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Expected Currency Returns and Volatility Risk Premia*

José Renato Haas Ornelas**

Abstract

This paper addresses the predictive ability of currency volatility risk premium - the difference between an implied and a realized volatility - over US dollar exchange rates using a time-series perspective. The intuition is that, when risk aversion sentiment increases, the market quickly discounts the currency, and later this discount is "accrued", leading to a future currency appreciation. Based on two different samples with a diversified set of 32 currencies, I document a positive relationship between currency volatility risk premium and future currency returns. Results remain robust even after controlling for traditional fundamental predictors like Purchase Power Parity and interest rate differential.

JEL Classification: G12, G15, G17, F31, F37.

Keywords: Currency return predictability, Volatility risk premium.

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I. Introduction

Predicting Exchange rate movements is one of the hardest tasks in finance, for both academics and practitioners. Fundamental models, like the PPP (Purchase Parity Power) and interest rate parity, have limited success in forecasting exchange rates (see, for instance, Cheung et all 2005). Some currency trading strategies, like carry trade, produce excess returns, but they are essentially driven by interest rate differentials, and not exchange rate movements.

In this paper, I address the predictive ability of the currency volatility risk premium over dollar exchange rates, using a time-series perspective. I document a positive relationship between Volatility Risk Premium (VRP) – the difference between an implied and a realized volatility[1] - and future currency returns, using one-week and one-month options and realized volatilities calculated using intraday returns. This is the same relationship found by Bollerslev, Tauchen and Zhou (2009, hereafter BTZ) for US equity market and Bollerslev et all (2014) for developed equity markets, both using variance risk premia with one-month options.

The intuition behind my empirical results can be gathered from the theoretical model of BTZ (2009). They propose a stylized general equilibrium model where the risky asset is an equity index, which can be forecasted by its variance risk premium, in a direct relationship. According to BTZ (2009) model intuition, "*when the market anticipates high (low) volatility going forward, there is a discount (premium) built into prices, resulting in high (low) futures returns*". In this paper, I argue that an emerging market currency can be considered the risky asset for an US-based investor. Even small developed markets can be viewed as a risky asset. However, for large developed markets currencies, it is not clear whether we can consider the US Dollar or the other currency as the risky asset. It is likely that the currency considered "risky" is time-varying, especially for large developed countries. In fact, Carr and Wu (2007) describe a time-varying option-implied skewness for major currencies pairs. Thus, the market may switch the risk assessment from one major currency to another through time.

[1] Although many papers define Volatility Risk Premium in this way, several other papers define in an inverse way: the realized minus implied. This other definition generates negative variance risk premia, which make the understanding more difficult. Nevertheless, this is just a convention, and does not change results.

Intriguingly, in a paper related to this one, Londono and Zhou (2015) find an inverse relationship using currencies returns and variance risk premium, also from a time-series perspective. However, they use 6-month options and realized variance calculated with 6 months of daily returns. From a cross-sectional perspective, Della Corte et all (2016) find also evidence suggesting the use of the cross-section of the volatility risk premium to buy currencies with low VRP (using the definition above) and sell those with high VRP [2]. Their data consist of one-year options with realized volatility calculated from previous one-year daily returns.

These opposite results are probably due to the size of the window used to calculate the realized volatility. In fact, variance and volatility risk premia calculated using different window sizes have a low correlation[3]. I argue that risk premia calculated using short-term windows and intraday data are a more accurate measure of the actual premia than those using large windows of daily data. Measures of variance using daily returns from the past year or six months capture old information, which are unlikely to reflect the current premium. Moreover, as mentioned by BTZ (2009), the use of high-frequency intraday data for calculating the realized volatility "*generally affords much more accurate ex post observations on the actual return variation than the more traditional sample variances based on daily or coarser frequency returns*". Nevertheless, it is interesting to see inverse relationships whether we use a short-term window or a long-term window.

My empirical investigation is based on two samples. The first sample uses a daily time-series of options with maturity in one month, thus there is a strong overlapping. The second sample has one-week options with no overlapping structure. The realized volatility is based on intraday returns of 30- and 5-minute respectively. While the second sample goes back to 2003, and has option data from only six currencies, the first starts in 2007 and has option data from 20 currencies – 10 developed and 10 emerging markets.

Empirical results find a positive relationship between Volatility Risk Premium (VRP) and future dollar exchange rate returns on both samples. The Global currency VRP – an equally weighted average of all VRPs with data available – shows predictive ability over an equally weighted average of returns from all currencies. When grouping by geographic region, results are stronger currencies from Latin America and Asia-Pacific, and weaker

[2] Della Corte et all (2014) paper defines VRP as realized volatility minus implied volatility.
[3] The one-month variance risk premium has a correlation of -8% and -3% with the 6-month and one-year variance risk premia, using a sample similar to Londono and Zhou (2015).

for Europe. A possible explanation for this result in European currencies is that the Euro is a reference for these currencies and not the US Dollar. Furthermore, the Euro is likely to assume the role of safe haven during certain periods of the sample. Thus, further studies using exchange rates against the Euro is needed to uncover the low predictability of European currencies. The only currency with statistically negative VRP coefficient is the Japanese Yen, meaning that investors favor the Yen when risk sentiment increases. This is consistent with the safe haven status of the Yen documented by Botman et al (2013).

Results are also stronger when using ATM (at-the-money) volatilities instead of volatilities calculated with the all range of strikes through a model-free approach. In general, ATM options are more heavily traded than other options, and this may make their volatilities more reliable.

Regarding traditional currency predictors, the PPP shows significant forecast ability, while the interest rate differential has some weak evidence. The signal of the interest rate differential suggests that high interest rates currencies tends to depreciate over the next week or month. This sign is consistent with the Uncovered Interest Parity (UIP). It is interesting to note that interest rates differential coefficients become stronger when controlling for the VRP, suggesting that risk sentiment can be important to explain UIP puzzle (see, for instance, Mayfield and Murphy, 1992).

A multivariate model using as independent variables the Global Currency VRP, PPP, lagged currency returns and interest rate differential can predict average currency returns in sample. The regression estimates suggests that one percentage point of annualized currency VRP leads to a 0.28% currency appreciation on average over the next month for the first sample and 0.16% over the next week for the second sample. In the weekly sample, the Global currency VRP is able to predict returns with a holding period up to four months, which is shorter than the 6 months from equity data in the BTZ.

A traditional out-of-sample comparison with a Random Walk is also performed. Results show that the Global Currency VRP model provides lower mean squared errors than a zero-mean Random Walk for estimation windows of 3, 4 and 5 years in the weekly sample. This result is statistically significant for Emerging Markets and Latin America currencies for all estimation windows. For the full group of currencies, results are statistically significant only for the 4-year estimation window. Other predictors – PPP, lagged returns and interest rate differentials – have a higher mean square error than the Random Walk, as reported in the literature.

I also contribute to the literature by calculating the VRP using future realized volatility, instead of past realized volatility, as is common practice. In this novel method, I compare the option-implied volatility with the realized volatility for the same period of the option. The traditional method compares implied volatility with the past realized volatility, assuming, thus, a unit autocorrelation. The novel method outperforms the traditional method in forecasting exercises in most of the cases.

Overall, this paper contributes to the literature by showing robust evidence that the currency VRP can predict future exchange rates for a diversified sample of currencies. In the next section, I explain the methodology for calculating the volatility risk premium. Section III describes the two samples used, while results for each sample are on sections IV and V. Finally, section VI concludes the paper.

