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Working Papers of the Institute of Empirical Economic Research

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Working Paper No. 125
April 2025

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

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Abstract

A modified dynamic model averaging framework, which allows for inferences regarding the shifting relevance and significance of explanatory variables, is employed to evaluate the in-sample performance of exchange rate models. This analysis is based on a set of 16,384 model specifications derived from 14 canonical and newly introduced explanatory variables. Our findings indicate: (a) frequent changes in the model specification that best describes an exchange rate, (b) the relevance of individual explanatory variables is not stable over time and varies across exchange rates, with these variables exhibiting differential and sometimes opposing effects, and displaying non-uniform strengths across different exchange rates and periods, (c) the combination of economic and/or financial variables that enhances the empirical evidence of purchasing power parity (PPP) is specific to each exchange rate. These results underscore the challenges associated with employing a single exchange rate model or the scapegoat hypothesis to describe all exchange rates across all time periods.

JEL Classifications: C11; F31

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

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Acknowledgments:

Cheung, Wang, and Westermann gratefully acknowledge the Sievert-foundation for its continuing support. Wang thanks the project 24YJC790180 supported by the Ministry of Education of Humanities and Social Science project and the Project ZR20220G069 supported by Shandong Provincial Natural Science Foundation.

1. Introduction

The exchange rate is a crucial economic variable that links a country's domestic economy to the global market. It interacts with other macroeconomic factors and significantly influences macroeconomic stability and cross-border capital flows. Despite its importance, there is no consensus on a commonly accepted exchange rate model. Since the seminal studies by Meese and Rogoff (1983a, 1983b), numerous empirical analyses have shown that exchange rate models often fail to provide good forecast performance.[1] These findings are primarily drawn from comparisons between the forecasting performance of these models and that of a random walk model. Generally, no single model consistently delivers good forecasts across all exchange rates and historical periods. The empirical evidence varies significantly across different currencies, depending on the choice of explanatory variables, sample periods, and statistical methodologies.

While exchange rate forecasting offers valuable information for market participants, in-sample evaluation provides alternative insights by uncovering the underlying relationships and patterns in historical data. Such insights are essential for constructing models that are both theoretically sound and practically relevant—for instance, when estimating value-at-risk (VaR) to support the development of robust stress testing and risk management strategies. Moreover, evaluating historical responses to shifts in economic fundamentals and policy interventions, across diverse economic scenarios, provides valuable guidance for effective policymaking.

Contrary to the plethora of empirical studies on forecast performance, there is a notable paucity of research that systematically examines the in-sample performance of exchange rate models. Recognizing the gap, and leveraging comprehensive historical data, our study adopts an alternative approach by evaluating the in-sample performance rather than the out-of-sample forecasting of exchange rate models. It is not our intention to compare the relative merits of these two approaches – they are complementary, and each has its contributions to the understanding and assessment of both the theoretical soundness and practical usefulness of exchange rate models.[2] Instead, we conduct an extensive in-sample evaluation exercise to provide insights into the pattern

1 See, for example, Cheung *et al*. (2005, 2019), Engel (2014), and Rossi (2013). Empirical findings of good performance are typically not robust to choices of exchange rates and sample periods. Engel and Wu (2023a, 2024) offer two different views on the performance of exchange rate models.

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.

of the interactions between exchange rates and their determinants, which form a basis to draw implications for model building and policymaking.

Given the proliferation of exchange rate models in recent decades, it is essential to select models that are well-recognized in the literature and represent significant efforts in modeling exchange rates. Our study focuses on specifications that are readily implementable and replicable for in-sample performance analysis. The basic specification is based on the longstanding purchasing power parity (PPP) condition. The PPP specification is then extended to include factors including momentum trading strategies, interest rate differentials, elements of the monetary model of exchange rate determination, the Balassa-Samuelson productivity effect, market uncertainty, liquidity, and lagged real exchange rates. Additionally, we assess the performance of two aggregate models formed by combining our set of explanatory variables.

Our empirical framework takes clues from existing studies on exchange rate models. For instance, time-varying parameters and currency-specific behaviors (Baillie and Kilic, 2006; Rossi, 2013; Sarno and Valente, 2009) complicate exchange rate modeling. The modeling effort is further challenged by the scapegoat theory (Bacchetta and Van Wincoop, 2004), which stipulates that market participants periodically change their views on the relative importance of exchange rate determinants. Over time, different factors are perceived as scapegoats influencing trading strategies and exchange rate movements. Similarly, different historical vintages of exchange rate models often include different explanatory variables. A case in point is that exchange rate models of the 21st-century models have introduced market uncertainty, liquidity, and lagged real exchange rates as significant factors.[3]

To accommodate these features, our in-sample performance evaluation employs a dynamic Bayesian model averaging approach (Raftery *et al.*, 2010; West and Harrison, 1997) that allows for time-varying parameters and inferring the changing relevance of explanatory variables. This Bayesian framework incorporates a dynamic linear specification and provides a data-driven method to evaluate time-dependent behavior and the scapegoat phenomenon.[4] Retrospective statistical inferences, which incorporate information from the entire sample, are used to reveal and

3 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).

4 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. Our exercise adopts data-driven techniques to infer time-dependent coefficient estimates and the changing importance of explanatory variables as implied by the scapegoat theory.

compare the evolution of explanatory powers of individual models and explanatory variables for each exchange rate under consideration.[5] Specifically, inferences of time-varying and shifting importance of individual models and explanatory variables are based on retrospective posterior distributions.

While we explicitly list a few selected exchange rate models in the next section, our empirical exercise considers a total of 16,384 model specifications constructed by various combinations of explanatory variables. Our goal is not to determine which model best explains exchange rates or which combination of variables yields the highest explanatory power. Given the large and evolving set of competing exchange rate models, finding the "best" model is a challenging and potentially elusive task. Instead, using retrospective statistical inferences, we aim to provide an extensive assessment and characterization of the relationships between exchange rates and their potential determinants. Specifically, we seek to shed light on time-varying behavior, the ability of models to explain exchange rate movements, the shifting relevance of individual explanatory variables, the empirical variations in the linkages between exchange rates and fundamentals, and the performance of the empirical PPP relationship in the presence of other variables.

The remainder of the paper is organized as follows. Section 2 succinctly describes the exchange rate models and explanatory variables used in our empirical exercise. Section 3 outlines the data and the modified Bayesian model averaging framework. Section 4 presents the empirical findings on the in-sample performance of model specifications, the roles of individual explanatory variables, and empirical PPP evidence. Section 5 provides additional results based on (a) quarterly averages of daily exchange rates instead of quarter-end rates, (b) a lagged exchange rate instead 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. Models and Explanatory Variables

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. Given the abundance of models explaining exchange

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

rate dynamics, we will be selective in choosing models for our in-sample performance exercise. In general, we select models and variables recognized in the economics literature, ensuring that the resulting reduced-form specifications are readily implementable and that empirical results are replicable.

2.1 *The Purchasing Power Parity (PPP) Condition*

The first and basic empirical model is based on the long-established PPP condition and is 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), $\tilde{p}_t$ 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), Δ is the first difference operator, α and β are parameters, and ε_t is the error term. As price indexes are used, (1) is related to the relative, rather than the absolute, PPP.

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. 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).

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 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 $\Delta s_t = \tilde{i}_{t-1,1} \cong \tilde{i}_{t-1}$, where $\tilde{i}_t$ 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 (Burnside *et al.*, 2011; Cheung and Wang, 2022; Engel, 2014; Fama, 1984; Sarno, 2005). 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

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

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.[6] 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

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

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 international finance that has been updated and extended over time.[7] 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, TB_t is the US trade balance normalized by GDP,[8] Δ is the first difference operator, and "~" is the inter-country difference operator.

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6 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.

7 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.

8 Hooper and Morton (1982) incorporate the trade balance in exchange rate modeling. Although its perceived

The resulting augmented PPP specification is

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

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.[9]

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

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

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.[10] To accommodate these recently popularized factors, we consider the specification

$$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_7 v_t + \delta_8 l_t + \delta_9 q_{t-1} + \varepsilon_t \,, \tag{6}$$

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}. The choices of v_t, l_t, and q_{t-1} are based on their stationarity properties. Our choices of proxies for risk/uncertainty are i) the infamous VIX index (vix_t), the three-month Treasury-Libor spread (TED_t), and the realized variance ($RVar_t = \Sigma_{i=1}^{N}[\Delta s_{t-1+i/N})]^2$, where $s_{t-1+i/N}$ is the *i*-th day logged exchange rate during the period *t*-1 to *t*).[11] 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

importance declined in the 1990s (Cheung and Chinn, 2001 and Cheung *et al*., 2004), 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).

9 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.

10 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).

11 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.

$i^*_{bond,t}$ and $i_{bond,t}$ are one-year government bond rates of, respectively, the US and another G7 country (Engel and Wu, 2023b).

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

$$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_7 v_t + \delta_8 l_t + \delta_9 q_{t-1} + \varepsilon_t \,. \quad (7)$$

The second aggregate specification is

$$\Delta s_t = \alpha + \beta\Delta\tilde{p}_t + \delta_1\Delta\tilde{m}_t + \delta_2\Delta\tilde{y}_t + \delta_3\Delta\tilde{i}_t + \delta_4\Delta\tilde{\psi}_t + \delta_5 TB_t + \delta_6\Delta\tilde{w}_t + \delta_7 v_t + \delta_8 l_t + \delta_9 q_{t-1} + \delta_{10}\tilde{i}_{t-1} + \delta_{11}\Delta s_{t-1} + \varepsilon_t \,, \quad (8)$$

which augments (7) with the UIP and bandwagon factors in section 2.2.1 and comprises the 14 explanatory factors considered in our exercise.

