DMA	0.972	0.616	2.538	1.130	0.900	1.577
HM	2.014	1.289	4.693	1.637	1.335	2.220

Notes: The Table presents the averages of the series $\{|\beta_{i,t} - 1|\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled (1) to (8), "MA" and "HM."

Appendix H. Results with First Differences of VIX, Rvar and Liquidity

Table H1: Retrospective Model Probabilities

	M	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample Period	(1)	0.008	0.052	0.049	0.033	0.073	0.025
(1999Q1-2023Q3)	(2)	0.015	0.069	0.063	0.056	0.103	0.033
	(3)	0.009	0.057	0.058	0.037	0.066	0.027
	(4)	0.089	0.134	0.169	0.153	0.154	0.108
	(5)	0.104	0.204	0.200	0.164	0.166	0.121
	(6)	0.026	0.184	0.198	0.179	0.257	0.151
	(7)	0.499	0.598	0.301	0.722	0.446	0.509
	(8)	0.435	0.481	0.246	0.573	0.341	0.461
Pre-crisis Period	(1)	0.017	0.134	0.030	0.027	0.184	0.030
(1999Q1-2007Q2)	(2)	0.038	0.173	0.051	0.064	0.234	0.047
	(3)	0.017	0.147	0.043	0.034	0.166	0.029
	(4)	0.145	0.239	0.103	0.162	0.301	0.180
	(5)	0.158	0.284	0.142	0.158	0.291	0.183
	(6)	0.048	0.241	0.266	0.178	0.589	0.086
	(7)	0.610	0.641	0.503	0.638	0.599	0.409
	(8)	0.716	0.678	0.508	0.656	0.480	0.458
Post-crisis Period	(1)	0.003	0.019	0.060	0.035	0.018	0.024
(2009Q1-2023Q3)	(2)	0.004	0.026	0.071	0.050	0.032	0.027
	(3)	0.004	0.021	0.068	0.038	0.017	0.027
	(4)	0.063	0.095	0.202	0.145	0.092	0.079
	(5)	0.079	0.168	0.230	0.164	0.115	0.099
	(6)	0.014	0.165	0.158	0.176	0.098	0.178
	(7)	0.419	0.569	0.188	0.765	0.370	0.561
	(8)	0.296	0.400	0.100	0.539	0.272	0.460

Notes: The Table presents the averages of the $\pi_{t|T,i}/\pi_{t|T,h}$ ratio, which measures the retrospective model probability of the *i*-th model specification relative to that of HM_t in the full-period sample, pre-crisis period, and post-crisis period. The model specifications (1) to (8) presented in Section 2 are listed under the column labeled "M." In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included.

Table H2: Modified Adjusted R-2 Estimates

	M	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample Period (1999Q1-2023Q3)	(1)	0.066	0.157	0.062	0.047	0.161	0.099
	(2)	0.096	0.181	0.084	0.116	0.229	0.120
	(3)	0.084	0.167	0.067	0.049	0.166	0.106
	(4)	0.360	0.284	0.160	0.229	0.315	0.243
	(5)	0.377	0.329	0.188	0.241	0.332	0.272
	(6)	0.207	0.320	0.185	0.246	0.330	0.266
	(7)	0.522	0.457	0.284	0.413	0.452	0.426
	(8)	0.532	0.471	0.251	0.418	0.475	0.444
	MA	0.497	0.436	0.272	0.346	0.444	0.367
	HM	0.593	0.567	0.409	0.472	0.578	0.510
Pre-crisis Period (1999Q1-2007Q2)	(1)	-0.104	0.072	0.055	-0.103	-0.059	-0.013
	(2)	-0.010	0.096	0.086	0.031	-0.040	0.048
	(3)	-0.129	0.045	0.029	-0.148	-0.093	-0.054
	(4)	-0.001	0.061	0.017	-0.030	-0.159	0.184
	(5)	-0.035	0.040	0.042	-0.075	-0.216	0.155
	(6)	-0.138	0.017	0.133	0.051	0.004	-0.045
	(7)	-0.030	-0.075	0.020	-0.085	-0.161	0.194
	(8)	-0.165	-0.196	-0.106	-0.216	-0.282	0.157
	MA	0.129	0.083	0.163	0.104	0.021	0.214
	HM	0.116	0.277	0.296	0.233	0.260	0.440
Post-crisis Period (2009Q1-2023Q3)	(1)	0.067	0.079	-0.013	0.038	0.025	0.010
	(2)	0.050	0.098	-0.025	0.051	0.021	0.012
	(3)	0.092	0.088	0.004	0.043	0.009	0.019
	(4)	0.306	0.157	-0.014	0.162	0.120	0.100
	(5)	0.323	0.175	0.003	0.180	0.149	0.140
	(6)	0.212	0.163	-0.038	0.204	0.083	0.127
	(7)	0.428	0.272	-0.030	0.344	0.180	0.262
	(8)	0.454	0.276	-0.152	0.333	0.197	0.262
	MA	0.455	0.309	0.096	0.292	0.225	0.222
	HM	0.549	0.410	0.220	0.383	0.388	0.348