II. Volatility Risk Premium Estimation

In order to calculate the Volatility Risk Premium, we need a measure of implied (Risk-Neutral) volatility and a measure of realized (physical) volatility. The latter is not difficult to calculate, but the former is not straightforward.

The simplest way to measure the implied volatility is just taking the implied volatility of an at-the-money option. This way has the advantage of being readily available through data providers. Another way is to calculate the risk-neutral (implied) variance from options with several strikes, and then take the square root. This is similar to the way CBOE (Chicago Board Options Exchange) calculate the VIX[4] index, the most known volatility index. This approach starts with the following formula to calculate the risk-neutral return variance:

$$E^{\mathbb{Q}}\left[\sigma_{t,t+T}^{2}\right] = 2e^{rT}\left(\int_{0}^{F_{t,t+T}} \frac{1}{K^{2}} P_{t,t+T}(K)dK + \int_{F_{t,t+T}}^{0} \frac{1}{K^{2}} C_{t,t+T}(K)dK\right) \quad (1)$$

Where

[4] The VIX index is based on one-month S&P 500 options.

$E^{\mathbb{Q}}[\sigma_{t,t+T}^2]$ is the annualized risk-neutral variance from time t to time t + T;
t is the current time;
T is the time to maturity of the options;
r is the annualized risk-free interest rate for the currency, for a period T;
K is the strike of the option;
$F_{t,t+T}$ is the forward value at time t, for a contract maturing at time $t+T$;
$P_{t,t+T}$ is the price of a Put option at time t, for a contract maturing at time $t+T$;
$C_{t,t+T}$ is the price of a Call option at time t, for a contract maturing at time $t+T$.

This formula is basically a continuous strike integration of option prices. In practice, we need a discrete approximation, since the number of strikes is finite. We use the following formula to calculate the model-free implied volatility using a finite number n of options and strikes:

$$E^{\mathbb{Q}}[\sigma_{t,t+T}^2] = \frac{2e^{rT}}{T}\sum_{i=1}^{n}\frac{\Delta K_i}{K_i^2}\theta_{t,t+T}(K_i) \tag{2}$$

Where

$E^{\mathbb{Q}}[\sigma_{t,t+T}^2]$ is the annualized risk-neutral variance from time t to time $t+T$;
n is the number of options available for the calculation;
K_i is the strike of the i_{th} option, and is sorted in an ascending order;
ΔK_i is the interval between previous strike and next strike, calculated as $\Delta K_i = (K_{i+1} - K_{i-1})/2$. For the highest strike, ΔK_i is the difference for this strike and the second highest. For the lowest strike, ΔK_i is the difference between second lowest and this strike.
$\theta_{t,t+T}(K_i)$ is the price of an out-of-the-money option at time t, maturing at time $t+T$, with strike K_i. This option is a Call if $K_i > F$ and a Put if $K_i < F$.

This formula is similar to the one CBOE uses for VIX index, with some small adaptations to the characteristics of our over-the-counter (OTC) option data, especially the fact that we have constant maturity and median strike equal to forward price.

This approach is often called model-free, since no specific option-pricing model like Black and Scholes or Garman and Kohlhagen is assumed.

I assume throughout the paper that $E^{\mathbb{Q}}[\sigma_{t,t+T}] = \sqrt{E^{\mathbb{Q}}[\sigma_{t,t+T}^2]}$, and thus ignoring convexity bias (see Della Corte et all, 2016 for details).

The physical or realized volatility is calculated using actual returns. Usually they are calculated using daily observations, but BTZ (2009) argue that the use of high-frequency intraday data for calculating the realized volatility is generally a much more accurate ex post observation of the actual return variation. In this paper, I use intraday data with 5 and 30 minutes frequencies to calculate currency returns realized volatilities.

Having both risk-neutral and physical measures, we can calculate the VRP. There are three approaches for this calculation. The traditional approach in the literature (including BTZ, 2009 and Della Corte et all, 2016) uses the current date implied volatility and the past realized volatility up to the current date, i.e., backwards volatility:

$$VRP_{t,back} = E^{\mathbb{Q}}[\sigma_{t,t+T}] - E^{\mathbb{P}}[\sigma_{t,t+T}] = E^{\mathbb{Q}}[\sigma_{t,t+T}] - \sigma_{t-T,t} \tag{3}$$

$VRP_{t,back}$ is the Volatility Risk Premium at time t calculated using this backwards method. $E^{\mathbb{P}}$ is the physical measure. Note that this equation implicitly assumes that $E^{\mathbb{P}}[\sigma_{t,t+T}] = \sigma_{t-T,t}$, i.e., that volatility has a unit autocorrelation, which is a quite strong assumption. In fact, empirical data shows that volatility behaves in clusters or regimes. When we have a change of regime, this unit autocorrelation assumption is severely violated. Furthermore, it is strange to compare the risk-neutral volatility forecasted between t and $t+T$ with a backwards realized volatility between t - T and t. There is a mismatch between the period for which option traders forecast volatility and the period for which volatility is measured. The market may expect a volatility in the future different from the past.

An alternative and perhaps more intuitive approach is to compare the risk-neutral volatility forecasted between t and $t+T$ with the future realized volatility also between t and $t+T$. In this way, we would compare the forecasted risk-neutral volatility with realized volatility for the same period of the forecast, without having to assume a unit autocorrelation. However, the cost of this approach is that the risk-neutral volatility information will be T periods "old", since we need to measure realized volatility over a T period. This VRP forward approach can be calculated as follows:

$$VRP_{t,fwd} = E^{\mathbb{Q}}[\sigma_{t-T,t}] - E^{\mathbb{P}}[\sigma_{t-T,t}] = E^{\mathbb{Q}}[\sigma_{t-T,t}] - \sigma_{t-T,t} \quad (4)$$

$VRP_{t,fwd}$ is the Volatility Risk Premium at time *t* calculated using the alternative forward method. It is important to highlight that this method use only information available at time *t*. Note that while the backward approach uses current (time *t*) risk-neutral volatility, the forward approach uses risk-neutral volatility with a T lag, i.e., the risk-neutral volatility is an old information.

My empirical results show that the forward approach performs better. Perhaps this is due to my small period *T*. When *T* is small enough (say one month), the forward approach tends to be better performance, while a higher *T* (say one year) could make the backward approach better.

Equation (4) for the expected VRP using the forward approach assumes $E^{\mathbb{P}}[\sigma_{t-T,t}] = \sigma_{t-T,t}$, i.e., that the expected physical volatility can be forecasted without errors by the agents. In this way, as in the real world agents do not have perfect forecast, this measure embed the volatility forecast error. This may make this measure noisier, but it is unlikely the existence of some kind of forecast bias. Anyway, this is a lighter assumption than backward approach, where equation (3) assumes both unit autocorrelation and no forecast error. It may be the case that this forecast error is correlated with future returns and lead to predictive ability found in this paper.

The third approach is to use a volatility forecasting method for the expected physical volatility. In this way, instead of assuming unit autocorrelation as in (3), more sophisticated methods could be used to forecast future volatility. The main issue here is which volatility forecasting method to use, since there is a vast literature on this topic. Beakaert and Hoerova (2014) evaluates a plethora of volatility forecasting models to calculate the Variance Risk Premium for the US equity market. BTZ (2009) uses the HAR-RV (Heterogeneous Autoregressive Realized Volatility) proposed by Corsi (2009) as robustness test.

On this paper, I use only the two simple approaches of equations (3) and (4), leaving the use of complex volatility models for future works.