To recap, equations (1) to (8) are reduced-form specifications of selected 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.

We do not impose parameter restrictions in these specifications because parameters can assume different values under differing exchange rate models.[12] 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 the eight specifications listed above and includes all the empirical specifications that can be constructed from our list of explanatory variables. Without convincing evidence that a specific model represents the true exchange rate generation

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12 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).

process, we employ data information and data-driven criteria to infer in-sample performance. Specifically, we adopt a Bayesian approach to assess model uncertainties, aggregate information from different specifications, and study in-sample relationships between exchange rates and their determinants. 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 the eight 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 and their associated models over time.

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

3. Data and Empirical Framework

3.1 Data

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.[13] 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.[14] 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.[15] The sources and definitions of the exchange rates and other explanatory variables used in this empirical study are given in Appendix A.

These currencies exhibit distinct characteristics. For example, the Japanese yen and Swiss franc are often considered safe haven currencies and are popular funding currencies for carry trades. Conversely, the Australian dollar is a high-interest currency and a common target currency for

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

carry trades. The Canadian dollar, a commodity currency, is sensitive to oil prices. The euro serves as a common currency for a diverse group of European countries, while the British pound was the dominant global currency before the current US dollar regime. These currency-specific characteristics hint at unique exchange rate behaviors for each currency.

3.2 Empirical Framework

The choice of our empirical framework for in-sample performance evaluation is guided by the distinctive characteristics of exchange rate dynamics. To capture the exchange-rate-specific time-varying behavior, we employ an equation-by-equation time-varying Bayesian dynamic linear model (DLM) approach (Beckmann and Schüssler, 2016; Byrne *et al.*, 2018; Koop and Korobilis, 2012; Raftery *et al.*, 2010). By adopting a retrospective approach that leverages information from the entire sample (Shmueli, 2010), we 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 *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.

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

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

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 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. If $\boldsymbol{W}_t = 0, \forall t$, the model is a static one.

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.

Our sample of empirical specifications includes the eight specifications from Section 2, as well as all models constructed from the 14 explanatory variables. This results in K=16,384 (=2^{14}) exchange rate equations. Data-driven retrospective likelihood values are used to evaluate these empirical specifications and conduct the model averaging analysis. Rather than selecting one of these K model specifications, we base our inferences on the retrospective posterior likelihood functions and the retrospective posterior distributions of parameter estimates of all K specifications. Retrospective likelihood functions help derive the retrospective model probabilities, indicating the relative importance and relevance of these K specifications.

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. The averaging process 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 (Kass and Raftery, 1995; Havranek *et al.*, 2015). An explanatory variable with a PIP less than 0.5 is not deemed "important."

PIP serves as a data-driven indicator of the importance and relevance of a variable to be a factor explaining exchange rates, as well as the likelihood of the variable being included in an exchange rate model. There can be connections between shifts in market perception of a variable's relevance and importance and changes in the PIP of that variable. Thus, PIP can be an indirect measure of the presence of a scapegoat – a market perceived driving force of exchange rate movements (Bacchetta and Van Wincoop, 2004), or how likely a variable is to be a scapegoat.

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. Appendix B offers a technical description of the empirical framework.

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 a visual inspection of these graphs, 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 model is the best, we use the DMA method to analyze currency-specific results from DLM regressions. Data-driven measures are used 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. 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 of and explanatory powers of these eight selected specifications are quite unstable and exchange rate specific.

These ratio plots indicate that the model probabilities of these eight specifications usually are less than one-half of the corresponding HM_t. With the exception of the CHF exchange rate, 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). In general, these ratios are declining, albeit at different rates across exchange rates, over time.

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. For instance, the average model probability ratios of the eight selected specifications are in general small. Out of 48 cases in each sample period, there are three cases in the full sample, eleven cases in the pre-crisis period, and three cases in the post-crisis period that have a ratio larger than one-half of the corresponding HM_t.

The aggregate specifications, especially (7), yield the largest average ratios in these exchange rate series – the 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 in Table 1. The other vintage specifications have quite small average ratios – especially (1), (2) and (3) that are attributed to the PPP, uncovered interest parity, and the bandwagon effect yield 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. 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 from currency-specific DLM regression results of specifications (1) to (8). The R^M measures show that the in-sample 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) has 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 obtained via specification (6) is negative.[16]

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 between specifications (1) to (8).

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

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

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

where $\pi_{t|T,k}$ is the retrospective model probability, $\boldsymbol{z}_{t,k}$ 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.[17] 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. Ideally, 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 a R^M measure larger than (or equal to) those from specifications (1) to (8) in the 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. Our results show that 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 model specification with the largest retrospective model probability ($\pi_{t|T,h}$) at time t among the set of K=16,384 model specifications, and its structure can change over time.

Amongst 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 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 ($\pi_{t|T,h}$).

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17 For the "MA" case, $\hat{n}_t = \Sigma_{k=1}^{K} \pi_{t|T,k} n_{t,k}$ is the number from model averaging $n_{t,k}$'s – the numbers of explanatory variables of the K specifications in the model space.

Figure 3 and Table 3 offer some information about the model specifications in the $\{HM_t\}$ series. Figure 3a depicts a heatmap of explanatory variables included in the $\{HM_t\}$ series. The liquidity (l_t) and lagged real exchange rate (q_{t-1}) variables have a relatively high level of presence in these models. The lagged exchange rate change variable (Δs_{t-1}) is absent from the Japanese yen $\{HM_t\}$ series but presents, albeit in small numbers, in other series. For each exchange rate, the set of explanatory variables in the $\{HM_t\}$ series is not constant over time and likely to be different from those of other exchange rates.

The histogram plots in Figure 3b 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 $\tilde{w}_t$ is the only economic factor and the liquidity measure l_t is the only financial factor that appears in these six mostly appeared model specifications. These model specifications do not include any of the specifications (1) to (8) and account for a relatively small fraction of the $\{HM_t\}$ series: 18.7% of the CAD case and 6.6% of the GBP case.

Figure 3c indicates the variability of the specification of HM_t by plotting the number of explanatory variables in HM_t against time. Again, note that different model specifications can have the same number of explanatory variables. Thus, Figure 3b offers a lower bound of the instability of HM_t specifications. Despite this caveat, the change in the number of explanatory variables can be larger than one. It is also apparent that different exchange rates exhibit dissimilar patterns of changes and numbers of explanatory variables.

The frequencies at which HM_t experiences a change in model specifications are presented in Table 3b. 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 period than in the post-crisis period. Despite the difference, these results suggest the HM_t specification has experienced quite a frequent change during the sample 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.

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. The model specifications (1) to (8) are included to facilitate this discussion.

Our empirical results indicate that the in-sample performance of model specifications 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 other specifications 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 obtained from the DLM-and-DMA framework. 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 in our exercise. Indeed, we anticipate a high level of model uncertainty that prevents unambiguous evidence of a single model 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)

The PIP derived from the DMA procedure is used to infer how likely a variable should be in the (true) model after examining the data and offers information on the level of relevance of a variable in explaining exchange rate movements, and the prospect of the variable is a scapegoat – a market perceived driving force of exchange rate movements (Bacchetta and Van Wincoop, 2004).

The PIP of the *i*-th parameter θ_i is $PIP_t^{DMA}(\theta_i) = \Sigma_{k=1}^{K} \pi_{t|T,k} \boldsymbol{I}_k\left(\theta_i\right)$, where $\boldsymbol{I}_k\left(\theta_i\right)$ 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 these plots. Also, the evolution of PIPs in each plot is nonidentical to those in the others. The PIP time path of an explanatory variable can vary greatly across exchange rates, and different explanatory variables display different variability patterns. 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 the PIPs of these explanatory variables less than 0.5 outnumber those larger than 0.75; that is, the chance of these explanatory variables to be not "important" is higher than having a substantial effect. 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 implies a substantial effect (Kass and Raftery, 1995; Havranek *et al.*, 2015) 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 the PIP of the variable. 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. In this regard, our results indicate that a variable can be a scapegoat for one exchange rate but not for the others, or 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. Using PIP to gauge the empirical relevance of a variable in explaining exchange rates, Table 4 buttresses the basic observations from Figure 4; it shows that the performance 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.

Comparing the pre- and post-crisis periods, 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 less often in the former period than the latter one. 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 the data-driven PIP measure indicate that the relevance and empirical importance of these explanatory variables are unevenly distributed across exchange rates and unstable over time. The relevance can experience large variations – and the timing of big movements is non-synchronized between exchange rates. If the information is used to infer the scapegoat hypothesis, then 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 can be exchange rate specific and time period specific. A case in point 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 that have a PIP in the range of 0.75 and 0.95 and display a substantial effect 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

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

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 impact and variability of individual 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.[18] 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. In Table 5, $\Delta\tilde{m}_t$ 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. Under the monetary model of exchange rate determination, $\Delta\tilde{y}_t$ is expected to have a negative effect. However, our results show that it exerts a positive impact on the AUD exchange rate,[19] and 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 $\Delta\tilde{w}_t$

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

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

exhibit similar baffling results. The financial factors vix_t, TED_t, $RVar_t$, and l_t also yield non-uniform effects on these exchange rates and in different sample 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 different sample periods.

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, for any one of these exchange rates, the groups of significant dynamic model averaging estimates in different sample periods are not the same. The full sample period typically yields the smallest number of significant estimates, while the pre-crisis period yields the largest number. 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 in the full sample period, seven for the CAD exchange rate, and 11 for the CHF exchange rate in the pre-crisis sample.

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.[20]

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

20 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).

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 set of explanatory variables which is prone to vary over time. Individual explanatory variables can have dissimilar effects on different exchange rates and be relevant variables in one period but not in the other.