Notes: The modified adjusted R-2 estimates, R^{M}'s, of the specifications (1) to (8), the retrospective model averaging estimate of y_t, and the $\{HM_t\}$ series are given in rows labeled (1) to (8), "MA" and "HM," respectively, under column "M" in the full-period sample, pre-crisis period, and post-crisis period. In the full sample and pre-crisis subsample, the first eight quarters (initial period, 1999Q1-2000Q4) are not included in calculating these ratios.

Table H3a: The Model Specification with Most Frequent Presence in the {HM$_t$} Series

ID	#	Specification
AUD	13	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_{73}\Delta RVar_t + \delta_8\Delta l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
CAD	7	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{72} TED_t + \delta_{73}\Delta RVar_t + \delta_8\Delta l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
CHF	15	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_2\Delta\tilde{y}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_{72} TED_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \delta_{11}\Delta s_{t-1} + \varepsilon_t$
EUR	13	$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_{71}\Delta vix_t + \delta_{72} TED_t + \delta_{73}\Delta RVar_t + \delta_9 q_{t-1} + \varepsilon_t$
GBP	6	$\Delta s_t = \alpha + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{71}\Delta vix_t + \delta_{72} TED_t + \delta_8\Delta l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$
JPY	11	$\Delta s_t = \alpha + \delta_3\Delta\tilde{i}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_{71}\Delta vix_t + \delta_{72} TED_t + \delta_{73}\Delta RVar_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \varepsilon_t$

Notes: The model specification appears the most often in the {HM$_t$} series is listed for each exchange rate. Column one gives the exchange rate codes and Column two is the number of times the model specification appeared in the {HM$_t$} series.

Table H3b: Change Frequency of HM$_t$ model specifications

	AUD	CAD	CHF	EUR	GBP	JPY
Full Sample	37.4%	56.0%	53.8%	41.1%	57.1%	36.3%
Pre-Crisis	46.2%	65.4%	42.3%	52.0%	69.2%	30.8%
Post-Crisis	32.2%	52.5%	57.6%	33.9%	50.8%	37.3%

Notes: The Table lists the frequency of changes in the model specification of the {HM$_t$} series for each exchange rate and each sample period.