III. Sample

The sample consists of two datasets. Both use exchange rate option prices from over-the-counter (OTC) quotes. Data about implied volatility surface is not actual trades, but estimates collected by data providers or financial institutions. Option data is collected from Bloomberg and JP Morgan. Bloomberg data comes from a pool with several foreign exchange dealers.

The realized volatility is based on intraday returns: 30-minute on part I, taken from Bloomberg and 5-minute on part II, taken from Gain Capital website. While on part I options have a one-month maturities, on part II they have one-week maturities. Given that on part I the sample time span is shorter, I use overlapping data on a daily basis. Table I summarizes the characteristics of the samples.

Table I – Sample Characteristics

	Part I	Part II
Source of option data	Bloomberg	JP Morgan
Time to maturity of Option data	One-month	One-week
Overlapping	Yes, on a daily basis	No
Source of realized volatility data	Bloomberg	Gain Capital
Frequency of returns for realized volatility calculation	30-minute returns	5-minute returns
Time period	Oct 2007 to Aug 2014	Feb 2003 to Dec 2014

III.1 Sample Part I – One-Month Options with Overlapping data

The exchange rate option prices used in this first analysis is collected from Bloomberg. Options have one-month expiration with a daily periodicity, so that there is an overlapping structure. This part uses realized volatilities based on 30-minute intraday quotes. Bloomberg calculates this intraday volatility on a daily basis based using 30-minute quotes. I aggregate this data in order to have volatilities based on 30-minutes data using the following formula $\sigma_T^2 = (1/T)\sum_{i=1}^{T}\sigma_i^2$, where σ_i is the intraday volatility taken from Bloomberg. The window T is set to 20 business days.

I use two set of currencies. The first set has 20 currencies, and is restricted to those where both the implied volatility surfaces and the intraday realized volatilities are available. The second set includes additional 12 currencies where I could not find either the implied volatility surfaces, or the intraday realized volatility. For this second set, the VRP is not calculated, but they are included in the analysis where I use the Global currency VRP (the average of all currency VRP) instead of individual VRPs as independent variables. The sample time period goes from October 2007 to August 2014, approximately 7 years of daily data. The mains statistics are summarized on Table II.

In the first set of currencies, the volatility risk premium is calculated for 20 exchange rate pairs, all against the US Dollar. Half of the currencies are from developed countries, the so-called G-10 currencies: Australian Dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand Dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), and Swiss Franc (CHF). The sample includes 10 emerging markets currencies: Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Israeli Shekel (ILS), Indian Rupee (INR), Malaysian Ringgit (MYR), Mexican Peso (MXN), Polish Złoty (PLN), Turkish Lira (TRY) and South African Rand (ZAR). In the second set, another 12 other emerging markets currencies are used in the forecast exercise, but in these cases, only the spot exchange rate data is considered. These additional currencies are: Bulgarian Lev (BGN), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), South Korean Won (KRW), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB).

The original data from Bloomberg consists of four risk-reversals, four butterflies, besides the at-the-money volatility. Risk-reversals and butterflies have four different deltas: 10, 15, 25 and 35. These quotes are then converted to Call and Put options volatilities with 10, 15, 25 and 35 delta, and an at-the-money volatility.

Besides the options data, I have collected also data from the spot exchange rate and deposit rate. All spot and deposit rates are from Bloomberg. Deposit rates are either from Bloomberg or Libor-like rates, when available. When not available, the Swap treasury market is used.

Table I – Summary Statistics – Overlapping One-Month Option Sample

	ATM Volatility	Model-free Volatility	Realized Volatility	Model-free Volatility Risk Premium		Interest Rate
				Forward	Backward	
AUD	13,3	18,8	14,0	4,8	4,7	4,3
CAD	10,3	14,6	10,6	4,1	4,0	1,4
CHF	11,0	15,6	11,2	4,5	4,5	0,5
DKK	9,9	13,9	10,1	3,7	3,8	1,5
EUR	10,9	15,4	10,2	5,3	5,2	1,2
GBP	10,0	14,1	9,9	4,2	4,2	1,4
JPY	11,4	16,4	10,9	5,5	5,4	0,3
NOK	13,2	18,5	13,7	4,7	4,8	2,7
NZD	14,0	19,8	14,9	5,0	4,9	3,9
SEK	13,5	18,9	13,8	5,0	5,1	1,8
BRL	15,1	22,1	14,8	7,5	7,4	9,8
CLP	12,8	18,3	11,1	7,2	7,2	0,4
CZK	13,5	19,3	14,3	4,8	5,0	1,4
ILS	9,2	13,2	9,8	3,5	3,4	2,0
INR	10,3	14,0	8,2	5,7	5,8	7,3
MXN	13,0	19,0	12,0	7,0	7,0	4,8
MYR	7,8	9,6	7,0	2,5	2,6	2,9
PLN	16,6	24,0	16,5	7,5	7,5	3,9
TRY	13,0	18,6	12,3	6,4	6,3	9,3
ZAR	17,4	25,1	18,3	6,9	6,8	6,7
Overall Mean	12,3	17,5	12,2	5,3	5,3	3,4
Developed Mean	11,7	16,6	11,9	4,7	4,6	1,9
Emerging Mean	12,8	18,3	12,4	5,9	5,9	4,8

This table shows descriptive statistics regarding options of 20 currencies. The first three columns show the average values of the at-the-money (ATM), model-free and realized volatilities for each currency. The next two columns show the volatility risk premium calculated using forward and backward realized volatilities. The last column shows the mean one-month Libor-like interest rate of the currency. The last three rows show the average values for all currencies, the average value for the developed currencies and the average values for the emerging markets currencies. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY) and South African Rand (ZAR). Data is from Bloomberg. The sample period is from October 2007 to August 2014, with 1809 daily observations. Volatilities, VRP and deposit rates are shown on an annualized basis in percentage points. The maturity of the options is one month. Options are quoted considering an exchange rate expressed as foreign currency per U.S. Dollar, except for AUD, EUR, GBP and NZD.

III.2 Sample Part II – One-Week Options with non-Overlapping data

The exchange rate option prices used in this part is collected from JP Morgan data query application. I use volatilities with one-week expiration. The realized volatility is based on the tick-by-tick quotes provided by Gain Capital on its website[5]: 5-minute Log returns are calculated by aggregating tick-by-tick ask quotes into 5-minute time-series of exchange rates, and then taking the first difference of the log.

This sample also has two set of currencies. The first is restricted to those with option and intraday realized volatility data, and the second set is expanded to all other currencies with spot and interest rate data available. The first set includes six currencies pairs, all against the US Dollar. The currencies are from developed countries: Australian Dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Euro (EUR), Japanese Yen (JPY), and Swiss Franc (CHF). The second set has additional 24 currencies: Danish Krone (DKK), New Zealand Dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Brazilian Real (BRL), Chilean Peso (CLP), Colombian Peso (COP), Czech Koruna (CZK), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Israeli Shekel (ILS), Icelandic Króna (ISK), Indian Rupee (INR), Mexican Peso (MXN), Malaysian Ringgit (MYR), Peruvian Sol (PEN), Philippine Peso (PHP), Polish Złoty (PLN), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD), Thai Baht (THB), Turkish Lira (TRY) and South African Rand (ZAR).

The sample time period goes from February 2003 to December 2014, approximately 12 years of weekly data with no overlapping. The main statistics of the first set are summarized on Table III. In some few cases, when data is not available in a week, I repeat the values of the previous week.