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 $\mathrm{var}(\hat{\theta}_{it|T,k})$. 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 quite limited. There is a high level of sampling uncertainty surrounding the coefficient estimates at each point in time, and the data do not provide clear and unambiguous estimates of the effects of the 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 significance of individual variables can fluctuate over time, reflecting the volatile nature of market sentiments and supporting the scapegoat hypothesis, which suggests shifting perceived determinants of exchange rates. The strength of the relationship between exchange rates and their explanatory variables, as indicated by dynamic model averaging estimates, varies depending on the exchange rate and time period. 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 at different times and across various exchange rates, 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.[21] 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 variable, 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,

21 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).

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 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 model specifications (HM_t's) that yield the highest retrospective model probability provide good support for the PPP hypothesis? Unfortunately, our exercise does not offer a meaningful comparison because, for each exchange rate, 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 average deviation and the average of absolute deviations based on the HM_t specifications that include $\hat{\beta}_t$. Indeed, for each exchange rate, the HM_t specifications that include $\hat{\beta}_t$ do not yield an average measure smaller than the corresponding best one 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 differ across 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. What is the in-sample performance of exchange rate models based on period-average exchange rates? We replicated the DLM-and-DMA estimation exercise using quarterly averages of daily exchange rates and, for brevity, included the results in Appendix F.[22] The main observations are described as follows.

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, the R^M measures indicate that the proportion of the variation in changes in quarter-average exchange rates explained by these specifications is larger than that of end-of-period exchange rates. Compared with changes in end-of-period exchange rates, it is relatively easier to describe the variations in changes in quarter-average 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, for each exchange rate, the model specification that gives the highest model probability changes quite frequently over time. The model specification that appeared most often in the $\{HM_t\}$ series accounts for a small proportion of the $\{HM_t\}$ series, and is different from the corresponding one of the end-of-quarter exchange rate case. Further, these

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22 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.

model specifications tend to have more explanatory variables than those of the end-of-quarter exchange rate cases. For these model specifications that appeared most often in the $\{HM_t\}$ series, the inter-country price differential is the only economic factor and the lagged real exchange rate is the only financial factor that appears in these model specifications.

In addition to the choices of model probabilities or R^M measures, sample periods, and exchange rates, the relative in-sample performance of model specifications depends on whether end-of-quarter or quarter-average exchange rates are considered.

The empirical relevance of individual explanatory variables and the strength of their linkages with exchange rates seem to be stronger in models of quarter-average exchange rates. On a net basis, the explanatory variables tend to garner a high proportion of 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. Again, these significant variables have different distributions across the three sample periods and six exchange rate series. Compared with the results in Table 5, the variables $\tilde{i}_{t-1}$, $\Delta\tilde{y}_t$ and TB_t show a decline in the number of significant cases while the variables $\Delta\tilde{p}_t$, Δs_{t-1}, $\Delta\tilde{i}_t$ show the largest increases in the number of significant cases. Despite these differences, the average coefficient estimates of these explanatory factors still display different signs for different exchange rates and even in different sample periods of an exchange rate.

Again, if the variance $\{\mathrm{var}(\hat{\theta}_{it|T,k})\}$ 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 estimates of the effects of explanatory variables. The weak data information result is similar to the result 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 in quarterly data. For each exchange rate, there is at least one specification that yields a deviation from long-run PPP smaller than that of the specification (1). Nevertheless, the group of variables that mitigates PPP deviations varies across exchange rates and measures of deviations. The specifications that improve the PPP evidence are usually not the same as those identified for end-of-quarter data. Besides being exchange rate specific, the specification/variables that help to explain PPP deviations depend on whether period average or end-of-period data are considered.

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

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.[23] 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

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

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

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.[24] 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 roles of vix_t, $RVar_t$ and l_t in describing exchange rate dynamics are affected by the choice of using the variables themselves or their differences. 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.

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

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, similar to the changes in the results pertaining to vix_t, $RVar_t$ and l_t, 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. Notably, the optimal model specification for describing exchange rate behavior frequently changes over time and varies across different exchange rates. The variables identified as relevant and significant are both time-varying and dependent on the specific exchange rate. Further, the model specification that can enhance empirical PPP evidence is also exchange rate specific.

6. Concluding Remarks

Employing a Bayesian dynamic linear model in conjunction with a modified dynamic model averaging method, we conduct an analysis of the in-sample performance of exchange rate models using a set of 16,384 model specifications derived from 14 canonical and newly introduced explanatory variables. This empirical framework facilitates the inference of the evolving relevance and significance of the explanatory 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 not stable over time and differs across exchange rates. These variables can have differential and even opposing effects on different exchange rates and in different periods. The strength of their interactions with exchange rates, as indicated by coefficient estimates and their significance varies over time and across exchange rates.

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

These findings highlight the challenge of identifying a universal exchange rate model that accurately describes all exchange rates at all times. This aligns with perspectives presented in exchange rate forecasting exercises. The scapegoat hypothesis, which suggests 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. However, the differential and at times opposing effects displayed by these variables make it challenging for a canonical exchange rate model, or even the scapegoat hypothesis, to account for all exchange rates in all periods.

Modeling period-average rather than period-end exchange rates tends to offer better in-sample performance measures and occasionally affects the interactions between exchange rates and their determinants. Replacing the lagged real exchange rate with the lagged exchange rate, and the proxies for uncertainty and liquidity (vix_t, $RVar_t$ and l_t) with their first differences, led to some quantitative changes. However, these modifications do not qualitatively change the general inference that it is difficult to have an exchange rate model describe all exchange rates at all times.

Compared with exchange rate forecasting exercises that offer useful information to market participants and evaluate whether insights from in-sample exercises hold when confronted with new data, the in-sample performance evaluation provides insights into the relevance of theoretical frameworks and the interactions between economic variables and exchange rates – these insights have 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 policies. Our empirical findings pose significant challenges for modeling exchange rate dynamics and complicate the uses of models in exchange rate risk management and economic policymaking. The unstable links and non-uniform patterns across exchange rates undermine the reliability and credibility of traditional empirical models, which employ historical data and stable relationships to infer exchange rate behaviors and make forecasts. Beyond canonical economic factors, exchange rate movements depend on current market conditions and sentiments.

While the explanatory variables in our exercise are recognized factors, they do not exhaust the list of influences on exchange rates. The marginal computing burden of increasing the list of explanatory variables, however, is substantial. Further, this study does not explain why some variables serve as scapegoats, as exploring this issue is beyond the current exercise's scope. Future studies employing flexible and robust modeling techniques to accommodate the rapid and frequent shifts in the roles of explanatory factors are warranted.

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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.

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.

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.

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.

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.

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)**
vix_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.

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

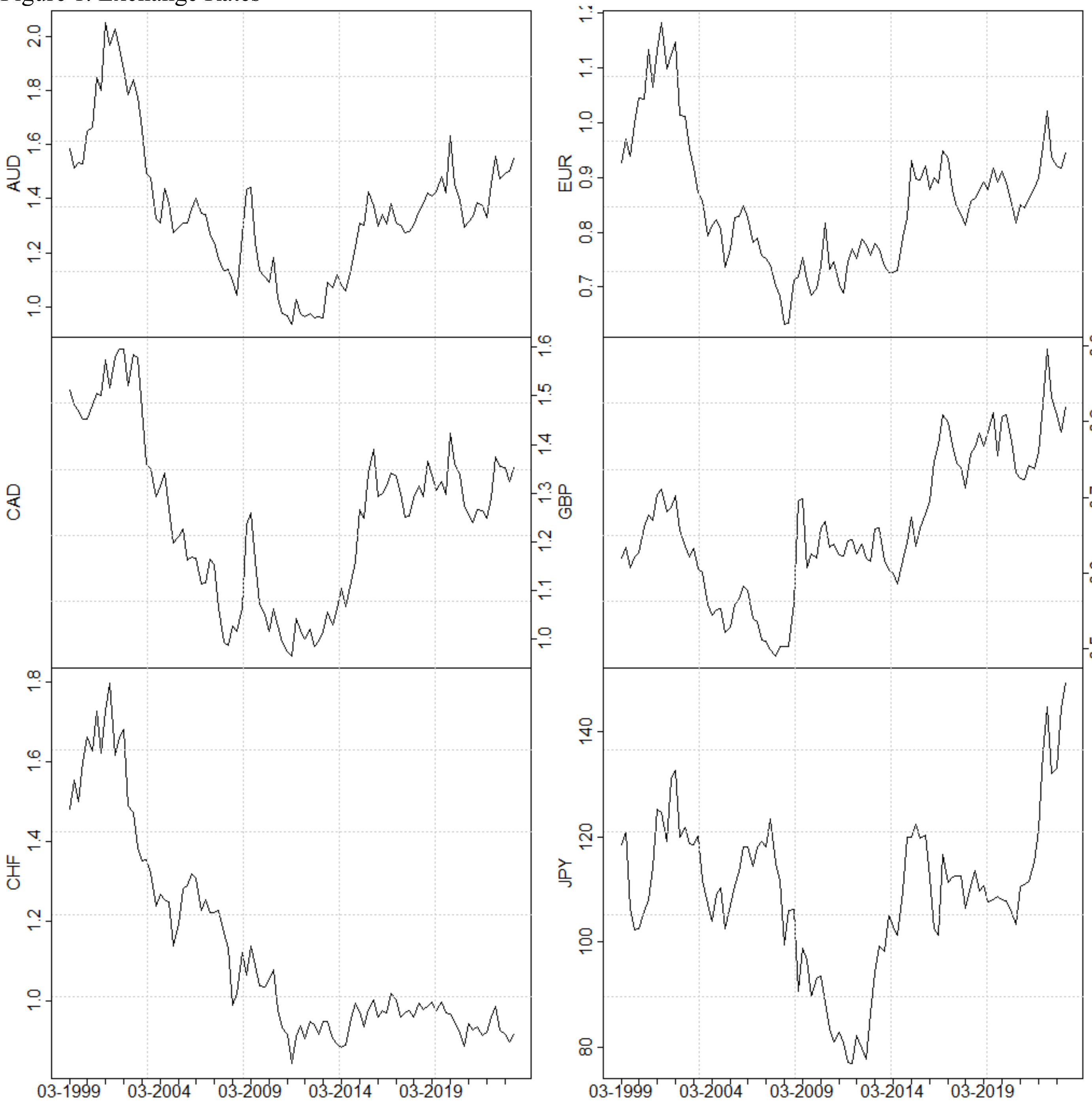
Notes: The Table presents the averages of the series $\{\beta_{i,t} - 1\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled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

