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PREDICTING EXCHANGE RATES IN ASIA: NEW INSIGHTS ON THE ACCURACY OF SURVEY FORECASTS

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Predicting exchange rates in Asia: New insights on the accuracy of survey forecasts

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Abstract

This paper evaluates aggregated survey forecasts with forecast horizons of 3, 12, and 24 months for the exchange rates of the Chinese yuan, the Hong Kong dollar, the Japanese yen, and the Singapore dollar vis-à-vis the US dollar using common forecast accuracy measures. Additionally, the rationality of the exchange rate predictions are assessed utilizing tests for unbiasedness and efficiency. All investigated forecasts are irrational in the sense that the predictions are biased. However, these results are inconsistent with an alternative measure of rationality based on methods of applied time series analysis. Investigating the order of integration of the time series and using cointegration analysis, empirical evidence supports the conclusion that the majority of forecasts are rational. Regarding forerunning properties of the predictions, the results are less convincing, with shorter term forecasts for the tightly managed USD/CNY FX regime being one exception. As one important evaluation result, it can be concluded, that the currency regime matters for the quality of exchange rate forecasts.

JEL classification: F31, F37, G17, O24.

Keywords: Exchange rates, survey forecasts, forecast evaluation, forecast acccuracy, forecast rationality, cointegration, impulse response analysis.

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1. Introduction

The foreign exchange (FX) market belongs to the largest financial markets globally (see, for example, Sosvilla-Rivero and Ramos-Herrera, 2013). Additionally, exchange rates are crucial price variables in open economies and international finance (see Dreger and Stadtmann, 2008; Dick, MacDonald, and Menkhoff, 2015) and have a significant impact on foreign trade and cross border investments (see, for example, Kan, 2017). Hence, the understanding of the price building processes in the FX market is relevant for decision makers in general and for forecasters in particular (Ince and Molodtsova, 2017). This is also true for Asian currencies, because with respect to global GDP growth, cross border investments and world trade Asian economies are becoming increasingly important, and, in recent years, asset managers outside Asia seeking to diversify their investment positions are focusing on Asia's financial markets (see, for example, Dunis and Shannon, 2005).

During the global financial crisis, various currencies have been under pressure of a pronounced and unanticipated appreciation of the US dollar (Fratzscher, 2009). These movements are a potential source of severe economic and financial consequences, because uncertainty regarding exchange rate movements might hinder economic activity including cross border trade (see, for example, Thorbecke, 2008; Chit, Rizov, and Willenbockel, 2010). Hayakawa and Kimura (2009) have shown that especially in East Asia intra-regional trade is negatively affected by FX volatility. In addition to that, both foreign and domestic companies have to deal with currency risk (see Aggarwal, Chen, and Yur-Austin, 2011; Aggarwal, 2013). De Grauwe and Markiewicz (2013) note that especially in non-U.S. equity markets, and in certain sub-periods, currency risks have been the major driver of risk premiums in the stock market. Since currency risk is non-neglectable, FX forecasts may create economic value for financial market participants, central banks, policy decision makers as well as importers and exporters. Following Duffy and Giddy (1975), FX forecasts have to be seen as *"significant inputs to decisions concerning practically every aspect of international business"* (see Duffy and Giddy, 1975, p. 1).

Owing to the growing importance of Asia's major economies and the region's most important financial centers, this paper focuses on the investigation of forecasts for exchange rates of the Chinese yuan, the Hong Kong dollar, the Japanese yen, and the Singapore dollar vis-à-vis the US dollar. Using measures of forecast accuracy, common tests for rationality (i.e. unbiasedness and efficiency), as well methods of applied time series analysis (i.e. cointegration analysis and impulse response functions), the quality of survey forecasts for these exchange rates will be assessed. As a consequence of significant differences in FX regimes in the currency areas under investigation, it will also be examined whether there exists empirical evidence for regime dependent variations in the quality of survey forecasts.

Given the relevance of the FX regime on the price building processes for exchange rates, it is expected that survey forecasts do vary regarding accuracy and rationality. For forecasters classifying the relevant exchange rate regime is a crucial step (see, for example, Von Spreckelsen, Kunze, Windels, and von Mettenheim, 2014). Against the background of a strong influence of policy makers on exchange rates in managed FX regimes and the statutory provisions in currency boards it is standing to reason, that fixed and strongly managed exchange rates are "easier" to forecast, because policy makers are following an anticipated or even mandatory agenda. On the other hand, free float FX regimes seem to lack these policy guidelines which makes it more difficult to forecast the future path of exchange rates. Hence, while focusing on the investigation of survey based exchange rate forecasts provided by *Consensus Economics* for four different currency regimes, this paper seeks to combine two strands of research dealing with FX forecast evaluation and FX regimes and, while doing so, to fill a relevant gap in the literature.

The remainder of the paper is structured as follows. Chapter 2 delivers an overview of the relevant literature. Chapter 3 lists the chosen currency areas as well as the data set and describes the underlying regimes. Before exhibiting the methodological framework Chapter 4 delivers initital empirical results. Chapter 5 presents the evaluation results. Chapter 6 discusses the implications of the results in more detail and concludes the paper.

2. Literature overview

Frenkel and Mussa (1980) note that policy makers have to deal with FX market fluctuations and that the predictability of FX rates is important in this context. Nevertheless, they also comment that *"the facts indicate, however, that exchange-rate changes are largely unpredictable"* (see Frenkel and Mussa, 1980, p. 374). In their seminal paper Meese and Rogoff (1983) discuss the inability of fundamental models to forecast exchange rates in detail and motivate a large body of research dealing with the quality of FX predictions (see, for example, Frankel and Rose, 1994; Cheung and Chinn, 1998; Kilian and Taylor, 2003; Frenkel, Mauch, Rülke, et al., 2017, to name but a few). Despite the findings of Meese and Rogoff (1983) as well as Frenkel and Mussa (1980), FX survey forecasts are still of relevance for economic agents. Especially for financial market practitioners and decision makers, unable or unwilling to build up forecasting models for numerous financial variables of their own, survey forecasts (for exchange rates) may serve as one alternative. Ter Ellen, Verschoor, and Zwinkels (2013) annotate that investors in the FX market have to gather costly information to be able to form expectations. Not surprisingly, FX survey forecasts (both in aggregated and disaggregated form) have been intensively assessed with regard to their rationality (as regards, for example, unbiasedness and efficiency) as well as accuracy.

In the context of the evaluation of FX survey forecasts, data sets from numerous providers have been used.[1] Especially, the rationality of FX predictions, which is also in the focus of this paper, has been analyzed intensively (see, for example, Audretsch and Stadtmann, 2005; De Grauwe and Markiewicz, 2013; Rülke and Pierdzioch, 2013) with diverging results. Audretsch and Stadtmann (2005), who focus on disaggregated survey forecasts from the *Wall Street Journal*, find no evidence for the assumption of rational agents forming homogeneous expectations. Dominguez (1986) investigates survey forecasts for FX markets in emerging economies and concludes that the rational expectation hypothesis has to be rejected. Avraham, Ungar, and Zilberfarb (1987) find similar evidence for the Israeli shekel. Frenkel, Mauch, Rülke, et al. (2017) examine forecasters' rationality regarding exchange rate predictions. Their work is of high relevance for the focus of this paper because the authors empirically assess differences between currency forecasts for developed and emerging economies. They present a link between forecast accuracy as well as rationality and different currency areas and, hence, fill a relevant gap in the literature on FX survey forecast evaluation.