[5] http://ratedata.gaincapital.com/

Table III – Summary Statistics – Non-Overlapping One-Week Option Sample

Currency	ATM Volatility	Model-free Volatility	Realized Volatility	Volatility Risk Premium Forward		Interest Rate
				ATM	Model-Free	
AUD	12,02	17,10	12,80	-0,78	4,30	4,52
CAD	9,50	14,18	10,13	-0,63	4,05	1,96
CHF	10,45	13,52	10,63	-0,18	2,89	0,53
EUR	10,04	13,66	9,62	0,41	4,04	1,56
GBP	9,09	14,32	9,25	-0,16	5,06	2,47
JPY	10,65	15,43	10,28	0,37	5,14	0,18
Mean	10,29	14,70	10,45	-0,16	4,25	1,87

This table shows average volatilities for a sample of six currencies against the US Dollar. The columns show the average values of the at-the-money (ATM) implied volatility, Model-Free implied volatility, realized volatility, volatility risk premium using the forward approach, and the interest rate for each currency. The realized volatility is calculated for each week using 5-minute log returns based on the ask price. The last row show the average values for all currencies. The currencies are Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Euro (EUR), Japanese Yen (JPY), Swiss Franc (CHF). Option data is from JP Morgan and foreign exchange quotes are from Gain Capital website. The sample period is from February 2003 to December 2014, with 622 weekly observations. Volatilities are shown on an annualized basis in percentage points. The maturity of the options is one week. Options are quoted considering an exchange rate expressed as foreign currency per U.S. Dollar, except for AUD, EUR, and GBP.

IV. Volatility Risk Premium and Future Returns with Overlapping Data

IV.1 Grouped Volatility Risk Premium

Initially, I consider the first sample, which consists of one-month options for each currency. The implied volatility is calculated using the model-free approach, as in equation (2), while the realized volatility is based on moving windows of 20 business days, with 30-minute observations. The volatility risk premium is calculated with both the forward and backward approaches, as in equations (3) and (4).

The regression specification (5) uses the one-month (based on a 20-business-day month) ahead returns as dependent variable, and the volatility risk premium as independent variables, besides a constant. Regressions are estimated with a daily periodicity, so that there is a strong overlapping. In order to cope with this overlapping structure, I use Hansen-Hodrick standard errors.

In this section, I use regressions where returns and VRP are grouped by geographic region (Latin America, Europe and Asia-Pacific) and by Developed or Emerging markets. When grouping returns and VRP, I use equal weights. Next section will use as regressor the global VRP, i.e., the average VRP of all currencies.

The regression specification is the following:

$$R_{t,t+T} = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t \quad (5)$$

Where:

$R_{t,t+T}$ is the currency cumulative return between business day t and $t + T$, using an exchange rate expressed as US Dollars per one unit of foreign currency, so that positive returns mean US Dollar depreciation and appreciation of the other currency. In this section, I consider monthly returns, so that T is equal to 19, i.e., cumulative returns of 20 business days. When considering a group of currencies, R is an equal weighted average of currencies returns.

VRP_t is a measure of the annualized expected volatility risk premium on business day t for each currency. I consider two ways of calculation the expected VRP: forward and backward, according to equations (3) and (4). The realized volatility is calculated using 30-minutes observations over a month.

Results for this base case are shown on Table IV. Coefficients are mostly positive, supporting the BTZ (2009) model prediction that a high (low) VRP leads to future positive (negative) returns. However, they are not statistically significant for the Backward VRP, except for Latin America. On the other hand, results for the forward VRP approach are much stronger. It shows statistically significant coefficients for the overall case (the global VRP), and for Developed markets. When grouping by geographical region in the forward approach, Europe is the only region with no statistical significance.

The coefficient for Developed markets in the forward VRP approach is twice the Emerging markets coefficient. However, one should expected the opposite, meaning a stronger discounting per unit of risk premium for emerging market currencies, i.e., a stronger reaction to risk.

Overall, results of this section support the use of the forward instead of backward VRP to forecast returns. Appendix table A.IV shows results for this same regression using returns and VRP from individual currencies.

Table IV – Grouped Volatility Risk Premium Regressions

Polled Returns	Grouped Volatility Risk Premium Model-Free, Backward			Grouped Volatility Risk Premium Model-Free, Forward		
	coefficient	t-statistics	adjusted R^2	coefficient	t-statistics	adjusted R^2
Overall	0,06	0,54	0,30	0,18	***1,68***	6,56
Developed	-0,03	-0,24	0,04	0,23	***2,02***	6,59
Emerging	0,08	0,88	0,81	0,13	1,37	4,86
Latin America	0,07	***1,90***	1,06	0,08	***2,04***	3,50
Asia-Pacific	0,11	0,98	0,89	0,15	***1,81***	4,29
Europe	-0,05	-0,38	0,14	0,18	1,32	4,02

This table shows results of the regressions $R_{t,t+19} = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t$. The dependent variable R is the equally weighted average returns (positive for appreciation of the currency and negative for appreciation of the USD) of that group of currencies. The groups are: developed markets, emerging markets, Latin America, Asia-Pacific and Europe. The regressor is the group's equally weighted average Volatility Risk Premium (VRP). The implied volatility used for the VRP calculation uses the model-free approach, while the realized volatility uses 30-minute returns. Columns 1 to 3 show the point estimates, t-statistic and Adjusted R^2 for the Volatility Risk Premium calculated using backwards approach. Columns 4 to 6 show the point estimates, t-statistic and Adjusted R^2 for the Volatility Risk Premium calculated using the forward approach. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY) and South African Rand (ZAR). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days. The maturity of the options is one month. Constant coefficients α are omitted.

IV.2 Global Volatility Risk Premium

In this section, I use the equal-weight average VRP across all currencies as dependent variable, i.e., a Global currency VRP. The specification is the same of equation (5), but now VRP is the average of all 20 currencies VRPs, with equal weights. As all exchange rates are against the USD, this average would capture a common risk premium. In addition, averaging across many currencies may reduce estimation error of this common factor for individual currencies with illiquid or inefficient option markets.

Table V brings these results. Almost all coefficients are positive. Note that the overall case is the same regression of Table IV, which I repeat here for convenience. As in the previous section, the forward VRP approach provides several significant coefficients, while the backward VRP approach has little significance. The forward VRP is significant in all cases, except for Europe. The emerging market coefficient is now significant. Therefore, the use of a Global VRP is able to improve the predictability for Emerging Markets, which can be explained by a less efficient option markets, so that borrowing information from other currencies VRP may give robustness to the risk premium information. Furthermore, this is perhaps an evidence that emerging currencies are more sensible to a global (systematic) VRP, while developed currencies have more idiosyncratic VRP sensibility. Differently from Table IV, the value of the point estimates are similar for emerging and developed countries in the case of the forward VRP.

Regarding the Adjusted R^2, it confirms that the use of a Global VRP increases the predictability for emerging markets, but reduce for developed markets. It also improves predictability for Latin America and Asia-Pacific. The Adjusted R^2 also provides evidence in favor of the forward VRP approach against the backward.

Appendix table A.V shows results for this same regression using returns from individual currencies, and support the use of the forward VRP approach.