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

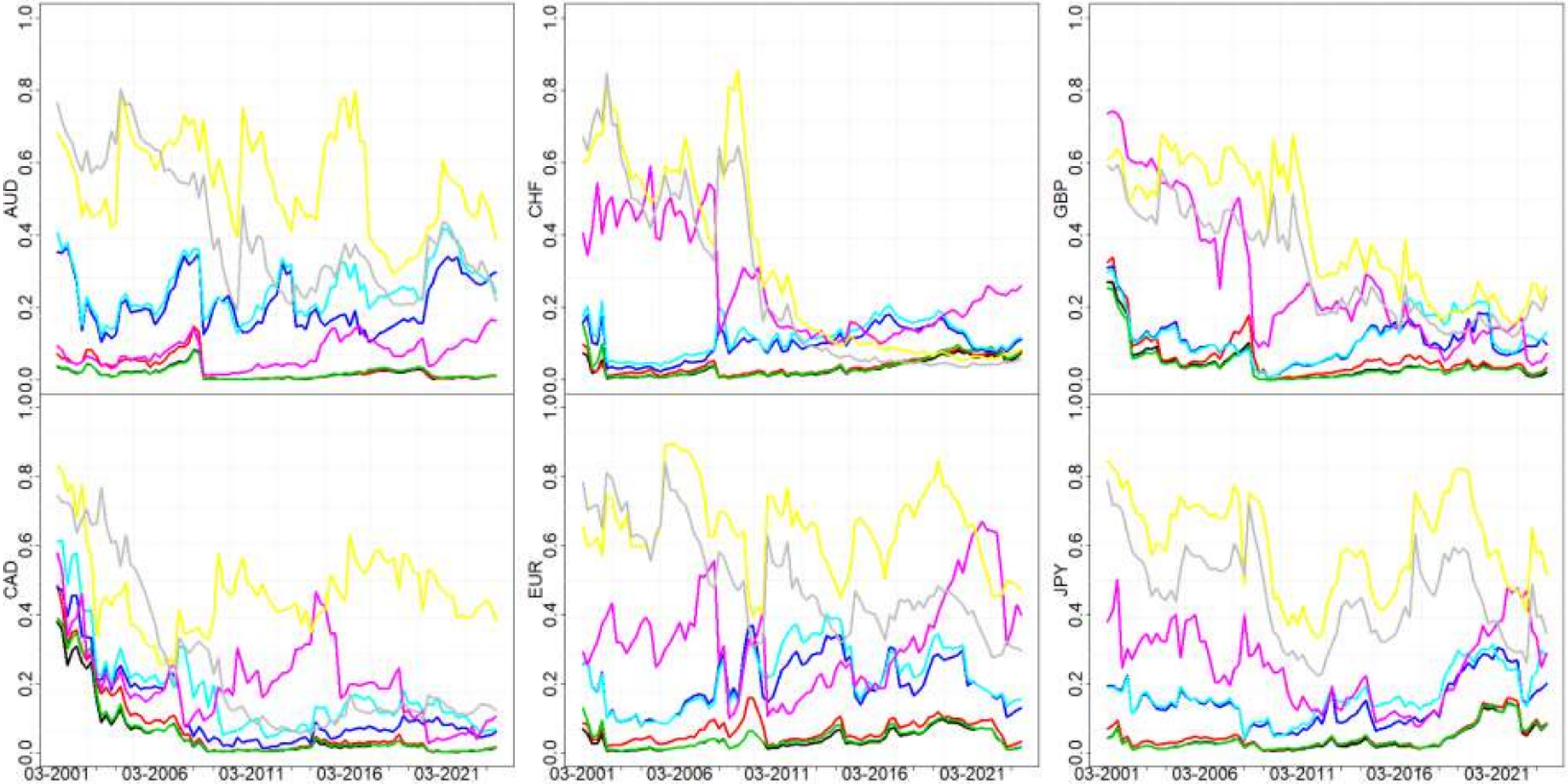
Notes: The Table presents the averages of the series $\{|\beta_{i,t} - 1|\}$, where $\beta_{i,t}$ is the PPP coefficient from the specifications (1) to (8), the specification based on dynamic model averaging estimates, and the $\{HM_t\}$ series. The specifications are given in the first column labeled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

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.

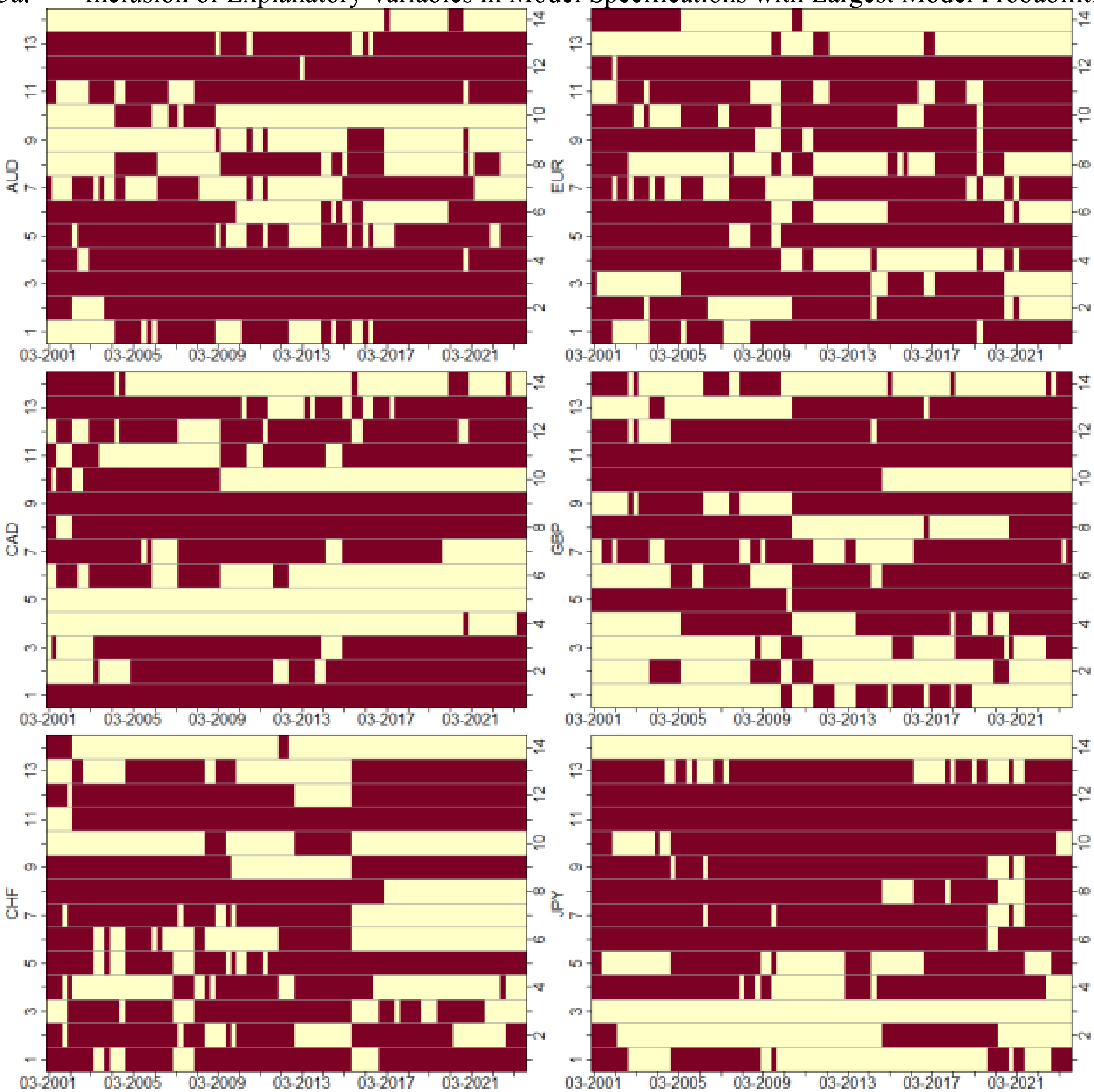
Figure 2. The Model Probability Ratios



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).