Table H4: Frequencies of PIPs Larger than 0.625

	$\Delta\tilde{p}_t$	$\tilde{i}_{t-1}$	Δs_{t-1}	$\Delta\tilde{m}_t$	$\Delta\tilde{y}_t$	$\Delta\tilde{i}_t$	$\Delta\tilde{\psi}_t$	TB_t	$\Delta\tilde{w}_t$	Δvix_t	TED_t	$\Delta RVar_t$	Δl_t	q_{t-1}
Full Sample Period (1999Q1-2023Q3)														
AUD	0	0.187	0.967	0.648	0.022	0.011	0.099	0	0	0.473	0.374	0.571	0.22	0
CAD	0.055	0.253	0.209	0	0	0.011	0.176	0	0.363	0.319	0	0.022	0.033	0
CHF	0.077	0	0.033	0	0.088	0.022	0	0	0.110	0.033	0.066	0.879	0	0.066
EUR	0.133	0.011	0.022	0.056	0.744	0	0	0.056	0	0.211	0	0.822	0	0.022
GBP	0	0.044	0	0.044	0.637	0	0	0.011	0.242	0.011	0.110	0.604	0.099	0
JPY	0.066	0	0	0.571	0	0	0.143	0.176	0.429	0.451	0.011	0.066	0.022	0
Pre-crisis Period (1999Q1-2007Q2)														
AUD	0	0.077	0.923	0.077	0.077	0	0	0	0	0.500	0	0.538	0.654	0
CAD	0	0	0	0	0	0.038	0	0	0	0.308	0	0	0.115	0
CHF	0	0	0	0	0	0.077	0	0	0.385	0	0	0.846	0	0.231
EUR	0	0	0	0	0.800	0	0	0	0	0	0	0.840	0	0.08
GBP	0	0.154	0	0	0	0	0	0	0.154	0	0	0	0	0
JPY	0.038	0	0	0.923	0	0	0	0.038	0	0	0	0	0.077	0
Post-crisis Period (2009Q1-2023Q3)														
AUD	0	0.254	1.000	0.898	0	0.017	0.153	0	0	0.424	0.542	0.644	0.051	0
CAD	0.085	0.390	0.322	0	0	0	0.169	0	0.525	0.322	0	0.034	0	0
CHF	0.085	0	0.034	0	0.102	0	0	0	0	0.017	0.102	0.881	0	0
EUR	0.169	0.017	0.034	0.085	0.763	0	0	0.085	0	0.322	0	0.847	0	0
GBP	0	0	0	0.068	0.983	0	0	0.017	0.254	0.017	0.169	0.932	0.119	0
JPY	0.085	0	0	0.475	0	0	0.220	0.254	0.576	0.610	0.017	0.102	0	0

Notes: The table presents for each exchange rate the frequencies that the PIP of a variable is larger than 0.625 in the full-period sample, pre-crisis subsample and post-crisis subsample. The exchange rate codes are listed in the first column. In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included.

Table H5 Summary of DMA coefficient estimates with First Differences of VIX, Rvar and Liquidity