Focusing on a specific Asian market, Tsuchiya and Suehara (2015) investigate forecasts provided by *Consensus Economics* for the USD/CNY exchange rates between July 2005 and December 2012. The authors examine the directional accuracy of the forecasts and conclude that forecasters are not inferior to a naïve benchmark. Tsuchiya and Suehara (2015) find evidence for changes in FX forecasters herding behavior due to the financial crisis and central bank interventions and conclude that the monetary policy respectively the currency regime is of high relevance when evaluating FX forecasts. Duffy and Giddy (1975) compare the predictability of flexible and fixed exchange regimes and state that predictions for flexible exchange rates are futile. The monetary authorities' influence on the Japanese FX market (i.e. the exchange rate between the Japanese yen and the US dollar) and the resulting forecast dispersion has been assessed by Reitz, Stadtmann, and Taylor (2010). Also using data provided by *Consensus Economics* the authors conclude that while with increasing volatility of the USD/JPY FX forecast dispersion increases, policy interventions in the FX market have dampening effects on forecast dispersion. MacDonald and Nagayasu (2015) evaluate USD/JPY forecasts provided by the *Japan*

[1] In addition to the forecasts provided by *Consensus Economics* (Leitner and Schmidt, 2006; Beine, Bénassy-Quéré, and MacDonald, 2007; Jongen, Verschoor, Wolff, and Zwinkels, 2012; Ince and Molodtsova, 2017) predictions collected via the *Wall Street Journal (WSJ) Poll* (Audretsch and Stadtmann, 2005; Mitchell and Pearce, 2007; Frenkel, Rülke, and Stadtmann, 2009; Rülke, Frenkel, and Stadtmann, 2010), *FX Week* (e.g. Ter Ellen et al., 2013), *Bloomberg* (e.g. Pancotto, Pericoli, and Pistagnesi, 2014), *Forecasts Unlimited* (Bacchetta, Mertens, and Van Wincoop, 2009; Beckmann and Czudaj, 2017a,b; Ince and Molodtsova, 2017), *Blue Chip Forecasts* (Baghestani, 2010), *Reuters* (e.g. Bofinger and Schmidt, 2003) as well as the *ZEW Finanzmarkttest* (e.g. Bofinger and Schmidt, 2003; Leitner and Schmidt, 2006; Spiwoks and Hein, 2007; Heiden, Klein, and Zwergel, 2013) have been investigated. The data sets provided from *Consensus Economics* which come to use in this paper carry the advantages of a large historical database and three forecast horizons.

Center for International Finance (JCIF) survey and conclude that predictions are irrational.

When examining Asia's foreign exchange markets it has to be acknowledged that, unlike in the EMU, there does not exist a common currency area in Asia. Even more than that, currency regimes do vary significantly. Following, for example, Klein and Shambaugh (2008) it can be stated that the choice of the FX regime does matter and is a central topic in international finance. For a lot of currency areas, the bipolar segmentation between hard pegs or free floating only appears on the surface (Obstfeld and Rogoff, 1995; Calvo and Reinhart, 2002). For example, Moosa and Li (2017) remark that in the case of China the identification of the FX regime is important for the debate whether the Chinese currency is undervalued or not. This, in turn, is a relevant decision variable for forecasters. Having said that, it has to be taken into consideration that with the course of time monetary respectively FX regimes have changed manifold (Hernandez and Montiel, 2003; Bordo, Choudhri, Fazio, and MacDonald, 2017). Moreover, most emerging economies do not have a long track record when it comes to floating FX regimes (Kohlscheen, 2014). As a matter of fact, professional forecasters might also adjust their behavior when publishing forecasts for different FX regimes. Chinn and Frankel (1994) note that forecasters might be reluctant to deliver naïve predictions – especially for unstable currencies. Duffy and Giddy (1975), focusing on flexible exchange rates, present results indicating that for major exchange rates forecasting is not profitable.

3. Data set and FX regime classification

The monthly mean of survey FX forecasts with regard to four Asian currencies collected by *Consensus Economics* is used. The data set contains three different forecast horizons (3, 12, and 24 months) and ranges from January 1999 to March 2017. Forecasts for the following exchange rates will be evaluated: Chinese yuan against the US dollar (USD/CNY), Hong Kong dollar against the US dollar (USD/HKD), Japanese yen against the US dollar (USD/JPY), and Singapore dollar against US dollar (USD/SGD).[2]

The four exchange rates are suitable for the purpose of this paper for various reasons. Firstly, the currency areas are of high economic relevance in Asia and / or fulfill an important role in global financial markets. In terms of nominal GDP, for example, China respectively Japan are the two largest economies in Asia and number two respectively three globally. Furthermore, China is the world's largest trade nation (as measured by exports plus imports) and the Japanese currency plays an important role as a safe haven

[2] Throughout the paper all exchange rates are given as units per US dollar. Hence, a rise in the exchange rate corresponds to a US dollar appreciation and a lower exchange rate corresponds to a depreciation of the US dollar.

asset for investors. Hong Kong and Singapore as city states share the common characteristic to belong to the world's most sophisticated financial centers (see, for example, Tse and Yip, 2006; Woo, 2016). Secondly, the four currency areas do vary significantly when it comes to their FX regimes (see, for example, Tse and Yip, 2006; Cheung, Chinn, and Fujii, 2007; Chow, 2007; Takagi, 2007). Since this study also aims to examine possible differences in the forecast accuracy controlling for the FX regime this classification is important for the purpose of this paper.

However, the officially announced *de jure* exchange rate regimes do very often deviate from the observable *de facto* exchange rate regimes (see Obstfeld and Rogoff, 1995; Calvo and Reinhart, 2002; Klein and Shambaugh, 2008; Patnaik, Shah, Sethy, and Balasubramaniam, 2011). Additionally, currency regimes are not necessarily stable over time. Since 1998, the IMF publishes *de facto* classifications of the countries' FX regimes (see Kokenyne, Veyrune, Habermeier, and Anderson, 2009). To ensure comparability the FX regime classification in this paper is taken from the official IMF publication *Annual Report on Exchange Arrangements and Exchange Restrictions* (i.e. years 2000 to 2016). This *de facto* classification is useful because it is regularly updated (Patnaik, Shah, Sethy, and Balasubramaniam, 2011). Table 1 summarizes the data used. Following this classification the "degree of control" ranges from the USD/JPY (least) to the USD/HKD (most). Furthermore, the USD/CNY FX rate is more strongly controlled than the USD/SGD FX rate.

Table 1: Overview of monthly FX forecasts under investigation

Country	Start	End	Quotation	Current FX regime
PR China	01/1999	03/2017	USD/CNY	Other Managed Arrangement
Hong Kong	01/1999	03/2017	USD/HKD	Currency Board
Japan	01/1999	03/2017	USD/JPY	Free Float
Singapore	01/1999	03/2017	USD/SGD	Stabilized Arrangement

Sources: IMF AREAR 2016, *Consensus Economics*

Given the data set examined in this paper and the potential for regime shifts some further preliminary thoughts regarding the definition of the four currency areas are warranted.[3]

In the current political and academic debate China's exchange rate regime receives a lot of attention. Here, the focus lies on the People's Bank of China's influence on the exchange rate vis-à-vis the US dollar or a basket of currencies. (Kan, 2017, delivers

[3]Following the reasoning of Hernandez and Montiel (2003); Bordo, Choudhri, Fazio, and MacDonald (2017) it has to be accounted for possible shifts in the FX regimes investigated here.

a good summary of the discussion). In recent years, the Chinese authorities carried out far reaching adjustments to the FX regime (Cheung, Hui, and Tsang, 2016, 2017). Most importantly, in 2005, the central bank announced that the Chinese currency would switch to a managed float regime *"with reference to a basket of currencies"* (see Tian and Chen, 2013, p. 16). Moosa and Li (2017) deliver a clear overview of the 2005 adjustments and the subsequent steps. The IMF's *de facto* classification, as well as important announcements by the Chinese government, can be found in Table 12 in the Appendix.[4]

In contrast to the Chinese FX regime the Japanese currency's floating exchange rate regime is already in place since 1973 (see, for example, Hamada and Hayashi, 1985; Hutchison and Walsh, 1992, as well as Table 15 in the Appendix). Hence, the existence of regime shifts with relevance for the focus of this paper can be ruled out completely. The same holds true for the currency board system of Hong Kong, which has been established as early as 1983 and, since, has been in place (see, for example, Ho, 2002; Cook and Yetman, 2014, as well as Table 13 in the Appendix). In contrast, the Monetary Authority of Singapore (MAS) operates an exchange rate based monetary policy and, hence, the FX rate is practically the instrument to steer both output and inflation (see, for example, Siregar, Har, et al., 2001; Devereux, 2003; Chow, 2007; Chow, Lim, and McNelis, 2014, as well as Table 15 in the Appendix). As a consequence there does not exist a free floating USD/SGD exchange rate, but a managed regime which occasionally results in the more volatile exchange rate vis-à-vis the US dollar in comparison to the Hong Kong dollar (Devereux, 2003).[5] This regime lasts for the entire time period under investigation.