Table V – Global Volatility Risk Premium Regressions

Polled Returns	Global Volatility Risk Premium Model-Free, Backward			Global Volatility Risk Premium Model-Free, Forward		
	coefficient	t-statistics	adjusted R^2	coefficient	t-statistics	adjusted R^2
Overall	0,06	0,54	0,30	0,18	***1,68***	6,56
Developed	0,04	0,33	0,11	0,16	***1,66***	5,51
Emerging	0,09	0,72	0,51	0,19	***1,68***	6,80
Latin America	0,22	***1,93***	2,35	0,27	***2,49***	9,71
Asia-Pacific	0,13	1,09	1,55	0,14	***1,80***	5,20
Europe	-0,05	-0,32	0,11	0,16	1,25	3,93

This table shows results of the regression $R_{t,t+19} = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t$. The independent variable is the Global VRP, which is the equally weighted VRP mean of all 20 currencies. The implied volatility used for the VRP calculation uses the model-free approach. The dependent variable R is the equally weighted average returns (positive for appreciation of the currency and negative for appreciation of the USD) of that group of currencies. The groups are: developed markets, emerging markets, Latin America, Asia-Pacific and Europe. The regressor is the group's equally weighted average Volatility Risk Premium (VRP). Only estimates for VRP coefficients are shown. Columns 1 to 3 show the point estimates, t-statistic and Adjusted R^2 for the Volatility Risk Premium calculated backwards, and averaged across all currencies. Columns 4 to 6 show the point estimates, t-statistic and Adjusted R^2 for Volatility Risk Premium calculated forwards, and averaged across all currencies. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY) and South African Rand (ZAR). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days. The maturity of the options is one month. Constant coefficients α are omitted.

IV.3 Using at-the-money volatility

Another way to calculate the VRP is to use solely the ATM (at-the-money) volatility, instead of the model-free volatility, which make use of options with several moneyness. This is a choice for simplicity, and makes calculations easier. Some papers use only ATM volatilities because time-series are longer for them. In general, ATM volatilities attract more attention than other options, and this may make their value more reliable.

Furthermore, articles that evaluate the predictive ability of currency Risk-Neutral densities find an adequate ability in the center of the distribution, but a poor ability in the tails (see Christoffersen and Mazzotta, 2005, for developed markets; and Ornelas, 2016, for emerging markets). This would be an evidence of the better informative power of ATM options over the other options.

Thus, I repeat the regressions of tables IV and V using ATM volatilities instead of model-free. I show on Table VI results only for the forward VRP. The first three columns contain calculations for grouped VRP, as in Table IV, and the following three columns show results for the Global VRP, as in Table V.

Coefficients estimates and t-statistics are higher for the ATM VRP than for the model-free VRP. Nevertheless, the Adjusted R^2 are similar. Again, the Global VRP provides stronger results for emerging markets than for developed. For the Global VRP, all coefficients are statistically significant.

Overall, results suggest that the ATM volatility has a slightly better forecasting performance than the model-free volatility. Appendix table A.VI shows results for this same regression using returns from individual currencies. When using the Global VRP and ATM options, 14 out of 20 currencies have statistically significant coefficients.

Table VI – ATM Volatility Risk Premium Regressions

Pooled Returns	Grouped Volatility Risk Premium ATM, Forward			Global Volatility Risk Premium ATM, Forward		
	coefficient	t-statistics	adjusted R^2	coefficient	t-statistics	adjusted R^2
Overall	0,24	***1,95***	6,67	0,24	***1,95***	6,67
Developed	0,24	1,56	4,70	0,20	***1,72***	4,78
Emerging	0,20	***1,99***	6,32	0,28	***2,11***	7,84
Latin America	0,12	***3,16***	4,01	0,36	***2,56***	9,95
Asia-Pacific	0,18	***2,02***	4,06	0,15	***1,97***	3,51
Europe	0,27	1,40	4,79	0,24	***1,66***	5,00

This table shows results of the regression $R_{t,t+19} = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t$ where the VRP is calculated using at-the-money (ATM) volatilities. The dependent variable R is the equally weighted average returns (positive for appreciation of the currency and negative for appreciation of the USD) of that group of currencies. The groups are: developed markets, emerging markets, Latin America, Asia-Pacific and Europe. Only estimates for VRP coefficients are shown. All results consider the Volatility Risk Premium calculated using the forward approach. Columns 1 to 3 show the point estimates, t-statistic and Adjusted R^2 for the grouped Volatility Risk Premium calculated as the equally weighted VRP mean of each group. Columns 4 to 6 show the point estimates, t-statistic and Adjusted R^2 for the Global Volatility Risk Premium calculated as the average VRP across all currencies. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY) and South African Rand (ZAR). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days. The maturity of the options is one month.

IV.4 Results with Control Variables

Other variables may also predict currency returns. This is the case of the classic Purchase Power Parity (PPP), and the interest rate differential, in the spirit of the uncovered Interest Parity (UIP). Recent research also found predictability of the stock market volatility risk premium. Therefore, this section adds control variables to the basic regression specification (5) in order to investigate if the predictability of the Currency VRP still survives to these external factors. The variables are:

- lagged currency one-month return;
- one-month Libor-like deposit interest rates differential;
- US Equity VRP calculated using equation (2) with VIX index as implied volatility and one-month daily realized volatility and;
- Undervaluation in percentage points of the current exchange rate against US Dollar PPP published by the World Bank[6].

[6] The PPP is published by the World Bank on December of the same year, and later a revision is done on June of the following year. Therefore, each July I start using the PPP of the previous year, so that the

The variables are equally weighted, except for the Equity VRP, which refers only to the US equity market. These control variables are related to the literature in foreign exchange markets predictability. Momentum strategies (Menkhoff et all, 2012a) are linked to the lagged returns. Carry trade strategies and UIP are linked to the interest rate differential (see Barroso and Santa Clara, 2015 or Menkhoff et all, 2012b). The PPP is the most known fundamental approach, and the Equity VRP is used by Aloosh (2013).

Besides these variables, I use the Global currency VRP calculated with implied volatility from one-month options and realized volatility based on 20 business days, with 30-minute observations. The currency-implied volatility is calculated using both the model-free approach and the ATM volatility. The volatility risk premium is calculated with the forward approach, as in equation (4).

Using the Global currency VRP, I am able to add other currencies in the analysis. These currencies were not included in the previous analysis because I could not find either option data or intraday volatility. Thus, I expand the sample in order to add more 12 Emerging Markets Currencies: Bulgarian Lev (BGN), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), South Korean Won (KRW), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB).

Before the full specification, I run preliminary univariate regressions using only each independent variable alone, together with a constant. The independent variables are: model-free Global Currency Volatility Risk Premium (MF CVRP), at-the-money Global Currency Volatility Risk Premium (ATM CVRP), Lagged one-month returns, Equity (S&P 500) VRP, depreciation of the PPP over current exchange rate, and interest rate differentials (Δi).

Results are on Table VII. The first two columns show the coefficients for the currency global VRP using model-free and ATM volatilities respectively. These regressions are the same of Tables V and VI (on the right side), but now there are 12 more emerging markets currencies. The US Equity VRP has also positive coefficients as in Aloosh (2013), but they are lower and with weaker statistical significance than those of Currency VRP. The Global currency VRP is highly correlated with equity VRP measures.

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variable is PPP = 100 (Spot / PPP_{WB} – 1), considering an exchange rates expressed as foreign currency per US Dollar, and where PPP_{WB} is the last World Bank PPP.

The global currency VRP using ATM options has a correlation higher than 60% with VRP measures using S&P500 and EuroStoxx50 options. When agents feels unsafe, they start charging risk premia from different kinds of risky assets. Although Equity VRP has ability to forecast currency returns, confirming results of Aloosh (2013), the global currency VRP has a better predictive performance.

The interest rate differential shows negative coefficients in all cases, but with only is statistically significant, the one from developed countries. This negative signal is consistent with the UIP, since currencies with higher interest rates tend to depreciate in the following month. However, statistical evidence for the UIP in this univariate case is weak. Recall that empirical literature usually rejects the UIP (see Engel 1996 for an overview).