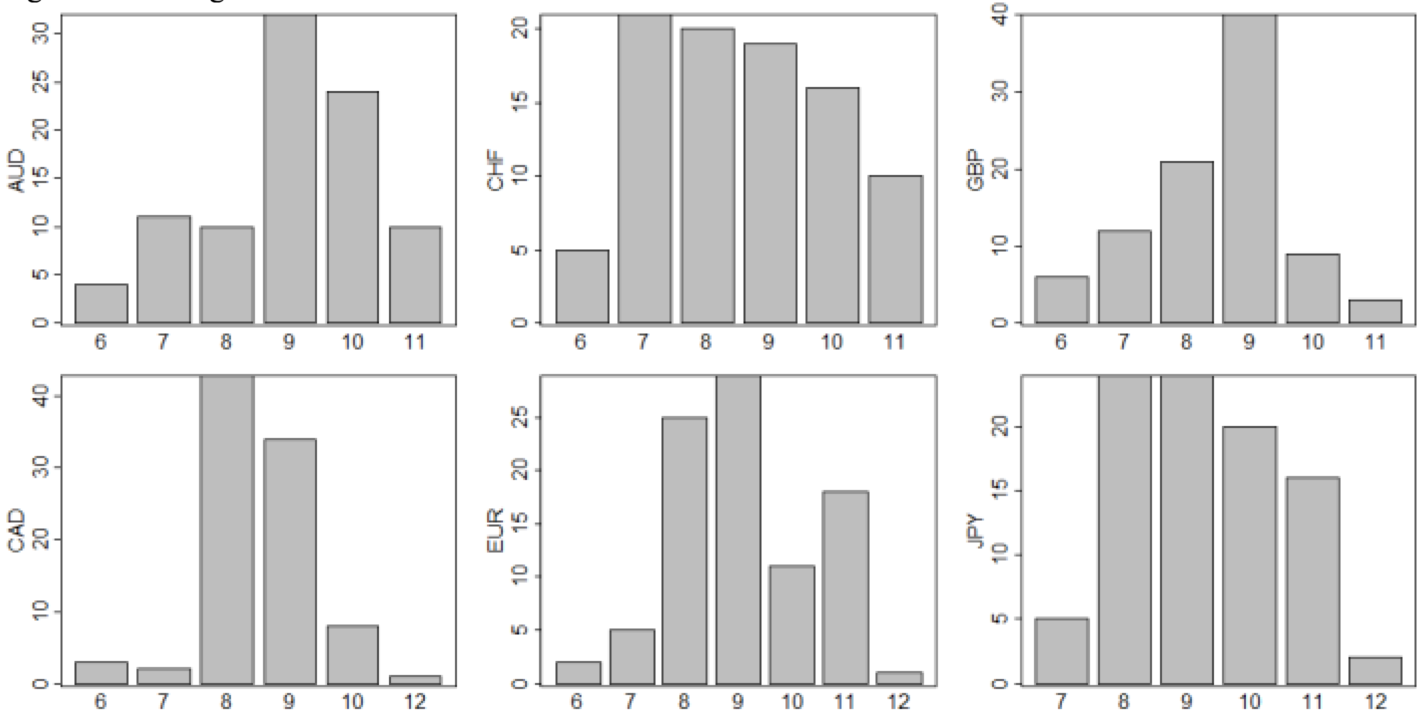
Figure 3. The Explanatory Variables in the $\{HM_t\}$ Series

Figure 3a. Inclusion of Explanatory Variables in Model Specifications with Largest Model Probabilities



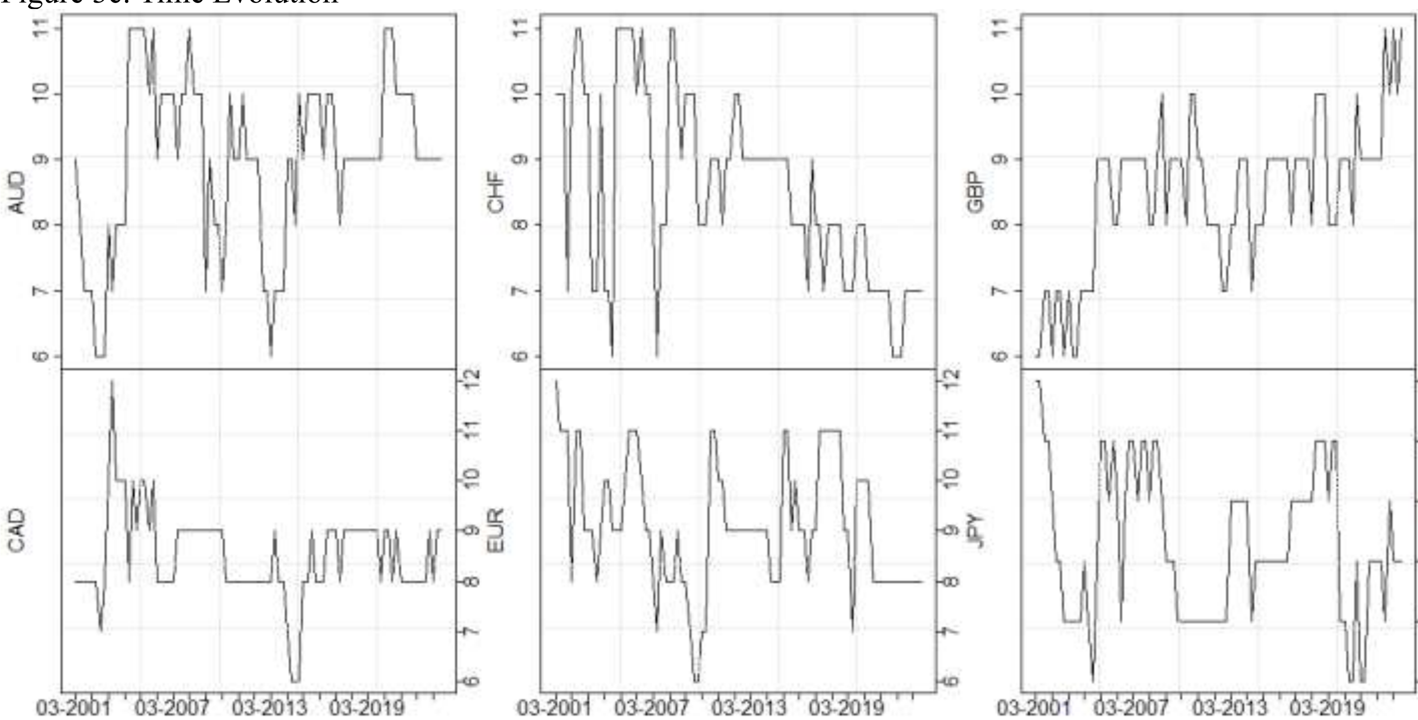
Notes: The variables included in the model specifications with the largest model probabilities (HMt's) are color-coded: variables included (red) and variables not included (yellow). The explanatory variables are labeled along the *y*-axis as follows: (1) intercountry differential of inflation ($\Delta\tilde{p}_t$), (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}).

Figure 3b. Histograms



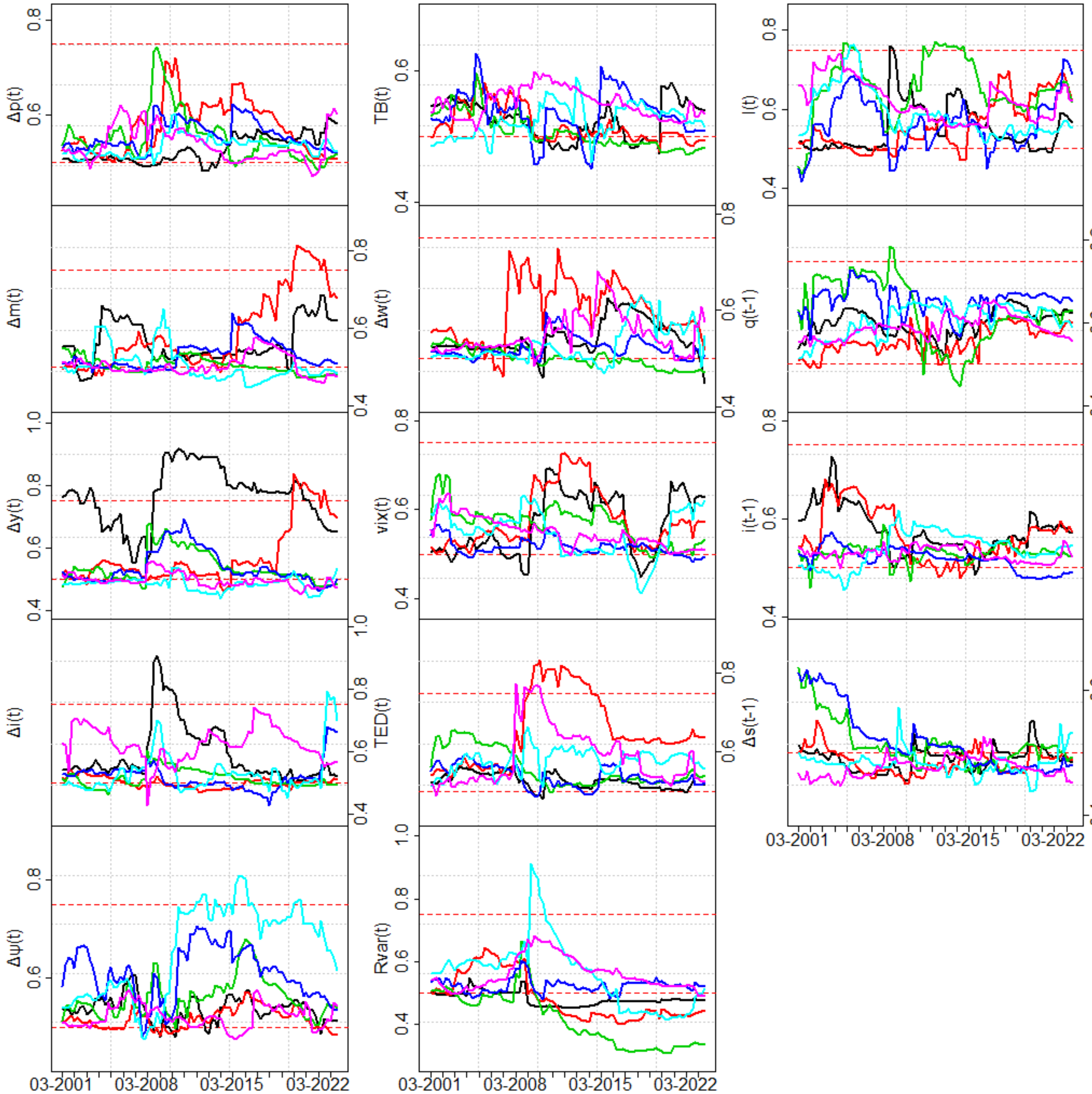
Notes: The vertical axis gives the number of occurrences and the horizon axis the number of variables in the HM_t specification.