4. Initial empirical analysis and methodological framework

Before starting to evaluate the forecasts for the FX rates it is necessary to investigate the trending behavior of the exchange rate time series and the corresponding forecasts. To test for unit roots, the non-parametric test procedure proposed by Phillips and Perron (1988) will be used. The results of the PP (Phillips and Perron) unit root tests in levels and first differences (Δ) are given in Table 2 below.

[4]The regime change in 2005 might also be relevant for the focus of this paper. Because of that, robustness checks will be executed. It is important to note that for the USD/CNY FX rate controlling for the notable regime shift in July 2005 would lead to a shorter data period ranging from August 2005 to March 2017.

[5]Based on standard deviation of log differences as an approximation of returns the volatility is highest for the USD/JPY, followed by the USD/SGD, USD/CNY, and USD/HKD.

Table 2: Phillips & Perron (PP) unit root tests

		p-value (pv)	
Country	Time Series	Level	Δ
USD/CNY	3M forecast	0.99	0.01
	12M forecast	0.99	0.01
	24M forecast	0.99	0.01
	actual	0.99	0.01
USD/HKD	3M forecast	0.03	0.01
	12M forecast	0.01	0.01
	24M forecast	0.01	0.01
	actual	0.04	0.01
USD/JPY	3M forecast	0.63	0.01
	12M forecast	0.77	0.01
	24M forecast	0.79	0.01
	actual	0.62	0.01
USD/SGD	3M forecast	0.61	0.01
	12M forecast	0.76	0.01
	24M forecast	0.85	0.01
	actual	0.54	0.01

Reported are the results (p-values) of the PP unit roots tests for the forecasts and the actual exchange rate for USD/CNY, USD/HKD, USD/JPY, and USD/SGD with the forecast horizons of 3, 12, and 24 months in levels and first differences (Δ).

Results unit root tests Following Table 2 above, with exception of the actual Hong Kong dollar exchange rate and the corresponding forecasts statistical evidence for unit roots are found for all time series under investigation.[6] These results will be discussed in more detail below.

[6]The results for the USD/CNY FX rate presented in Table 2 range from 01/1999 to 02/2017. The results for time period 08/2005 to 03/2017 are in general similar and will not be reported in order to preserve space.

4.1. Measures of forecast accuracy

Theil's U measure In a first step, straightforward measures of forecast evaluation will be used. It will be started by calculating the Theil's U measure (Theil, 1955). Equation 1 below shows the Theil's U measure.

$$U = \frac{RMSE^{Forecast}}{RMSE^{Naive}} \tag{1}$$

The major advantages of this metric, which compares two competing forecasts, are that it is easy to calculate, uncomplicated to interpret as well as dimensionless. Recently, Ahmed, Liu, and Valente (2016) as well as Byrne, Korobilis, and Ribeiro (2016) utilize the Theil's U measure in the context of evaluating FX forecasts. The Theil's U can easily be calculated as the fraction of the root mean squared error (RMSE)[7] of the forecast and the naïve prediction.[8]

Diebold Mariano test Additionally, the Diebold Mariano (DM) test to check for equal predictive ability of the survey forecast and the naïve prediction will be applied (see also Diebold and Mariano, 1995). In difference to the Theil's U measure the DM test allows to statistically validate possible differences in forecast accuracy between the survey forecasts and benchmark measures like the naïve prediction (see, for example, Kunze, Wegener, Bizer, and Spiwoks, 2017).

TOTA coefficient In the context of forecast evaluation, the TOTA coefficient developed by Andres and Spiwoks (1999) is a reasonable supplement to the Theil's U measure and the DM test. The TOTA coefficient, as the fraction of the coefficient of determination of the FX forecast and the actual FX rate at $t+h$ ($R^2_{Forecast;Actual,t+h}$) as well as the FX forecast and the actual FX rate at t ($R^2_{Forecast;Actual,t}$), is shown in the Equation 2 below.

$$TOTA = \frac{R^2_{Forecast;Actual,t+h}}{R^2_{Forecast;Actual,t}} \tag{2}$$

A comparably stronger linear relationship between the forecast and the FX rate at t results in a TOTA coefficient smaller than 1. On the other hand, a TOTA coefficient larger than 1 can be seen as an indication for the usefulness of the forecasts by definition (see Andres and Spiwoks, 1999). As stated above, this procedure has already been

[7]The RMSE itself is an often applied measure of forecast accuracy (see also Leitch and Tanner, 1991; Hyndman and Koehler, 2006; Herwartz and Schlüter, 2017; Ryan and Whiting, 2017).

[8]The naïve prediction is used as competing forecast for the survey prediction. Throughout this paper the naïve prediction is defined as the *no change forecast*, (i.e. $\hat{S}_{t+h} = S_t$) whereas S_t is the FX spot rate at t and $\hat{S}_{t+h}$ is the forecast of the FX spot rate for $t+h$. Alternatively, instead of the *no change forecast* the naïve prediction could have also been defined as *trend following*. However, given the specific data set (e.g. turning points respectively trend reversals) it is presumed that the *no change forecast* to be more appropriate for the purpose of this paper.

applied to FX forecasts. For example, Baghestani (2010) concludes that forecasts for the trade weighted USD/EUR FX rate delivered to the *Blue Chip* quarterly forecasts have been subject to topically oriented trend adjustment. In their earlier study Bofinger and Schmidt (2003) deliver similar results for the USD/EUR exchange rate.

Sign accuracy test Pierdzioch and Rülke (2015), for example, emphasize that despite possible biasedness of survey forecasts for exchange rates the predictions might still be useful in the sense of directional accuracy.[9] Hence, the directional accuracy of provided forecasts will be investigated using the widely acknowledged sign accuracy test (see Diebold and Lopez, 1996; Kolb and Stekler, 1996; Baghestani, 2008; Spiwoks, Bedke, and Hein, 2009; Baghestani, Arzaghi, and Kaya, 2015). There also exists a handful of studies focusing on the directional accuracy of exchange rate forecasts for Asian currencies. Tsuchiya and Suehara (2015) analyze the directional accuracy of USD/CNY forecasts also using *Consensus Economics* data and conclude that only 12M forecasts are useful. The authors investigate 1M, 3M, and 12M forecasts. Hence, the forecast horizons provided in the data set of this study might deliver additional insights regarding directional accuracy of USD/CNY forecasts. Pierdzioch and Rülke (2015) inter alia analyze FX forecasts for the Singapore dollar with horizons of one respectively three months. This paper follows the approach used for example by Spiwoks, Bedke, and Hein (2009). Table 3 below shows a two by two contingency table. The sum of the entries in N_{11} and N_{22} gives the number of correct forecasts for the directional change of the exchange rate. The number of incorrect forecasts is given by N_{21} and N_{12}, respectively.

Table 3: Sign accuracy test

Forecast \ Actual event	USD appreciates	USD depreciates	$\sum$
USD appreciates	N_{11}	N_{12}	$N_{1.}$
USD depreciates	N_{21}	N_{22}	$N_{2.}$
$\sum$	$N_{.1}$	$N_{.2}$	N

This table shows the two by two contingency table for the sign accuracy test (see Spiwoks, Bedke, and Hein, 2009).

It will be tested for significant differences regarding directional accuracy between a random directional prediction and the exchange rate forecast by performing a χ^2 test (see, for example, Diebold and Lopez, 1996; Nolte and Pohlmeier, 2007; Spiwoks, Bedke, and Hein, 2009; Baghestani, 2010; Tsuchiya and Suehara, 2015).

[9] The concept of rationality in the sense of unbiasedness and orthogonality will be presented in Section 4.2.

4.2. Rationality of foreign exchange forecasts

Finally, the rationality of predictions is an important attribute in the context of forecast evaluation. This is also true for exchange rate predictions. In the case of the USD/JPY exchange rate, for example, Frenkel, Rülke, and Stadtmann (2009) test for the rationality of FX survey forecasts by applying two criteria – namely, unbiasedness and orthogonality (i.e. efficiency). These criteria are common measures in the literature dealing with forecast evaluation (see also Ito, 1990; MacDonald and Marsh, 1996) and, hence, will be applied in this paper as well.