The PPP has positive coefficient estimates, which means undervalued currencies tend to appreciate in the following month. However, only those of European countries is statistically significant. Regarding lag returns, coefficients are positive, but never significant.

The Volatility Risk Premia variables perform better in this setting. The ATM currency VRP is not significant only for European markets, although the t statistics (1.57) is almost significant at 10%. Regarding the adjusted R^2, the Currency VRPs show the best values in all cases, except Europe, where PPP performs very well.

The next step is to put together the control variables in the same regression. However, there is an issue of multicolinearity, since the three VRP variables are highly correlated. As seen on Table VII, the best univariate performance among them comes from the ATM global currency VRP, which has correlation of 78% with the model-free global currency VRP and 70% with the equity VRP. In this way, I decided to keep only the ATM currency VRP in the multivariate regressions. Thus, the full regression specification with control variables is the following:

$$R_{t,t+T} = \alpha + \beta_1 CVRP_{t-1} + \beta_2 R_{t-21,t-1} + \beta_3 PPP_{t-1} + \beta_4 \Delta i_{t-1} + \varepsilon_t \qquad (6)$$

Where

$R_{t,t+T}$ is the currency cumulative return between business day t and $t + T$, using an exchange rate expressed as US Dollars per one unit of foreign currency, so that positive returns mean US Dollar depreciation and appreciation of the other currency. The period t to t+T comprises 20 business days;

$CVRP_t$ is the equally weighted currency volatility risk premium on business day t using the forward approach (like equation 4) with the implied volatility calculated using the ATM volatility, as in equation (2) with one-month options, and realized volatility based on 20 business days, with 30-minute observations. The VRP of 20 currencies with available data (see section III.1) are averaged with equal weights;

PPP_t is the exchange rate of day t expressed as foreign currency per US Dollar divided by the last available Purchase Power Parity exchange rate, minus one, and then times 100 to express in percentage points;

Δi_t is the interest rate differential on day t. Interest rates are Libor-like rates with one month maturity, and are expressed in annualized percentage points;

Table VIII show Currency VRP and PPP as the main predictors of currency returns. The Currency VRP coefficient estimates and statistical significance are higher than the univariate case. Again, it is not significant only for the European countries[7]. The PPP seems to help the Currency VRP in predicting returns, and it fails to be a good predictor only for the Asia-Pacific region.

The interest rate differential has again negative coefficients, but now it is statistically significant for the overall average returns case. Interestingly, its coefficient is not significant for the three regions. Anyway, we still have the signal expected by the UIP, and accounting for control variables makes statistical evidence stronger on these aggregated regressions. The interest rate differential coefficients and t-statistics in the multivariate case are more negative than in the univariate case, except for the Developed market case. These results seems consistent with the argument that the existence of a time-varying risk premium may explain why UIP is often rejected empirically (Mayfield and Murphy, 1992). Controlling for a kind of risk premium - the VRP – I am able to give some weak empirical support to the UIP in the aggregated case. This control for risk premium when testing UIP is also present in the recent articles of Ichiue and Koyama (2011), Li et al (2012) and Jiang et al (2013).

[7] Appendix Table A.VIII show that 23 of out 32 currencies have statistically significant VRP coefficient when using individual currency returns. From the nine currencies that does not have statistically significant VRP coefficients, seven are European.

Overall, results using this overlapping sample provides robust support for the Currency VRP predicting future currency returns, even after controlling for traditional exchange rate predictors. One percentage point of annualized currency global VRP leads to a 0.28% currency appreciation on average over the next month. Next section investigates again this predictive ability, but with a different sample, which is longer and has no overlapping.

Table VII – Univariate Regressions with Control Variables

Pooled Returns	Coefficients						Adjusted R^2					
	MF CVRP	ATM CVRP	Equity VRP	*Δi*	PPP	Lag Ret	MF CVRP	ATM CVRP	Equity VRP	*Δi*	PPP	Lag Ret
Overall	0,17	0,22*	0,06*	-0,14	0,05	0,10	6,7	**6,9**	5,1	0,2	4,3	0,9
Developed	0,16*	0,20*	0,06	-0,89*	0,08	0,01	**5,5**	4,8	4,3	2,9	3,9	0,0
Emerging	0,17	0,23**	0,06*	-0,03	0,04	0,12	6,9	**7,6**	5,2	0,0	4,3	1,6
Latin America	0,19**	0,25**	0,06*	-0,18	0,04	0,20	**7,7**	7,1	4,0	0,3	3,9	3,9
Asia-Pacific	0,16**	0,20***	0,04	-0,10	0,02	0,05	**8,6**	7,5	3,9	0,1	2,5	0,3
Europe	0,15	0,23	0,07	-0,09	0,12***	0,04	3,8	4,8	4,8	0,2	**10,0**	0,2

*This table shows results of the univariate regressions $R_{t,t+19} = \alpha + \beta_1 X_{t-1} + \varepsilon_t$ where R is the one-month currency return (positive for appreciation of the currency and negative for appreciation of the USD) and X is one of six variables: model-free Global Currency Volatility Risk Premium (MF CVRP), at-the-money Global Currency Volatility Risk Premium (ATM CVRP), Lagged one-month, Equity (S&P 500) VRP, depreciation of the PPP over current exchange rate, and interest rate differentials (Δi). The dependent variable R is: first, the equally weighted currency returns of all 32 currencies; second, the average return of currencies with equal weights grouped by Developed / Emerging markets, and by region: Latin America, Europe and Asia-Pacific. The independent variables are also an equally weighted average across all currencies, when data is available. The first six show the point estimates for regressions with each variable, while the following six columns show the adjusted R^2. Coefficients significantly different from zero at 10%, 5% and 10% are marked with *, ** and ***, respectively. The Equity VRP uses the VIX index as implied volatility. Both equity and currency VRPs use the forward approach. Options used for calculations have one-month expiration. Realized volatility is calculated using daily returns for equity, and 30-minute returns for currencies, both with an one-month moving window. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Bulgarian Lev (BGN), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), South Korean Won (KRW), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs and interest rates are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days.*

Table VIII – Regressions with Control Variables

Pooled Returns	Coefficients				t-statistics				Adjusted R^2
	Currency VRP ATM	Δi	PPP	Lag Return	Currency VRP ATM	Δi	PPP	Lag Return	
Overall	0,27	-0,64	0,08	-0,07	***2,35***	***-1,71***	***3,17***	-0,66	16,1
Developed	0,26	-0,84	0,09	-0,10	***2,03***	-1,48	***1,86***	-1,13	13,2
Emerging	0,28	-0,52	0,07	-0,05	***2,52***	-1,63	***3,42***	-0,45	16,5
Latin America	0,27	-0,41	0,05	0,06	***2,66***	-1,35	***2,71***	0,49	15,1
Asia-Pacific	0,26	-0,14	0,02	-0,11	***3,34***	-0,61	1,22	-0,84	12,4
Europe	0,21	-0,13	0,12	-0,02	1,57	-0,42	***2,48***	-0,21	14,3

This table shows results of the regression $R_{t,t+19} = \alpha + \beta_1 CVRP_{t-1} + \beta_2 R_{t-20,t-1} + \beta_3 PPP_{t-1} + \beta_4 \Delta i_{t-1} + \varepsilon_t$ where R is the currency return (positive for appreciation of the currency and negative for appreciation of the USD), Currency VRP is the at-the-money Global Currency Volatility Risk Premium using the forward approach, PPP is depreciation of the Purchase Power Parity over current exchange rate, and Δi is the interest rate differential against the USD interest rate. The variable R is the average currency returns of all 32 currencies with equal weights; second, the average returns of currencies with equal weights grouped by Developed / Emerging markets, and by region: Latin America, Europe and Asia-Pacific. Independent variables are an equally weighted average across all currencies, for each variable. The first four data columns show the coefficients of the four independent variables. The following four columns show the respective t-statistics, and the last column show the Adjusted R^2. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Bulgarian Lev (BGN), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), South Korean Won (KRW), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags on Panels A and C. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs and interest rates are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days.