Figure 3c. Time Evolution



Notes: The Figure traces, for each exchange rate, the evolution of the number of variables in the HM_t specification.

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.

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 are 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:

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

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

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 $\boldsymbol{\theta}_{t\text{-}1,k} \mid Y_{t-1}$ ~

$N(\hat{\boldsymbol{\theta}}_{t-1|t-1,k}, \boldsymbol{\Sigma}_{t-1|t-1,k})$ is the θ-estimate at time t-1 derived from information up to t-1. Then, given B.1.2,

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

where $\boldsymbol{R}_{t,k} \equiv \boldsymbol{\Sigma}_{t-1|t-1,k} + \boldsymbol{W}_{t,k}$. Following Raftery *et al.* (2010), we set $\boldsymbol{W}_{t,k} = (1-\lambda)\lambda^{-1}\boldsymbol{\Sigma}_{t-1|t-1,k}$, where the hyperparameter λ is also known as the "forgetting" factor, and obtain $\boldsymbol{R}_{t,k} = \lambda^{-1}\boldsymbol{\Sigma}_{t-1|t-1,k}$. We set λ = 0.95 in our exercise following Cheung and Wang (2023) and Koop and Korobilis (2012).[1]

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

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

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 $\boldsymbol{\theta}_{t,k} \mid Y_{t-1}$ (B.1.4, B.1.3), the Bayes' theorem implies

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

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 $\boldsymbol{\Sigma}_{t|t,k} = \boldsymbol{R}_{t,k} - \boldsymbol{R}_{t,k}\boldsymbol{x}_{t,k}(\hat{V}_{t|t,k} + \boldsymbol{x}'_{t,k}\boldsymbol{R}_{t,k}\boldsymbol{x}_{t,k})^{-1}\boldsymbol{x}'_{t,k}\boldsymbol{R}_{t,k}$.

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

The retrospective distributions of $\boldsymbol{\theta}_{t,k}$ 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)

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

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

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

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 $\boldsymbol{\theta}_{t,k}$ and $y_{t,k}$ for $t = 1, 2, \ldots, T$, $k = 1, 2, \ldots, K$, 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 $Q_{t-1} = [q_{t-1,\ell k}]$, where $q_{t-1,\ell k} = P(L_t = k \mid \boldsymbol{F}_{t-1}, L_{t-1} = \ell)$. Thus,

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

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

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

1 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.

where c is a small positive number to avoid a zero model probability caused by aberrant observations. We set τ = 0.95 in our exercise.

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

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

where $f_\ell(y_t \mid Y_T)$ is the retrospective likelihood value of the ℓ-th model at time t.[2]

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)

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

where $t = 1, 2, ..., T-1$, $k = 1, 2, ..., K$. Assuming $q_{t,k\ell}$'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 $\hat{\boldsymbol{\theta}}_t^{DMA} = \Sigma_{k=1}^{K} \pi_{t|T,k} \hat{\boldsymbol{\theta}}_{t|T,k}$, 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 $\boldsymbol{I}_k(\theta_i)$ 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 $\text{var}(\hat{\theta}_{it}^{DMA}) = \Sigma_{k=1}^{K} \pi_{t|T,k} [\text{var}(\hat{\theta}_{it|T,k}) + \hat{\theta}_{it|T,k}^2] - (\hat{\theta}_{it}^{DMA})^2$.

B.4 Derivation of (B.2.4).

The retrospective model probability of the k-th model is

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

The Bayes' theorem implies,

$$P(L_t = k \mid \boldsymbol{F}_T, L_{t+1} = \ell)$$

$$= P(L_t = k \mid \boldsymbol{F}_t, L_{t+1} = \ell) P(\boldsymbol{F}_{t+1/T} \mid \boldsymbol{F}_t, L_t = k, L_{t+1} = \ell)[P(\boldsymbol{F}_{t+1/T} \mid \boldsymbol{F}_t, L_{t+1} = \ell)]^{-1}$$

$$= P(L_t = k \mid \boldsymbol{F}_t, L_{t+1} = \ell) \quad \text{(B.4.2)}$$

$$= P(L_t = k \mid \boldsymbol{F}_t) P(L_{t+1} = \ell \mid \boldsymbol{F}_t, L_t = k)[P(L_{t+1} = \ell \mid \boldsymbol{F}_t)]^{-1} \quad \text{(B.4.3)}$$

$$= \pi_{t|t,k} q_{t,k\ell} (\pi_{t+1|t,\ell})^{-1}. \quad \text{(B.4.4)}$$

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, (B.4.3) follows from the Bayes' theorem.

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

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

The retrospective model probability depends on the transition matrix $Q_t = [q_{t,k\ell}]$. The data do not provide enough information about the transition matrix. Without any restrictions, there are infinite ways to define the transition matrix. For simplicity, we assume that all $q_{t,k\ell}$ s are the same for $k = 1, 2, ..., K$, and then, $q_{t,k\ell} = \pi_{t+1|t,\ell}$, 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.

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2 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).