	AUD			CAD			CHF			EUR			GBP			JPY		
	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post	Full	Pre	Post
$\Delta\tilde{p}_t$	-0.145	0.017	-0.218	0.671	0.243	0.810	-1.697	**-2.692**	**-1.115**	-0.459	**-1.015**	-0.152	0.004	-0.314	0.103	-0.836	**-1.505**	-0.485
	(0.579)	(0.142)	(0.702)	(0.584)	(0.534)	(0.529)	(0.919)	**(0.227)**	**(0.511)**	(0.636)	**(0.427)**	(0.508)	(0.294)	(0.175)	(0.220)	(0.636)	**(0.336)**	(0.470)
$\Delta\tilde{m}_t$	0.163	**-0.292**	0.385	0.405	**0.301**	0.462	0.028	-0.029	**0.052**	0.118	0.016	0.177	-0.232	**-0.455**	-0.110	0.085	**-0.278**	0.270
	(0.390)	**(0.062)**	(0.295)	(0.236)	**(0.080)**	(0.271)	(0.046)	(0.048)	**(0.015)**	(0.140)	(0.075)	(0.129)	(0.209)	**(0.059)**	(0.151)	(0.295)	**(0.070)**	(0.180)
$\Delta\tilde{y}_t$	1.419	**1.702**	1.239	-0.204	**0.134**	-0.376	-0.402	**-0.591**	-0.275	-0.322	0.018	**-0.434**	-0.012	**-0.164**	0.055	0.006	0.298	**-0.117**
	(0.726)	**(0.229)**	(0.820)	(0.304)	**(0.056)**	(0.235)	(0.328)	**(0.078)**	(0.335)	(0.286)	(0.234)	**(0.171)**	(0.151)	**(0.039)**	(0.140)	(0.207)	(0.158)	**(0.042)**
$\Delta\tilde{i}_t$	-7.818	-2.920	**-9.630**	-0.360	0.329	-0.455	-1.159	-0.857	-1.053	-2.946	0.643	-4.520	-4.368	-1.844	**-5.523**	**6.433**	**7.542**	**6.195**
	(4.232)	(2.421)	**(2.965)**	(2.148)	(1.360)	(2.384)	(1.141)	(1.197)	(0.880)	(4.086)	(1.845)	(4.013)	(2.684)	(1.011)	**(2.549)**	**(2.150)**	**(2.054)**	**(2.021)**
$\Delta\tilde{\psi}_t$	**1.031**	**1.008**	**1.054**	0.516	0.096	**0.694**	**0.991**	**1.390**	**0.793**	**1.788**	**2.310**	*1.576*	1.526	0.586	**1.974**	**0.485**	0.502	**0.472**
	(0.116)	**(0.146)**	**(0.093)**	(0.371)	(0.322)	**(0.239)**	**(0.334)**	**(0.200)**	**(0.175)**	**(0.787)**	**(0.368)**	*(0.846)*	(0.870)	(0.323)	**(0.717)**	**(0.241)**	(0.334)	**(0.204)**
TB_t	0.365	-0.258	**0.651**	**0.288**	**0.374**	**0.248**	0.233	**0.506**	0.096	0.376	**0.519**	0.311	0.315	**0.283**	0.328	-0.285	**-0.364**	-0.259
	(0.496)	(0.257)	**(0.306)**	**(0.092)**	**(0.104)**	**(0.057)**	(0.202)	**(0.068)**	(0.074)	(0.217)	**(0.058)**	(0.239)	(0.179)	**(0.040)**	(0.220)	(0.160)	**(0.059)**	(0.184)
$\Delta\tilde{w}_t$	-0.206	**0.210**	-0.421	**-0.980**	**-1.035**	-0.862	-0.124	-0.177	-0.110	0.156	0.125	0.184	0.459	**0.376**	0.548	0.653	**-0.864**	**1.311**
	(0.468)	**(0.106)**	(0.446)	**(0.476)**	**(0.192)**	(0.481)	(0.237)	(0.188)	(0.261)	(0.177)	(0.191)	(0.169)	(0.381)	**(0.152)**	(0.421)	(1.108)	**(0.372)**	**(0.602)**
Δvix_t	-0.006	-0.003	**-0.007**	0.002	0.003	0.001	0.004	**0.008**	0.003	-0.001	0.000	-0.001	-0.006	-0.002	**-0.008**	0.015	**0.018**	0.014
	(0.003)	(0.003)	**(0.002)**	(0.002)	(0.002)	(0.002)	(0.004)	**(0.003)**	(0.004)	(0.005)	(0.002)	(0.006)	(0.003)	(0.002)	**(0.002)**	(0.008)	**(0.005)**	(0.009)
TED_t	0.004	**0.016**	-0.001	0.005	0.004	0.004	0.003	**0.024**	-0.007	-0.003	**0.015**	**-0.011**	**0.014**	**0.020**	0.011	**-0.023**	**-0.016**	**-0.025**
	(0.008)	**(0.003)**	(0.003)	(0.007)	(0.005)	(0.008)	(0.015)	**(0.009)**	(0.005)	(0.012)	**(0.007)**	**(0.003)**	**(0.007)**	**(0.002)**	(0.006)	**(0.006)**	**(0.005)**	**(0.002)**
$\Delta RVar_t$	**1.799**	**2.274**	**1.618**	2.363	**4.728**	**1.322**	-0.423	**-1.610**	0.208	**4.515**	**4.984**	**4.169**	1.924	**4.793**	0.657	1.631	**3.388**	0.493
	(0.402)	**(0.344)**	**(0.231)**	(1.672)	**(0.995)**	**(0.545)**	(0.913)	**(0.201)**	(0.313)	**(1.850)**	**(1.440)**	**(1.989)**	(1.913)	**(0.676)**	(0.342)	(2.388)	**(0.852)**	(2.123)
Δl_t	**1.065**	**0.397**	**1.348**	-0.327	-0.430	-0.315	-0.168	0.082	-0.330	-0.186	**0.173**	-0.389	**-0.457**	-0.466	**-0.492**	0.372	0.148	0.445
	(0.493)	**(0.199)**	**(0.241)**	(0.244)	(0.260)	(0.217)	(0.289)	(0.133)	(0.203)	(0.465)	**(0.063)**	(0.455)	**(0.198)**	(0.243)	**(0.135)**	(0.374)	(0.218)	(0.404)
q_{t-1}	**-0.065**	**-0.046**	**-0.078**	-0.034	**-0.012**	**-0.046**	**-0.114**	**-0.109**	**-0.118**	**-0.072**	**-0.078**	**-0.072**	**-0.065**	**-0.057**	**-0.068**	**-0.024**	**-0.023**	-0.023
	(0.032)	**(0.011)**	**(0.031)**	(0.018)	**(0.004)**	**(0.011)**	**(0.024)**	**(0.009)**	**(0.028)**	**(0.013)**	**(0.017)**	**(0.007)**	**(0.016)**	**(0.010)**	**(0.018)**	**(0.010)**	**(0.004)**	(0.012)
$\tilde{i}_{t-1}$	**-2.003**	**-2.575**	**-1.892**	1.141	-1.555	**2.415**	**-1.644**	**-2.118**	**-1.429**	-0.262	**-1.462**	0.225	0.448	0.363	0.352	-0.619	**-1.968**	0.022
	(0.951)	**(1.104)**	**(0.718)**	(1.993)	(0.909)	**(0.906)**	**(0.463)**	**(0.181)**	**(0.399)**	(0.845)	**(0.704)**	(0.140)	(0.717)	(0.611)	(0.664)	(1.082)	**(0.351)**	(0.710)
Δs_{t-1}	**-0.038**	**-0.025**	**-0.045**	-0.047	-0.019	**-0.062**	**-0.072**	**-0.111**	**-0.057**	-0.038	-0.081	**-0.022**	**0.038**	**0.032**	**0.042**	0.007	**-0.017**	**0.019**
	(0.015)	**(0.004)**	**(0.014)**	(0.025)	(0.017)	**(0.014)**	**(0.036)**	**(0.044)**	**(0.013)**	(0.035)	(0.044)	**(0.007)**	**(0.016)**	**(0.011)**	**(0.016)**	(0.017)	**(0.006)**	**(0.004)**