V. Volatility Risk Premium and Future Returns with non-overlapping Data

V.1 Volatility Risk Premium Regressions Results without Control Variables

In the second part of the sample, I consider one-week options and a realized volatility based on 5-minute returns with one-week window. One key difference to the previous sample is the absence of overlapping in this analysis. The sample time length is enlarged to almost 12 years, although there are only six currencies with data available. The volatility risk premium is calculated with both the model-free approach and ATM volatilities. Given the superiority of the forward approach against the backward approach, I provide results only for the former.

The regression specification is the same of equation (5), but now the dependent variable is the weekly return. Table IX shows results for the individual model-free and ATM implied volatilities. Again, results show a positive relationship between VRP and future currency returns, except for the Yen. In fact, the market considers the Japanese Yen a safe haven currency as documented in Botman et al (2013). One mechanism that can explain this behavior relates to carry trade. The Yen is a common funding currency on carry trade operations. When risk sentiment increases investors sell the risky asset leg of the carry trade and buy back the Yen, inducing a Yen appreciation.

As in the monthly sample, ATM volatilities provide better predictive results than the model-free approach, and non-European currencies regressions perform better than European currencies. The Australian Dollar regression shows an adjusted R^2 well above the others, reaching 26% in the ATM case.

Table X shows results when changing the independent variable to the global currency VRP – an equal-weighted average of the VRP from the six currencies with VRP data. Using the Global currency VRP allows us to include another 24 currency returns as dependent variables. Results are shown for returns grouped by geographic region and by Developed or Emerging markets. Appendix table A.VI shows results for individual currency returns.

Results on Table X again support a positive relationship between VRP and future currency returns, and ATM volatilities provide better results than the model-free approach. All coefficients are statistically positive, except for the European model-free VRP case. Results are stronger for Latin America and weaker for Europe. In terms of economic magnitude, each percentage point of the ATM VRP lead to an additional 0.15% weekly return for the overall case.

Table IX – Individual VRP Regressions

Individual Returns	Individual Volatility Risk Premium Model-free, Forward			Individual Volatility Risk Premium ATM, Forward		
	coefficient	t-statistics	adjusted R^2	coefficient	t-statistics	adjusted R^2
AUD	0,171	***3,73***	14,68	0,322	***9,68***	26,40
CAD	0,039	***3,26***	0,81	0,132	***2,76***	2,80
CHF	0,010	0,27	0,07	0,007	0,09	0,01
EUR	0,015	0,71	0,16	0,055	1,42	0,46
GBP	0,033	1,40	0,56	0,177	***2,87***	4,61
JPY	-0,072	***-3,22***	3,85	-0,141	***-3,98***	7,05
Mean			3,35			6,89

This table shows results of the regression $R_t = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t$. VRP is the individual currency VRP and is calculated using the forward approach. The dependent variable R is the individual weekly return (positive for appreciation of the currency and negative for appreciation of the USD) of six currencies: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Euro (EUR), Japanese Yen (JPY) and Swiss Franc (CHF). Constant coefficients estimates are omitted. Columns 1 to 3 show the point estimates, t-statistic and Adjusted R^2 for the individual Volatility Risk Premium calculated using ATM volatilities. Columns 4 to 6 show the point estimates, t-statistic and Adjusted R^2 for the individual Volatility Risk Premium calculated using model-free volatilities. The t-statistics are calculated using Hansen-Hodrick HAC with 2 lags. The sample period is from February 2003 to December 2014, with 622 weekly non-overlapping. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points. The maturity of the options is one week. The realized volatility is calculated based on 5-minute log-returns with one-week windows. There is no overlapping.

Table X – Global VRP Regressions

Pooled Returns	Global Volatility Risk Premium Model-Free, Forward			Global Volatility Risk Premium ATM, Forward		
	coefficient	t-statistics	adjusted R^2	coefficient	t-statistics	adjusted R^2
Overall	0,037	***1,77***	1,12	0,153	***3,26***	6,47
Developed	0,037	***1,81***	0,84	0,146	***2,75***	4,22
Emerging	0,036	***1,71***	1,18	0,157	***3,51***	7,26
Latin America	0,081	***2,78***	4,46	0,235	***3,03***	12,29
Asia-Pacific	0,032	***1,94***	1,50	0,122	***3,21***	6,94
Europe	0,009	0,37	0,04	0,116	***2,97***	1,98

This table shows results of the regression $R_t = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t$. VRP is the Global Currency Volatility Risk Premium and is calculated as the average VRP of six currencies: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Euro (EUR), Japanese Yen (JPY) and Swiss Franc (CHF). The VRP is calculated using the forward approach. The Return R are calculated on a weekly basis and expressed in percentage points. Positive returns mean appreciation of the currency and negative returns appreciation of the USD. The Currencies considered are 30: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). The dependent variable R is the equally-weighted average returns of all currencies, and then grouped by developed markets and emerging markets, and by geographic region: Latin America, Asia-Pacific and Europe. Constant coefficients estimates are omitted. Columns 1 to 3 show the point estimates, t-statistic and Adjusted R^2 for the Global Currency Volatility Risk Premium calculated using ATM volatilities. Columns 4 to 6 show the point estimates, t-statistic and Adjusted R^2 for the Global Currency Volatility Risk Premium calculated using model-free volatilities. The t-statistics are calculated using Hansen-Hodrick HAC with 2 lags. The sample period is from February 2003 to December 2014, with 622 weekly non-overlapping. VRPs are expressed on an annualized basis in percentage points. The maturity of the options is one week. The realized volatility is calculated based on 5-minute log-returns with one-week windows.

V.2 Volatility Risk Premium Regressions Results with Control Variables

In this section, I test if results from previous section survive when three control variables are added to the regression. Only results for the ATM Global VRP using the forward approach are shown. The control variables are the same used on Table VIII: interest rate differentials, PPP and lagged returns. The interest rates for developed countries have a one-week term. For emerging markets, I use one-month terms, since it is difficult to find one-week deposits. Both returns are weekly.

As a preliminary analysis, Table XI shows univariate regressions of future returns with each control variable alone. Results for the ATM Currency VRP are repeated from Table X to help comparison. As in the first sample, there is a predictive power of the Global currency VRP and PPP. Furthermore, the significance and adjusted R^2 of the Currency VRP are stronger.

Moving further, I estimate a multivariate regression specification similar to equation (6), but now with no overlapping:

$$R_t = \alpha + \beta_1 CVRP_{t-1} + \beta_2 R_{t-1} + \beta_3 PPP_{t-1} + \beta_4 \Delta i_{t-1} + \varepsilon_t \quad (7)$$

Table XII confirms the strong predictive power of Global currency VRP and PPP. No matter the way we group the currencies, they have always statistically significant coefficients. Overall, each percentage point of the VRP lead to an additional 0.16% weekly return. Results are again stronger for Latin America and weaker for Europe.