Test for unbiasedness Firstly, the test for unbiasedness will be used (see, for example, Hafer, Hein, and MacDonald, 1992, who apply the test for unbiasedness for futures market quotes, forward rates and survey forecasts for interest rates). Audretsch and Stadtmann (2005), Frenkel, Rülke, and Stadtmann (2009), Frenkel, Mauch, Rülke, et al. (2017), as well as Ince and Molodtsova (2017) investigate whether survey forecasts are unbiased predictors of future FX rates and come to different conclusions. Following, for example, Chinn and Frankel (1994), and more recently Ince and Molodtsova (2017) a simple linear regression model with the actual exchange rate change ($s_{t+h} - s_t$) as dependent variable and the expected exchange rate change ($\hat{s}_{t+h} - s_t$) as the independent variable will be estimated, where s_t is the log of the price of one US dollar in the foreign currency and the forecast of the exchanges at t for the horizon h is given as $\hat{s}_{t+h}$ (with the forecast horizons h = 3, 12, or 24 months).[10] The error term is given by u_{t+h}. For the test for unbiasedness the joint $H_0 : \alpha = 0$ and $\beta = 1$ has to be empirically verified respectively discarded (see, once again, Ince and Molodtsova, 2017).[11]

$$s_{t+h} - s_t = \alpha + \beta(\hat{s}_{t+h} - s_t) + u_{t+h} \tag{3}$$

Test for efficiency To test for orthogonality (see, for example, Frenkel, Rülke, and Stadtmann, 2009) the test for efficiency will be used. This test is also widely used in the context of forecast evaluation (see inter alia Simon, 1989; Leitner and Schmidt, 2006). Using this procedure, it is possible to verify whether the forecast errors are not related to information available at the forecast date (see Nordhaus, 1987; Frenkel, Rülke, and Stadtmann, 2009; Pancotto, Pericoli, and Pistagnesi, 2014; Frenkel, Mauch, Rülke, et al., 2017). Within the empirically context of this paper this information will be represented

[10]Due to the non-stationarity of the USD/CNY, USD/JPY, and USD/SGD exchange rates and corresponding forecasts regressions in levels would lead to distorted results (see Granger and Newbold, 1974; Mitchell and Pearce, 2007). Notwithstanding, due to the stationarity of the USD/HKD FX rate and the corresponding forecasts, to test for unbiasedness in the case of the USD/HKD forecasts, the test will be executed in levels.

[11]In addition to that null hypothesis the residuals of the linear model have to be tested for autocorrelation. The widely acknowledged Durbin Watson (DW) test is applied here (see Durbin and Watson, 1950, 1951)

by the last available monthly exchange rate change at the forecast date ($s_t - s_{\text{t-h}}$).

$$s_{t+h} - \hat{s}_{t+h} = \alpha + \beta(s_t - s_{t-h}) + u_{t+h} \tag{4}$$

Here, the joint null hypothesis is given by $H_0 : \alpha = 0$ and $\beta = 0$. Hence, if α and / or β are significantly different from zero there does not exist any empirical evidence for efficiency of forecasts (see, for example, Frenkel, Rülke, and Stadtmann, 2009; Ince and Molodtsova, 2017).

Cointegration tests In addition to the before mentioned tests for rationality this paper focuses on alternative measures of rationality. Cheung and Chinn (1998) propose to investigate the properties of the relevant time series. Following Cheung and Chinn (1998), as a necessary condition for rationality, the time series of the actual exchange rates and the corresponding forecast should share the same order of integration. In addition to that, there should exist long term relationships (i.e. cointegration) between the two time series (see, for example, Liu and Maddala, 1992; Cheung and Chinn, 1998). Two time series are said to be cointegrated when they share a common stochastic trend (see, for example, Granger, 1981; Engle and Granger, 1987; Lütkepohl and Krätzig, 2004). To test for cointegrating relationships the Johansen procedure will be used (see Johansen, 1991). In a further step it will be tested for Granger causal relationships. If there exists a cointegrating relationship between the two time series this can be seen as evidence for the existence of at least unidirectional Granger causality. In general, a time series x_t Granger causes time series y_t when past values of x_t provide additional content when forecasting y_t. (see, for example, Engle and Granger, 1987; Gelper and Croux, 2007); or phrased somewhat differently past values of x_t help to predict future values of y_t. Hence, for the FX forecasts to be useful predictors of future currency movements in this sense the survey forecasts ($\hat{s}_{t+h,t}$) should Granger cause the actual exchange rates (s_{t+h}).

Order of integration Given the initial results from section 4, the first necessary condition is fulfilled for the forecasts under investigation, since the PP test for unit roots indicates that the actual FX rate and the corresponding survey predictions share the same order of integration for all currency pairs (see Table 2 above). The USD/CNY, USD/JPY and USD/SGD FX rate and their corresponding forecasts are I(1) (i.e. non-stationary). These results correspond to earlier findings of Cheung and Chinn (1998), who have investigated 1M, 6M, and 12M forecasts for the USD/JPY, USD/CAD and the USD/DEM forecast. The USD/HKD FX rate and the corresponding forecasts are I(0) (i.e. stationary). Owing to the FX regime of a currency board, this finding is not surprising at all. [12]

[12] Due to the stationarity testing for cointegration makes no sense in the case of the USD/HKD FX rate. Hence, the cointegration tests are only excecuted for the USD/CNY, USD/JPY, and USD/SGD

5. Empirical evidence

Results Theil's U, DM test, TOTA coefficient The results of the forecast accuracy measures Theil's U, DM test as well as the TOTA coefficient are shown in Table 4.

Table 4: Measures of Forecast Accuracy

Exchange rate	Time series	Theil's U	pv DM test	TOTA
USD/CNY	3M forecast	0.78	0.11	0.99
	12M forecast	0.71	0.32	0.99
	24M forecast	0.86	0.69	0.93
USD/HKD	3M forecast	1.22	0.02	0.97
	12M forecast	1.03	0.81	0.86
	24M forecast	0.92	0.63	1.03
USD/JPY	3M forecast	1.13	0.01	0.85
	12M forecast	1.12	0.08	0.51
	24M forecast	0.86	0.20	0.10
USD/SGD	3M forecast	1.09	0.04	0.95
	12M forecast	1.05	0.58	0.81
	24M forecast	1.04	0.78	0.58

Reported are the results for the Theil's U measure, the Diebold Mariano (DM) test and the TOTA coefficient for the forecasts for USD/CNY, USD/HKD, USD/JPY, and USD/SGD with forecast horizons of 3, 12, and 24 months.

Based on the results of the Theil's U measure (see Table 4) the mean forecast for the USD/CNY FX rate[13] seems to be more accurate than the naïve prediction for all three forecast horizons. For the USD/HKD 24M, as well as the USD/JPY 24M forecast, the Theil's U measure indicates that the survey predictions are more accurate than the naïve forecast. For the remaining seven forecast time series a Theil's U measure larger than one implies that the naïve prediction is more accurate. Considering the results from the DM test procedure for equal forecast accuracy delivers rather sobering results: From the five forecast time series with a Theil's U < 1 the H_0 of equal forecast accuracy cannot be rejected on the 10% level. Even more than that, the H_0 of equal forecast accuracy has to be rejected for four forecast time series which have a Theil's U > 1 (i.e. USD/HKD

FX rates.

[13]The results for the USD/CNY FX rate presented in this Chapter for the period January 1999 to March 2017 are similar to the results for the time period August 2005 to March 2017 and, hence, will not be reported in order to preserve space. The results are available by request from the corresponding author.

3M, USD/JPY 3M, USD/JPY 12M and USD/SGD 3M). Hence, especially in the case of shorter forecast horizons, the naïve predictions seems to be the superior forecast. Interestingly, the superiority of the naïve predicition seems to be regime independent. As regards topically oriented trend adjustments, the only TOTA coefficient > 1 belongs to the USD/HKD 24M forecast. Especially in the case of the USD/JPY forecasts, the topically oriented forecasting behavior becomes obvious (i.e. $TOTA = 0.10$).