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

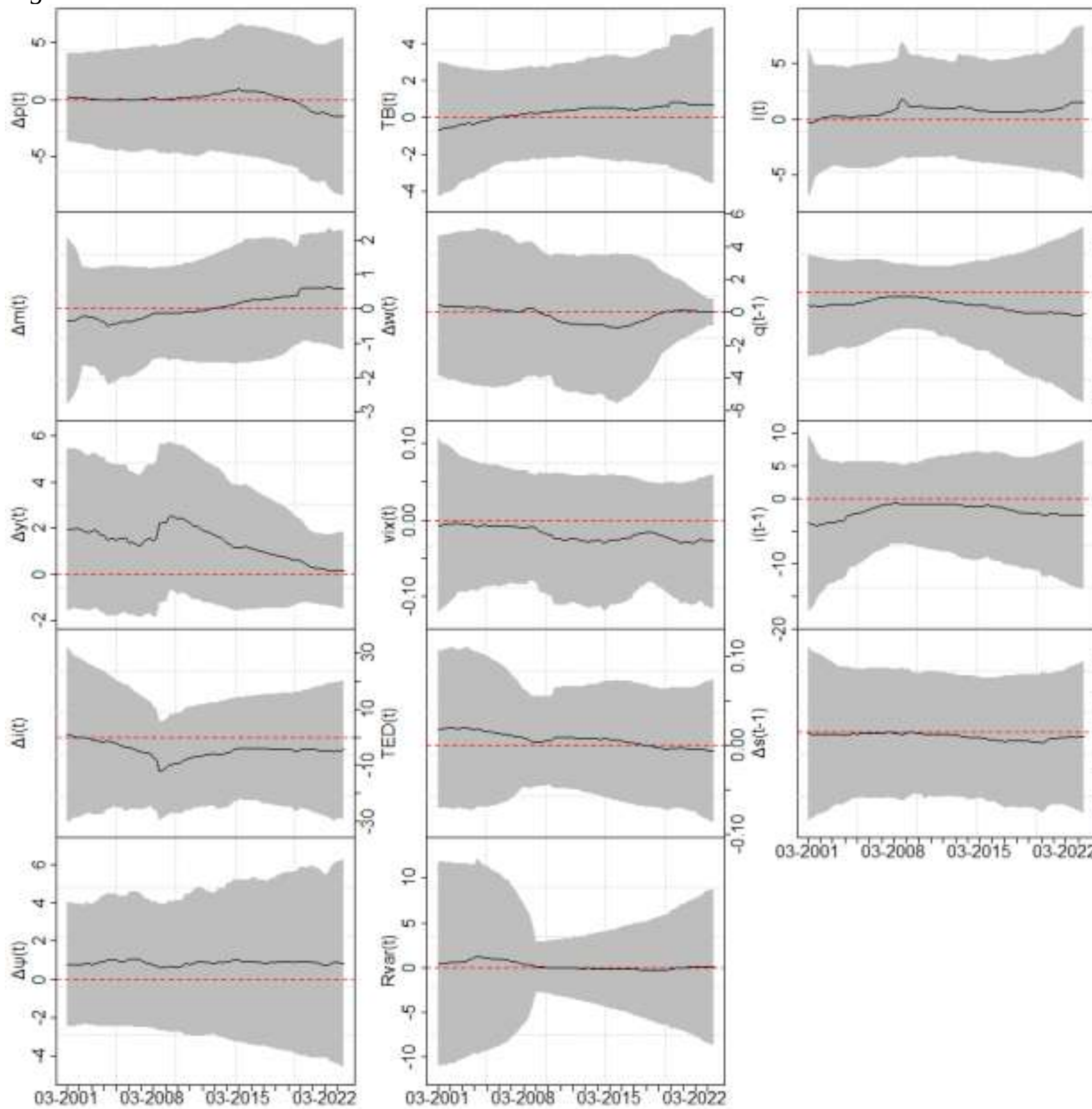


Figure E2: The CAD Case

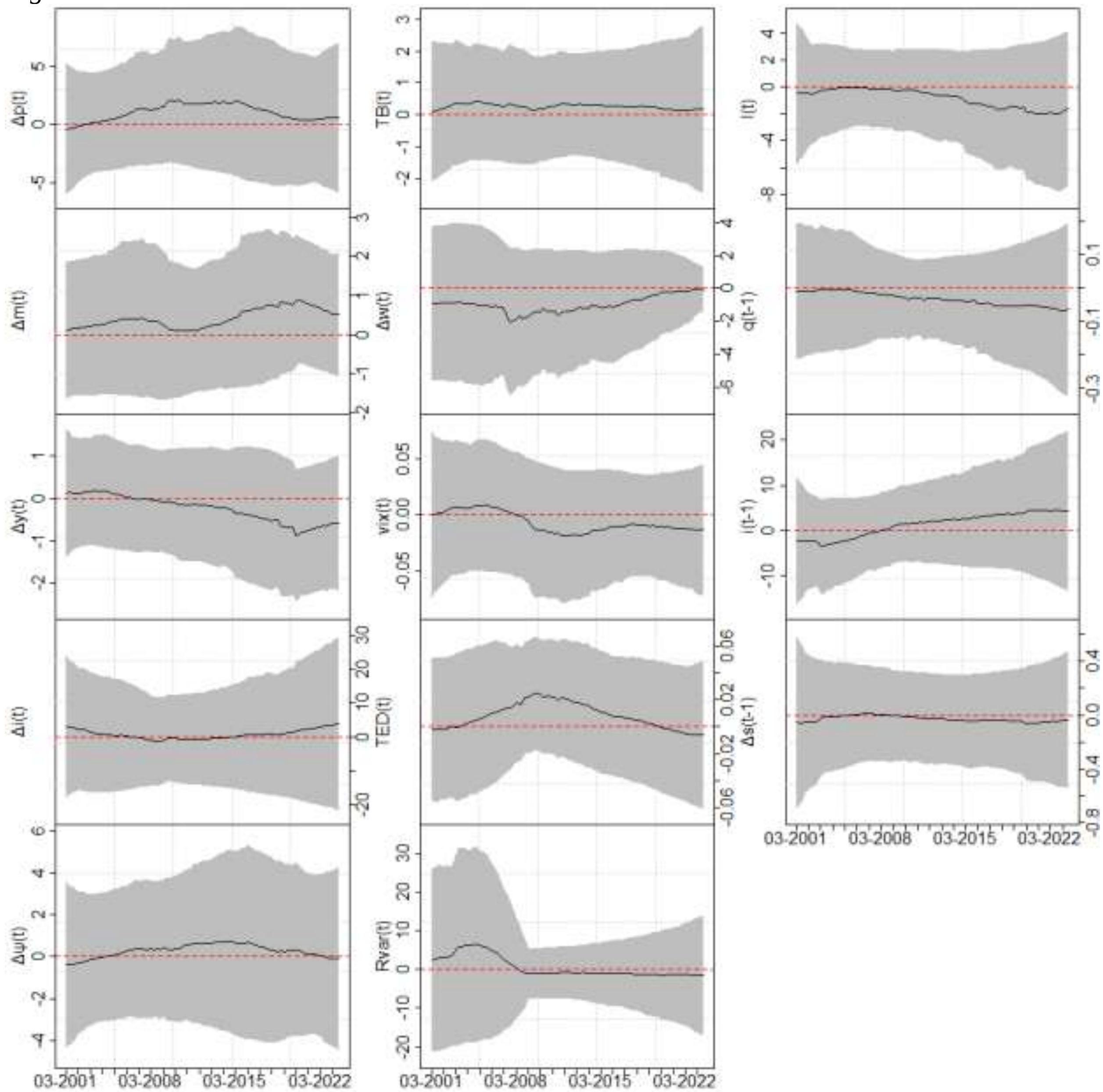


Figure E3: The CHF Case

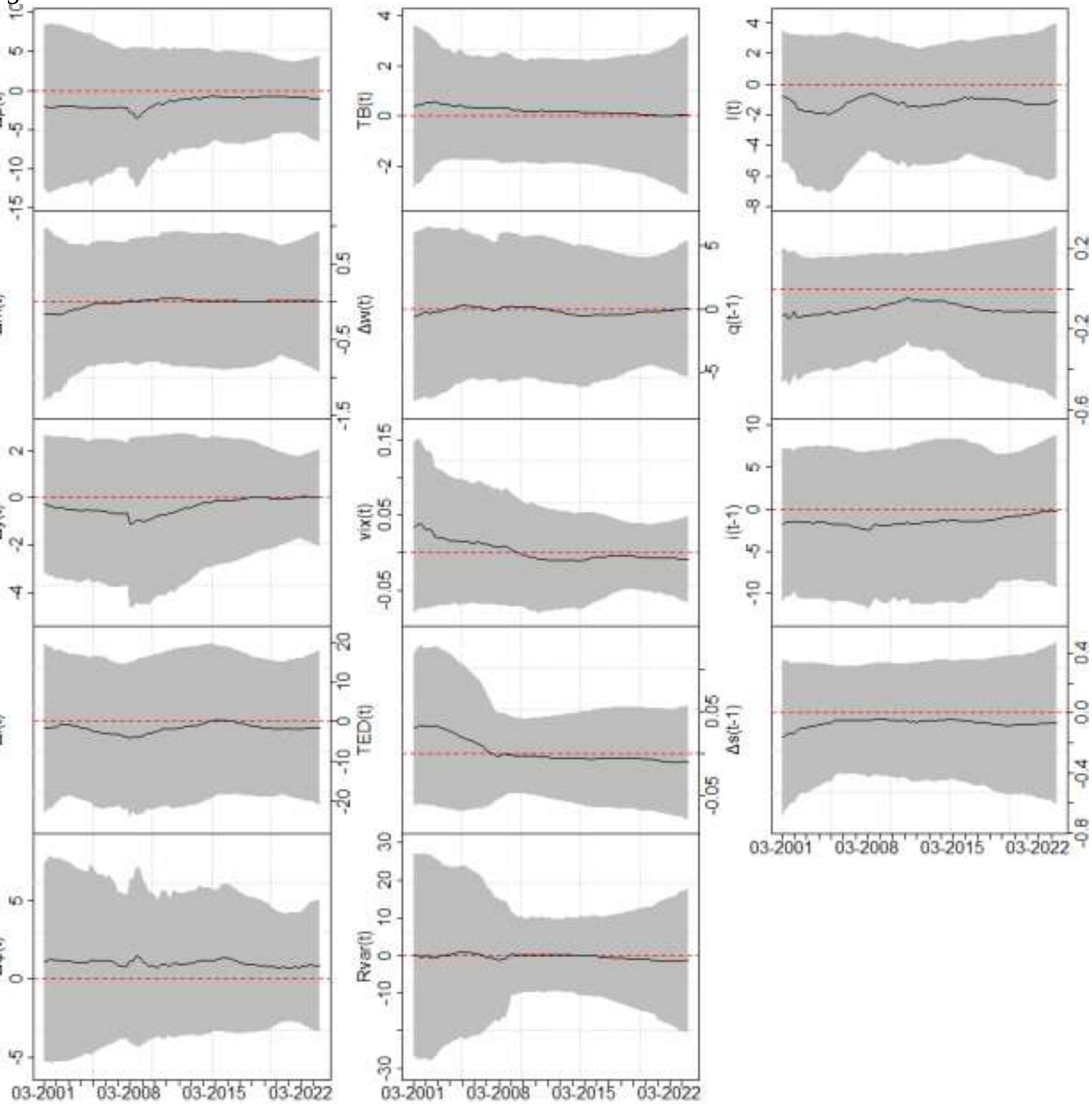


Figure E4: The EUR Case

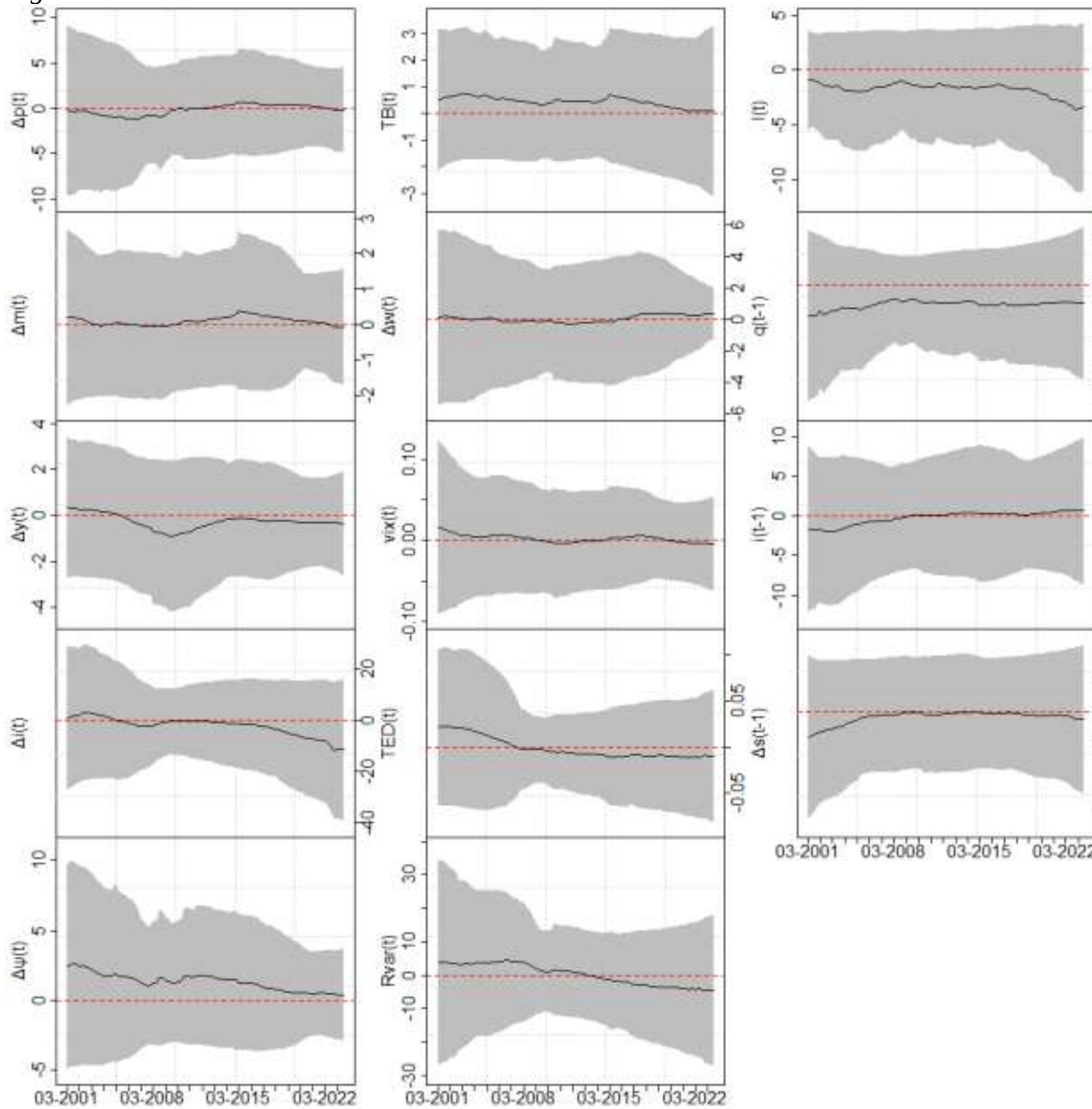


Figure E5: The GBP Case

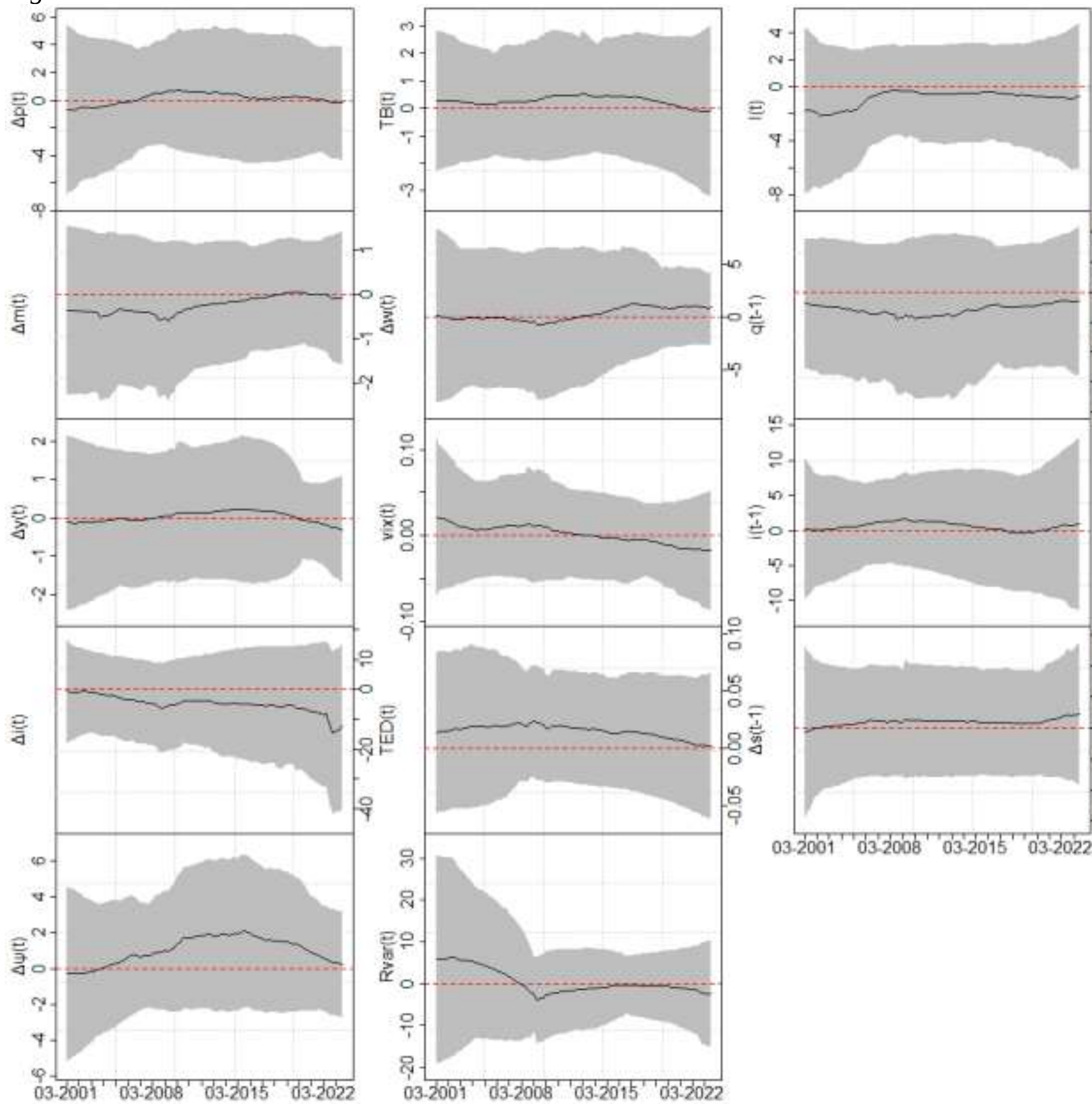
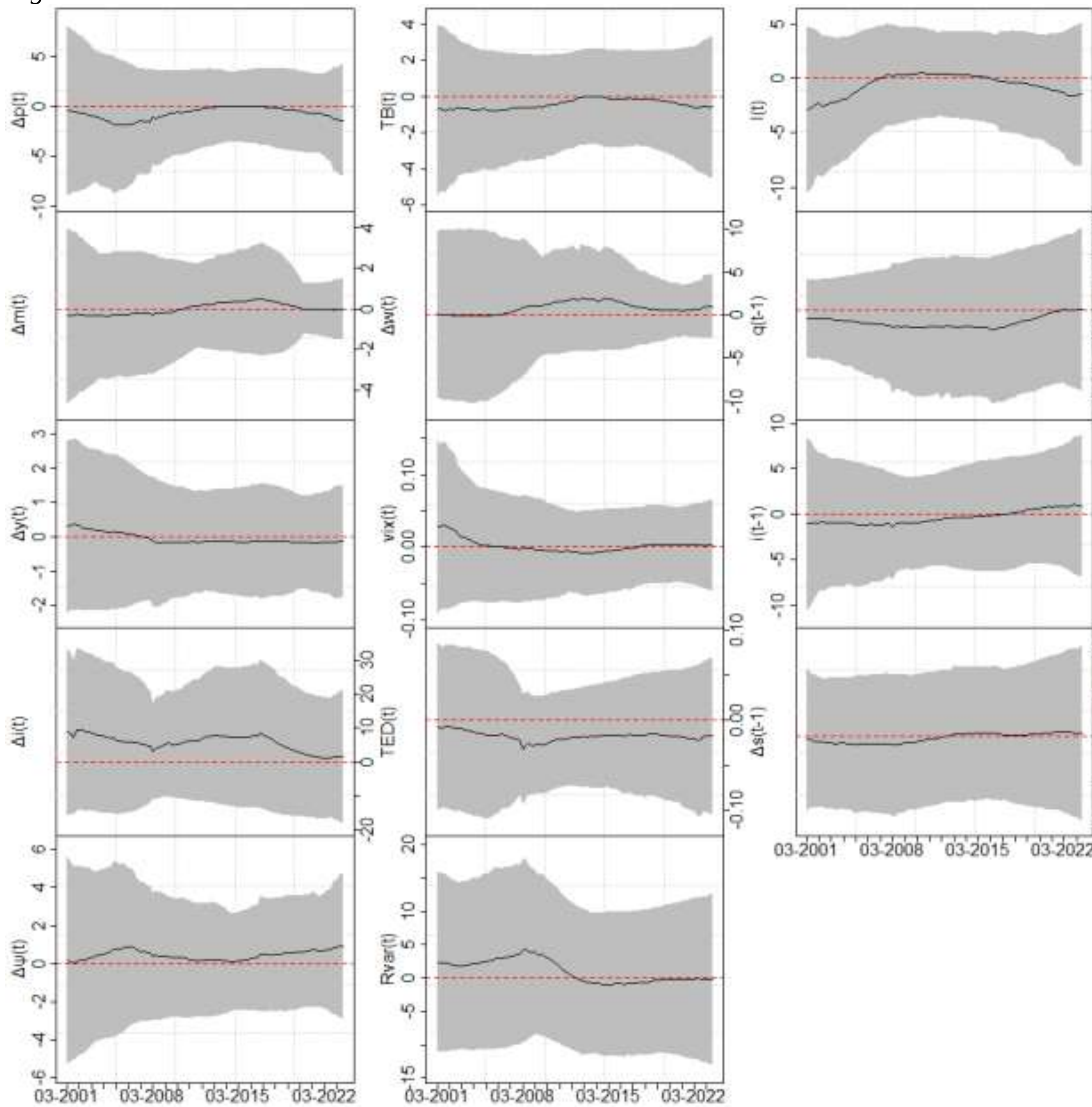


Figure E6: The JPY Case



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	(1)	0.241	0.330	0.121	0.286	0.300	0.101
(1999Q1-2023Q3)	(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	(1)	-0.123	0.037	-0.101	-0.121	-0.195	0.002
(1999Q1-2007Q2)	(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	(1)	0.149	0.271	0.129	0.264	0.157	0.044
(2009Q1-2023Q3)	(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."