Notes: The first element of an exchange-rate-explanatory-factor cell is the average of the series of dynamic model averaging estimates, and the second element presented in the round parentheses is the standard error of the series of dynamic model averaging estimates. The “Full,” “Pre,” and “Post” columns present results from the full sample period (1999Q1-2023Q3), pre-crisis subsample period (1999Q1-2007Q2), and post-crisis subsample period (2009Q1-2023Q3). In the full sample and pre-crisis subsample, the initial period comprising the first eight quarters (1999Q1-2000Q4) is not included. The numbers in bold denote the corresponding average-to-standard-error ratio is larger than 1.96.

Table H6a: Average Deviation of PPP Coefficient Estimates from Unity

	AUD	CAD	CHF	EUR	GBP	JPY
(6)	0.813	1.283	-2.284	0.423	0.587	-1.600
(7)	-3.405	-0.586	-5.927	-3.039	-2.061	-3.059
(8)	-2.452	-0.359	-6.247	-2.883	-2.116	-2.615
DMA	-1.145	-0.329	-2.697	-1.459	-0.996	-1.836
HM	-2.090	0.084	-4.697	-2.801	-0.962	-2.854

Notes: The Table presents the averages of the series $\{\beta_{i,t}-1\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled (1) to (8), "MA" and "HM."

Table H6b: Average Absolute Deviation of PPP Coefficient Estimates from Unity

	AUD	CAD	CHF	EUR	GBP	JPY
(6)	1.225	1.654	2.284	0.700	1.076	1.600
(7)	3.405	0.816	5.927	3.039	2.061	3.059
(8)	2.452	0.957	6.247	2.883	2.116	2.615
DMA	1.145	0.540	2.697	1.459	0.996	1.836
HM	2.222	1.070	4.697	2.801	1.188	2.854

Notes: The Table presents the averages of the series $\{|\beta_{i,t}-1|\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled (1) to (8), "MA" and "HM."