Results sign accuracy test The results of the sign accuracy test are presented in Table 5 below. On the 5%-level the USD/CNY as well as the USD/HKD forecasts are significantly better than a random forecast for all three forecast horizons. Hence, the results contradict the earlier findings of Tsuchiya and Suehara (2015). For the USD/JPY and USD/SGD predictions the results are more heterogeneous. For the 3M forecast for the USD/JPY as well as the USD/SGD no statistically significant difference from the random prediction regarding the sign accuracy has been found. The USD/JPY 12M forecast is worse than a random prediction for the direction of change, whereas the 12M forecast for USD/SGD outperforms the random prediction. The 24M forecasts both for the USD/JPY and for USD/SGD are better than a random prediction. As regards the regime dependent quality of FX forecasts it is noteworthy that the USD/CNY exchange rate as well as the USD/HKD exchange rate forecasts are consistently more sign accurate than the random prediction.

Table 5: Results sign accuracy test

Exchange rate	Time series	Test statistic	Test result
USD/CNY	3M forecast	18.15	+
	12M forecast	14.10	+
	24M forecast	4.00	+
USD/HKD	3M forecast	16.72	+
	12M forecast	42.32	+
	24M forecast	47.43	+
USD/JPY	3M forecast	1.42	*N/A*
	12M forecast	10.34	−
	24M forecast	3.46	+
USD/SGD	3M forecast	0.86	*N/A*
	12M forecast	5.04	+
	24M forecast	12.41	+

Reported are the test results for the sign accuracy test for USD/CNY, USD/HKD, USD/JPY and USD/SGD with the forecast horizons of 3, 12, and 24 months. The critical value on the 5%-level is 3.84. '+' indicates that the survey forecast is better than a random prediction. '−' indicates that the random prediction is better than the survey forecast. '*N/A*' indicates that no significant difference in sign accuracy exists.

Table 6: Results unbiasedness test

Exchange rate	Time series	α	SE α	β	SE β	Test statistic	DW-test
USD/CNY	3M forecast	0.08	0.03	0.99	0.00	19.60	0.68
	12M forecast	0.73	0.07	0.90	0.01	120.78	0.13
	24M forecast	1.68	0.10	0.77	0.01	331.95	0.04
USD/HKD	3M forecast	0.38	0.14	0.81	0.07	46.20	0.37
	12M forecast	1.03	0.16	0.50	0.08	98.21	0.57
	24M forecast	1.05	0.12	0.49	0.06	173.24	0.48
USD/JPY	3M forecast	0.00	0.00	-0.14	0.14	68.32	0.68
	12M forecast	0.00	0.01	-0.13	0.14	66.54	0.19
	24M forecast	0.02	0.01	0.94	0.14	2.57	0.06
USD/SGD	3M forecast	0.00	0.00	0.09	0.13	48.56	0.68
	12M forecast	0.01	0.00	0.40	0.18	27.52	0.16
	24M forecast	0.03	0.01	1.05	0.29	35.32	0.07

Reported are the test results for the test for unbiasedness: The test statistic of the F-test as well as the DW-test, the coefficients α and β and the corresponding standard errors (SE) for USD/CNY, USD/HKD, USD/JPY and USD/SGD with the forecast horizons of 3, 12, and 24 months. The critical value on the 5%-level is 3.88.

Results test for unbiasedness The results of the test for unbiasedness are presented in Table 6 above. For the forecasts under investigation the joint $H_0 : \alpha = 0$ and $\beta = 1$ could not be empirically verified, because the requirement of nonexistence of autocorrelated residuals is not fulfilled. Hence, the predictions are biased for all forecasts respectively regimes under investigation. These results generally confirm earlier findings in the literature (see, for example, Frenkel, Rülke, and Stadtmann, 2009; Frenkel, Mauch, Rülke, et al., 2017; Ince and Molodtsova, 2017). Having said that, the empirical evidence does not allow any robust conclusion with regard to FX regime dependent differences of forecast rationality.

Results test for efficiency The results of the efficiency tests are presented in Table 7 below. On the 5%-level empirical evidence for efficient forecasts has been found for the following forecasts: USD/CNY 3M, 12M and 24M, USD/HKD 12M, 24M, USD/SGD 12M, 24M. In contradiction to the results from the unbiasedness tests these findings are more convincing, because forecasts seem to be efficient for managed exchange rates.

Table 7: Results efficiency test

Exchange rate	Time series	Test statistic
USD/CNY	3M forecast	0.40
	12M forecast	0.03
	24M forecast	2.07
USD/HKD	3M forecast	12.2
	12M forecast	3.43
	24M forecast	0.85
USD/JPY	3M forecast	29.04
	12M forecast	14.39
	24M forecast	7.10
USD/SGD	3M forecast	9.92
	12M forecast	2.26
	24M forecast	2.70

Reported are the results of the efficiency tests' test statistic for USD/CNY, USD/HKD, USD/JPY and USD/SGD with the forecast horizons of 3, 12, and 24 months. The critical value on the 5%-level is 3.88.

Results cointegration tests Finally, as mentioned above, the procedure to test for the rationality of FX forecasts proposed by Cheung and Chinn (1998) will be applied. The results of the cointegration tests for the pairs of forecasts, and actual FX rate which are I(1) (i.e. the USD/JPY, the USD/SGD as well as the USD/CNY FX rate), are presented in the Tables 8 to 10 below. Interestingly, only the 24M forecast for the USD/JPY FX rate does not fulfill the condition of cointegration (see Table 9). For the remaining eight pairs of forecasts and actual FX rates empirical evidence for a cointegrating relationship has been found, i.e. the null hypothesis of no cointegration had to be rejected at least on the 5%-level.

Table 8: Results cointegration tests USD/CNY

	Test statistic	10%	5%	1%
3M forecast				
$r \leq 1$	0.91	6.50	8.18	11.65
$r = 0$	45.84	12.91	14.90	19.19
12M forecast				
$r \leq 1$	0.76	6.50	8.18	11.65
$r = 0$	25.62	12.91	14.90	19.19
24M forecast				
$r \leq 1$	0.77	6.50	8.18	11.65
$r = 0$	16.85	12.91	14.90	19.19

Reported are the test statistics and critical values for the cointegration tests for the USD/CNY forecast and the actual USD/CNY exchange rate for the 3M, 12M, and 24M forecast horizon. The H_0 of no cointegrating relationship is given by $r = 0$. The H_0 of at least one cointegrating relationship is given by $r \leq 1$.

Table 9: Results cointegration tests USD/JPY

	Test statistic	10%	5%	1%
3M forecast				
$r \leq 1$	3.53	6.50	8.18	11.65
$r = 0$	119.77	12.91	14.90	19.19
12M forecast				
$r \leq 1$	4.97	6.50	8.18	11.65
$r = 0$	22.50	12.91	14.90	19.19
24M forecast				
$r \leq 1$	3.44	6.50	8.18	11.65
$r = 0$	5.80	12.91	14.90	19.19

Reported are the test statistics and critical values for the cointegration tests for the USD/JPY forecast and the actual USD/JPY exchange rate for the 3M, 12M, and 24M forecast horizon. The H_0 of no cointegrating relationship is given by $r = 0$. The H_0 of at least one cointegrating relationship is given by $r \leq 1$.

Table 10: Results cointegration tests USD/SGD

	Test statistic	10%	5%	1%
3M forecast				
$r \leq 1$	0.96	6.50	8.18	11.65
$r = 0$	108.07	12.91	14.90	19.19
12M forecast				
$r \leq 1$	0.99	6.50	8.18	11.65
$r = 0$	23.53	12.91	14.90	19.19
24M forecast				
$r \leq 1$	2.00	6.50	8.18	11.65
$r = 0$	15.81	12.91	14.90	19.19

Reported are the test statistics and critical values for the cointegration tests for the USD/SGD forecast and the actual USD/SGD exchange rate for the 3M, 12M, and 24M forecast horizon. The H_0 of no cointegrating relationship is given by $r = 0$. The H_0 of at least one cointegrating relationship is given by $r \leq 1$.

Model estimation In a final evaluation, it will be tested for Granger causality using impulse response functions for the relevant bivariate vector autoregressive models (VAR) respectively bivariate vector error correction models (VECM). The results predetermine which model type is appropriate for the pairs of forecasts and actual FX rate. For the USD/CNY (3M, 12M, and 24M), the USD/JPY (3M, and 12M), as well as the USD/SGD (3M, 12M, and 24M) will be used. For the stationary USD/HKD time series (3M, 12M, and 24M) VAR models in levels will be used. And finally, for the USD/JPY 24M FX rates a VAR model in 1^{st} differences has to be applied due to the lack of a cointegrating relationship between the two non-stationary time series. Table 11 below summarizes the applied models. Lag lengths for the VAR models is determined using the Schwarz Criterion (SC) (see Schwarz et al., 1978). The vector error correction models have a lag of two.

Table 11: Estimated models for actual FX rates and corresponding forecasts

Exchange rate	Forecast horizon	Model	Lag
USD/CNY	3M	VECM	2
	12M	VECM	2
	24M	VECM	2
USD/HKD	3M	VAR in levels	3
	12M	VAR in levels	3
	24M	VAR in levels	3
USD/JPY	3M	VECM	2
	12M	VECM	2
	24M	VAR in 1^{st} differences	1
USD/SGD	3M	VECM	2
	12M	VECM	2
	24M	VECM	2

This table summarizes the estimated models (i.e. vector error correction model (VECM) as well as vector auto regressive (VAR) models) for the corresponding relationships between the forecasts and actual FX rates. Lag lengths are reported in the last column.

Useful financial market forecasts should deliver relevant information for actual future movements (see, for example, Schwarzbach, Kunze, Rudschuck, and Windels, 2012; Kunze, Wegener, Bizer, and Spiwoks, 2017). This should also be the case for exchange rates. As noted above the concept of Granger causality will be used to investigate the hypothesis whether forecasts under investigation are useful in a Granger sense.

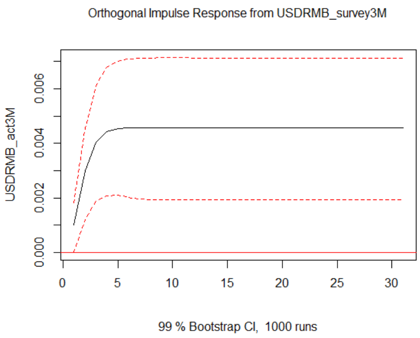
The empirical confirmation of a cointegrating relationship can be seen as evidence for the existence of at least unidirectional Granger causality. However, it is not clear whether the Granger causality is running from the forecast to the actual FX rate, from the actual FX rate to the forecast or if it is bidirectional. Furthermore, in the case of the VAR models no preliminary conclusions regarding Granger causal relationships are possible.

Impulse response analysis In an empirically setting impulse response functions are a useful tool to analyze these possible relationships between time series regarding Granger causality (see, for example, Basse and Reddemann, 2011). One advantage of impulse response functions stems from the fact that they are easy to interpret. The results of the impulse response analysis can be found in the Figures 1 to 4 below. The confidence intervals (with a confidence level of 99%) have been derived by bootstrapping (see Efron and Tibshirani, 1994) and 1,000 runs have been used. For the orthogonal impulses (see Sims, 1980) the length of the impulses is 30. Empirical evidence for a Granger causal relationship would be indicated by a significant response of the forecast time series to a shock to the actual times series or vice versa. A significant response is defined by a move of the response time series including the upper and lower confidence band above, or below the zero line (see Kunze, Wegener, Bizer, and Spiwoks, 2017).

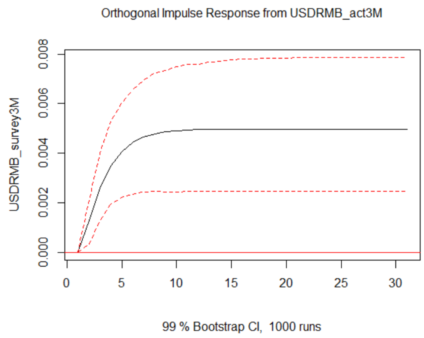
Following the IRF results for the USD/CNY 3M VECM shown in the panels (a) and (b) in Figure 1 it can be stated that there exists empirical evidence for bidirectional Granger causality between the time series of the FX forecast and the actual FX rate. Hence, short term forecasts for the USD/CNY FX rate are not only rational in the sense of the approach proposed by Cheung and Chinn (1998) (i.e. sharing the same order of integration), but it is also shown that the USD/CNY FX forecast with a three months horizon (3M) has forerunning properties regarding the USD/CNY exchange rate. However, for the longer term forecast horizons this finding is not sustainable (see panels c, d, e, and f in Figure 1). Instead, the 12M and 24M forecasts for the FX rates are only granger caused by the actual USD/CNY rate. This result may also be seen as supporting evidence for the results from the measures of forecast accuracy (i.e. especially the TOTA coefficient).

In the case of the VAR models for the forecast and actual time series for the USD/HKD exchange rates only one Granger causal relationship has been found (i.e. the response from the 3M USD/HKD forecast to an impulse from the the 3M USD/HKD actual rate as shown in panel b of Figure 2). For all three forecast horizons the USD/HKD FX rate predictions have no statistical significant forerunning properties for the actual FX rate. This may come as a surprise, because given the special properties of the currency board arrangement conventional wisdom would indicate that predicting the FX rate is easier. Having said that, it is important to note, that due to the stationarity of the time series under investigation for neither forecast horizon there exists a long term relationship between the actual rate and the forecast.

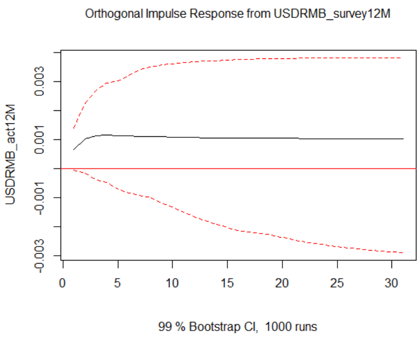
The interpretation of the results for the IRF for the USD/JPY as well as for the USD/SGD forecasts is rather straightforward. Based on the vector error correction models no evidence for forerunning properties of relevant forecast time series has been found (see Figure 3 panel a and c as well as Figure 4 panel a, c, and e). The same holds true for the VAR model in first differences for the USD/JPY exchange rate with a 24M forecast horizon (see Figure 3 panel e).



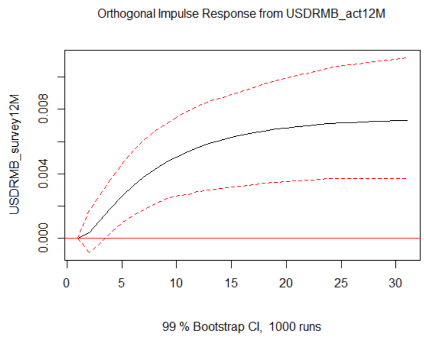
(a) 3M: Impulse by USD/CNY forecast



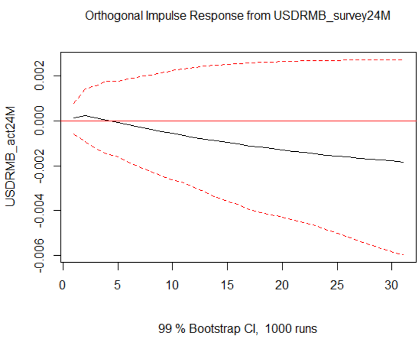
(b) 3M: Impulse by USD/CNY actual



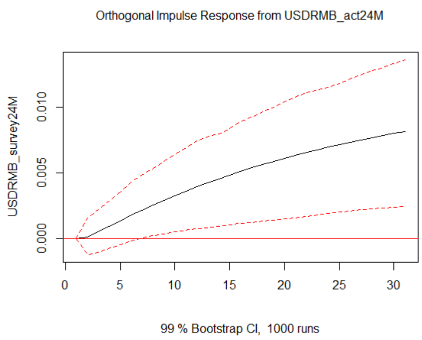
(c) 12M: Impulse by USD/CNY forecast



(d) 12M: Impulse by USD/CNY actual

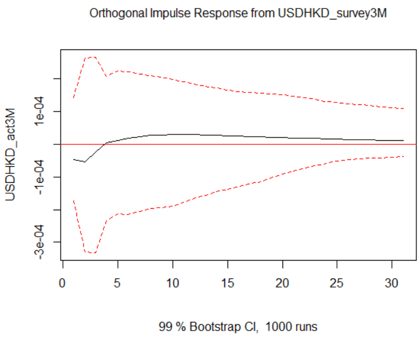


(e) 24M: Impulse by USD/CNY forecast

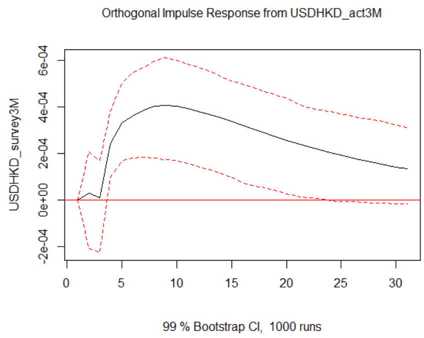


(f) 24M: Impulse by USD/CNY actual

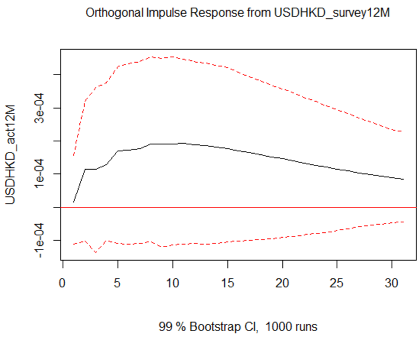
Fig. 1. The graphs show the impulse response functions for the USD/CNY forecast and the actual USD/CNY exchange rate for the 3M, 12M, and 24M forecast horizon.



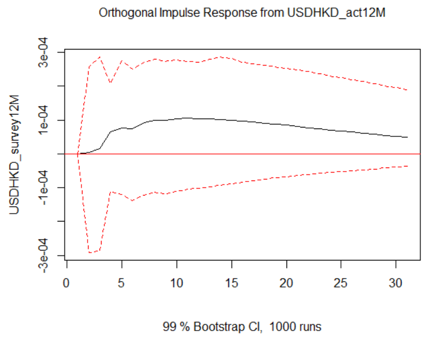
(a) 3M: Impulse by USD/HKD forecast



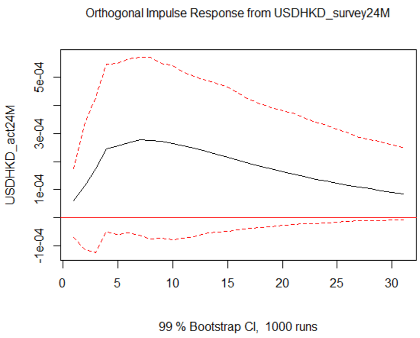
(b) 3M: Impulse by USD/HKD actual



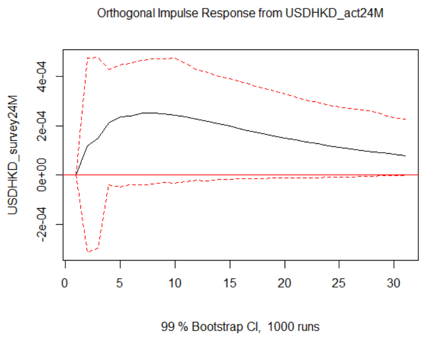
(c) 12M: Impulse by USD/HKD forecast



(d) 12M: Impulse by USD/HKD actual

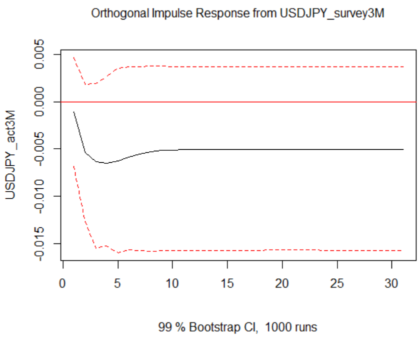


(e) 24M: Impulse by USD/HKD forecast

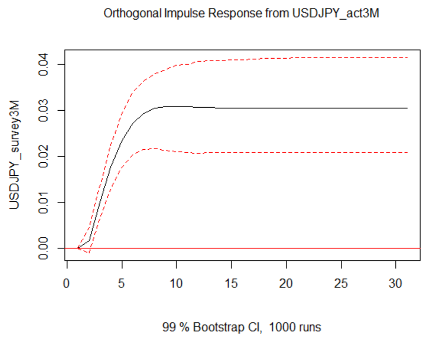


(f) 24M: Impulse by USD/HKD actual

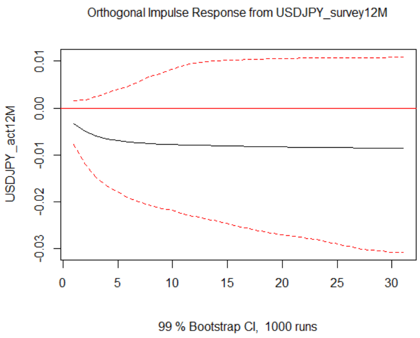
Fig. 2. The graphs show the impulse response functions for the USD/HKD forecast and the actual USD/HKD exchange rate for the 3M, 12M, and 24M forecast horizon.



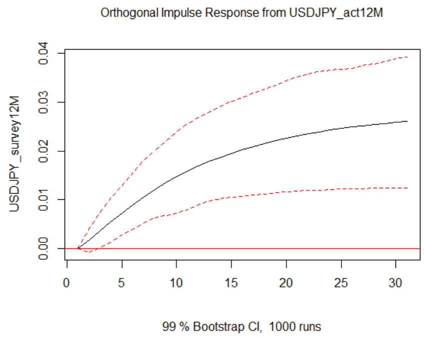
(a) 3M: Impulse by USD/JPY forecast



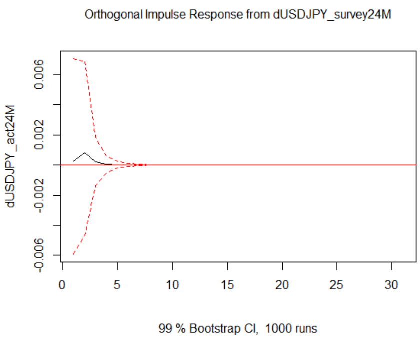
(b) 3M: Impulse by USD/JPY actual



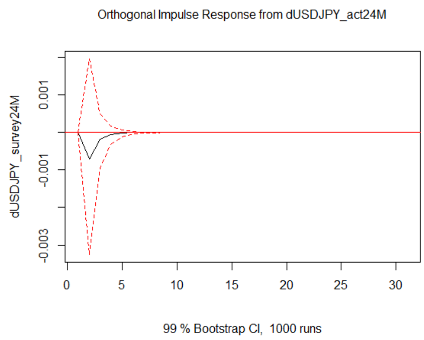
(c) 12M: Impulse by USD/JPY forecast



(d) 12M: Impulse by USD/JPY actual

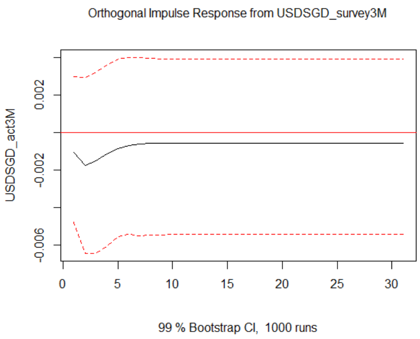


(e) 24M: Impulse by USD/JPY forecast

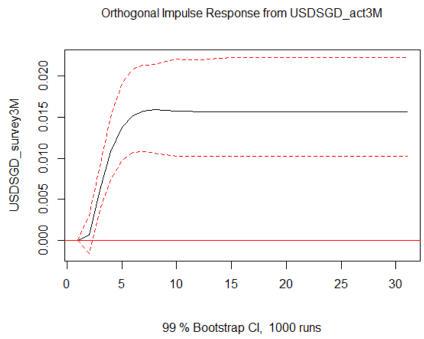


(f) 24M: Impulse by USD/JPY actual

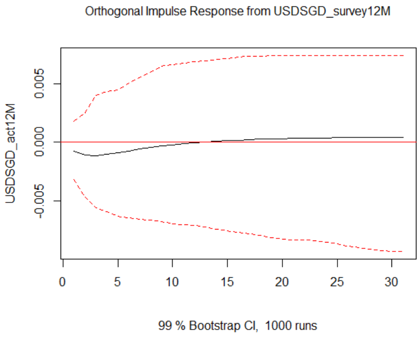
Fig. 3. The graphs show the impulse response functions for the USD/JPY forecast and the actual USD/JPY exchange rate for the 3M, 12M, and 24M forecast horizon.



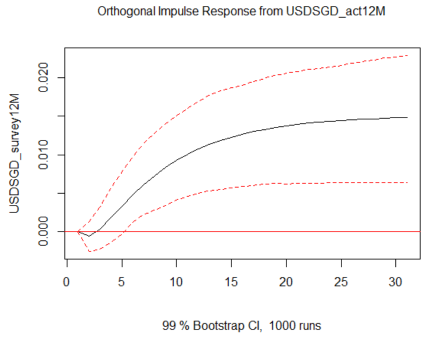
(a) 3M: Impulse by USD/SGD forecast



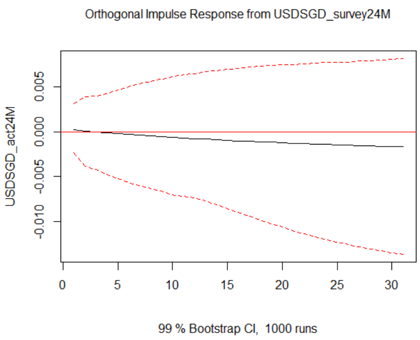
(b) 3M: Impulse by USD/SGD actual



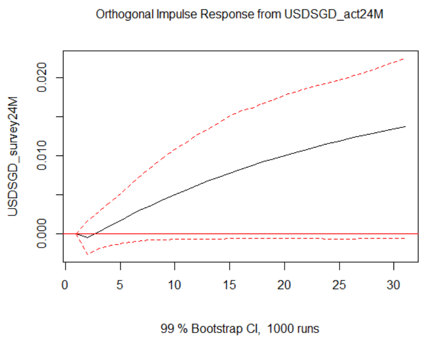
(c) 12M: Impulse by USD/SGD forecast



(d) 12M: Impulse by USD/SGD actual



(e) 24M: Impulse by USD/SGD forecast



(f) 24M: Impulse by USD/SGD actual

Fig. 4. The graphs show the impulse response functions for the USD/SGD forecast and the actual USD/SGD exchange rate for the 3M, 12M, and 24M forecast horizon.

6. Conclusions

In this paper monthly survey based exchange rate forecasts for the exchange rates of the Chinese yuan, the Hong Kong dollar, the Japanese yen as well as the Singapore dollar vis-à-vis the US dollar have been investigated regarding accuracy and rationality. Thereby, some interesting and relevant general results are worth mentioning. Rather strong empirical evidence for topically orientated (TOTA) forecasting behavior for all four exchange rates has been found. Furthermore, especially for shorter forecast horizons (i.e. 3M) the naïve *no change* prediction seems to outperform the survey forecasts with the three months forecasts for the USD/CNY exchange rate being the only exception. As regards sign accuracy for the forecasts for the USD/CNY and USD/HKD, empirical evidence supports the conclusion that the survey forecasts are more precise than a random prediction for all three forecast horizons under investigation. These results have been supported by the test for efficiency. Having said that, empirical evidence shows that all forecasts are irrational in the sense of the test for unbiasedness, due to the existence of autocorrelated residuals.

Applying an alternative framework to test for rationality proposed by Cheung and Chinn (1998), it has been shown that, for all four currency regimes the forecasts and actual exchange rates share the same order of integration. Furthermore, for the foreign exchange regimes with I(1) time series (i.e. USD/CNY, USD/JPY, and USD/SGD) empirical evidence supports the hypothesis of the existence of cointegrating relationships and, hence, a long term relation has been statistically validated. The only exception has been the USD/JPY forecast with a forecast horizon of 24 months. However, impulse response analysis for all currency regimes under investigation indicated that only the three months forecast for the managed USD/CNY exchange rate has forerunning properties. More generally, forerunning properties of the remaining survey forecasts under investigation are rather limited.

Furthermore, as regards regime dependent differences with respect to accuracy and rationality it has not been shown that exchange rates for fixed or closely managed exchange rates are in general easier to forecast. Despite the fact that no definite conclusion regarding FX regime dependent forecast accuracy respectively rationality of the survey predictions is suitable, the presented empirical evidence indicates that the forecasts for the managed Chinese exchange rate systems are closest to be being rational and forerunning, especially for the three months forecast horizons. Furthermore, also taking into account the results for the forecast evaluation of the USD/HKD exchange rate it can be stated that forecast accuracy – especially when it comes to sign accuracy – seems to be higher for stronger controlled exchange rate regimes. These findings are relevant both for the recipients of foreign exchange forecasts (e.g. corporate managers or politicians) and for the monetary respectively FX policy makers themselves.

After all, these findings may not be extraordinary surprising, as in managed foreign exchange regimes monetary policy authorities have to follow a self or government obliged framework. However, it has to be taken into account, that strongly regulated FX markets may be much more exposed to event risks and tail events, respectively, like for example currency crisis and, most importantly in the context of the results of this study, shifts in the FX regimes (see, for example, Husain, Mody, and Rogoff, 2005; Fiess and Shankar, 2009; Abildgren, 2014). Having said that, further research is necessary and should, particularly, focus on the predictability of regime shifts in managed exchange rate systems and currency boards, the credibility of fixed exchange rate regimes as well as the influence thereof on forecast accuracy and rationality, respectively.

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Appendix

Table 12: China FX arrangement based on IMF's Annual Report on Exchange Arrangements and Exchange Restrictions

Arrangement	AREAER reports	Important announcements / changes
Conventional pegged arrangement	2000 - 2005	○ July 21st, 2005: People's Bank of China (PBOC) revalued USD/CNY to 8.11; CNY FX rate will be determined by an undisclosed basket of currencies
Crawling peg	2006 - 2007	○ effective August 1st. 2006 IMF classifies FX arrangement as crawling peg
Stabilized arrangement	2008 - 2009	○ from April 30st, 2008 IMF FX arrangement was classified as crawl-like arrangement due to changes in IMF classification
Crawl-like arrangement	2010 - 2015	○ effective June 1st, 2008 IMF classifies FX arrangement as stabilized arrangement
Other managed arrangement	2016	○ effective June 21st, 2010 the de facto exchange rate was reclassified to a crawl-like arrangement
		○ April 16th, 2012: USD/CNY trading band was officially widened from +/-0.5% to 1.0%
		○ March 17th, 2014: USD/CNY trading band was officially widened from +/-1.0% to 2.0%
		○ effective December 24th, 2014 the de facto exchange rate was reclassified to other managed arrangement

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Table 13: Hong Kong FX arrangement based on IMF's Annual Report on Exchange Arrangements and Exchange Restrictions

Arrangement	AREAER reports	Important announcements / changes
Currency board	2000 - 2016	◦ May 18th, 2005: Hong Kong Monetary Authority (HKMA) established a trading band of USD/HKD 7.75 to USD/HKD 7.85

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Table 14: Japan FX arrangement based on IMF's Annual Report on Exchange Arrangements and Exchange Restrictions

Arrangement	AREAER reports	Important announcements / changes
Independently floating	2000 - 2007	◦ from April 30st, 2008 IMF FX arrangement was classified as free floating due to changes in IMF classification
Free floating	2008 - 2016	◦ September 15th, 2010: Ministry of Finance intervened in FX market
		- March 18th, August 4th, October 31st, 2011 Ministry of Finance intervened in FX market

IMF'S Annual Report on Exchange Rate Arrangements and Exchange Restrictions 2000-2016

Table 15: Singapore FX arrangement based on IMF's Annual Report on Exchange Arrangements and Exchange Restrictions

Arrangement	AREAER reports	Important announcements / changes
Managed floating with no pre-announced path for the exchange rate	2000 - 2005	◦ effective January 1, 2006, the de facto exchange rate arrangement has been reclassified retroactively to other managed arrangement
Other managed arrangement	2006 - 2009	◦ effective April 14th, 2010 arrangement was (retroactively) reclassified to crawl-like arrangement
Crawl-like arrangement	2010 - 2013	◦ effective September 12th, 2011 arrangement was reclassified to other managed arrangement
Stabilized arrangement	2014 - 2016	◦ effective November 9th, 2011 arrangement was reclassified to crawl-like arrangement
		◦ effective January 1st, 2013 arrangement was reclassified to stabilized arrangement

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