The interest rate differential coefficient is negative in all groups, but have some statistical significance only for Emerging Markets. As in results of the first sample presented on Section IV.4, coefficients of interest rate differentials are stronger when using control variables. Thus, it has again the sign predicted by the UIP accounting for a risk premium. Nevertheless, these coefficients are not statistically significant, except for Emerging Markets.

Table XI –Regressions with Control Variables

Pooled Returns	Coefficients				Adjusted R^2			
	ATM CVRP	Δi	PPP	Lag Ret	ATM CVRP	Δi	PPP	Lag Ret
Overall	0,15***	-0,01	0,004**	0,05	**6,5**	0,0	0,8	0,3
Developed	0,15***	-0,03	0,023**	0,03	**4,2**	0,1	1,2	0,1
Emerging	0,16***	-0,01	0,003***	0,05	**7,3**	0,0	0,8	0,3
Latin America	0,23***	0,03	0,003***	-0,03	**12,3**	0,1	1,0	0,1
Asia-Pacific	0,12***	-0,04	0,002*	0,10**	**6,9**	0,3	0,5	1,0
Europe	0,12***	-0,03	0,008**	0,03	**2,0**	0,1	0,7	0,1

*This table shows results of the univariate regressions $R_t = \alpha + \beta_1 X_{t-1} + \varepsilon_t$ where R is the one-week currency return (positive for appreciation of the currency and negative for appreciation of the USD) and X is one of four variables: ATM Global Currency VRP, depreciation of the PPP over current exchange rate, and interest rate differentials (Δi) and Lagged weekly Currency returns. The dependent variable is: first, the equally weighted currency returns of all currencies; second, the average return of currencies with equal weights grouped by Developed / Emerging markets, and by region: Latin America, Europe and Asia-Pacific. The independent variables are also an equally weighted average across all currencies, when data is available. Columns 1 to 4 show the point estimates for regressions with each variable, while columns 5 to 8 show the adjusted R^2. Coefficients significantly different from zero at 10%, 5% and 10% are marked with *, ** and ***, respectively. The implied volatility used for the currency VRPs calculation are the model-free. Currency VRPs use the forward approach. Options used for calculations have one-month expiration. Equity VRP uses daily returns, while Currency VRP uses 30-minutes returns, both for one-month moving window. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). The t-statistics are calculated using Hansen-Hodrick HAC with 2 lags. The sample period is from February 2003 to December 2014, with 622 weekly non-overlapping. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points. The maturity of the options is one week. The realized volatility is calculated based on 5-minute log-returns with one-week windows. Adjusted R^2 in bold are the highest for that dependent variable.*

Table XII –Regressions with Control Variables

Pooled Returns	Coefficients				t-statistics				Adjusted R^2
	Currency VRP - ATM	Δi	PPP	Lag Return	Currency VRP - ATM	Δi	PPP	Lag Return	
Overall	0,162	-0,056	0,006	0,034	***3,56***	-1,63	***3,43***	0,71	8,5
Developed	0,150	-0,038	0,025	0,033	***2,85***	-0,81	***2,52***	0,84	5,8
Emerging	0,167	-0,056	0,005	0,028	***3,91***	***-1,75***	***3,62***	0,53	9,5
Latin America	0,245	-0,020	0,004	-0,041	***3,17***	-0,64	***3,54***	-0,72	14,4
Asia-Pacific	0,130	-0,039	0,002	0,098	***3,38***	-1,19	***1,85***	***2,49***	9,3
Europe	0,123	-0,065	0,010	0,013	***3,35***	-1,51	***2,52***	0,33	3,4

This table shows results of the regression $R_t = \alpha + \beta_1 CVRP_{t-1} + \beta_2 R_{t-1} + \beta_3 PPP_{t-1} + \beta_4 \Delta i_{t-1} + \varepsilon_t$ where R is the weekly currency return (positive for appreciation of the currency and negative for appreciation of the USD), CVRP is the at-the-money Global Currency Volatility Risk Premium, PPP is depreciation of the Purchase Power Parity over current exchange rate, and Δi is the interest rate differential against the USD interest rate. The dependent variable is the average currency returns of all 30 currencies with equal weights; then the average returns of currencies with equal weights grouped by Developed / Emerging markets, and by region: Latin America, Europe and Asia-Pacific. Independent variables are an equally weighted average across all available currencies, for each variable. The first four data columns show the coefficients of the four independent variables. The following four columns show the respective t-statistics, and the last column show the Adjusted R^2. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). The t-statistics are calculated using Hansen-Hodrick HAC with 2 lags on Panels A and C. The sample period is from February 2003 to December 2014, with 622 weekly non-overlapping. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points. The maturity of the options is one week. The realized volatility is calculated based on 5-minute log-returns with one-week windows.

V.3 Long-Term Returns

Future returns on the previous sections consider a horizon of just one week. This section evaluates if the predictability survives to returns of longer horizons, still using the weekly sample. Regression specification (5) is used again, and now the return horizon T is set to vary from one to 30 weeks. In this setting, we have an overlapping structure. The independent variable is the ATM Global Currency VRP. Figure 1 shows the coefficients for the equal-weighted average returns. In order to keep comparability among the different return horizons, I have annualized returns by multiplying by $52/n$, where n is the return horizon in weeks.

The coefficients on Figure 1 decrease with the horizon almost monotonically. It is statistically significant with 95% confidence interval up to four months approximately. The pattern here is different from Equity VRP case of BTZ (2009), where the maximum effect is at three months horizon and then decreases. In the BTZ (2009) empirical application, predictability survives up to seven months with 95% confidence.

Figure 2 shows the Adjusted R^2 for the long-term regressions. The shape has a downward pattern, but it is quite noisy in the beginning. The adjusted R^2 starts above 6% and quickly drops, reaching values under 1% for horizons over 13 weeks. Overall, results suggests that the VRP effect on returns fades in a few months.

Figure 1 – Long-Term Regression Coefficients

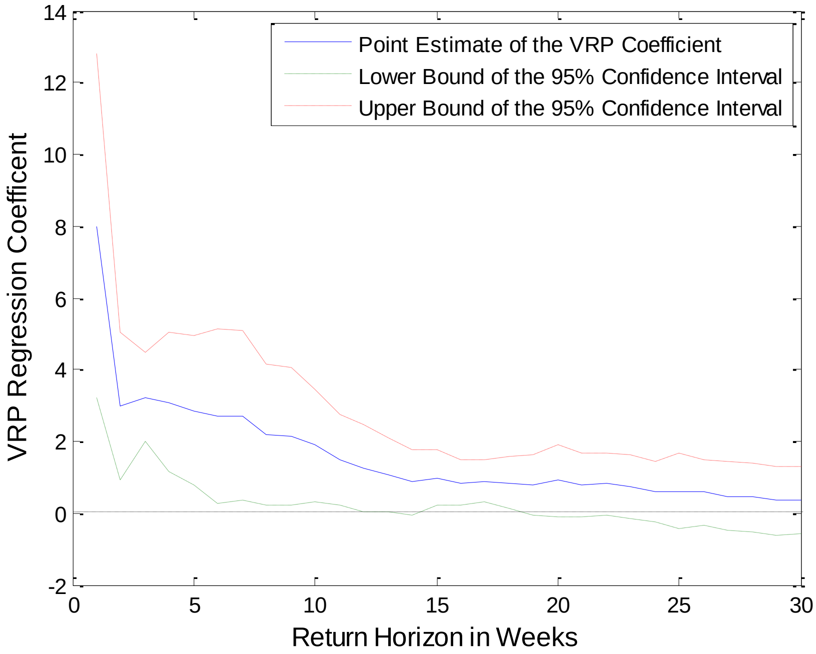
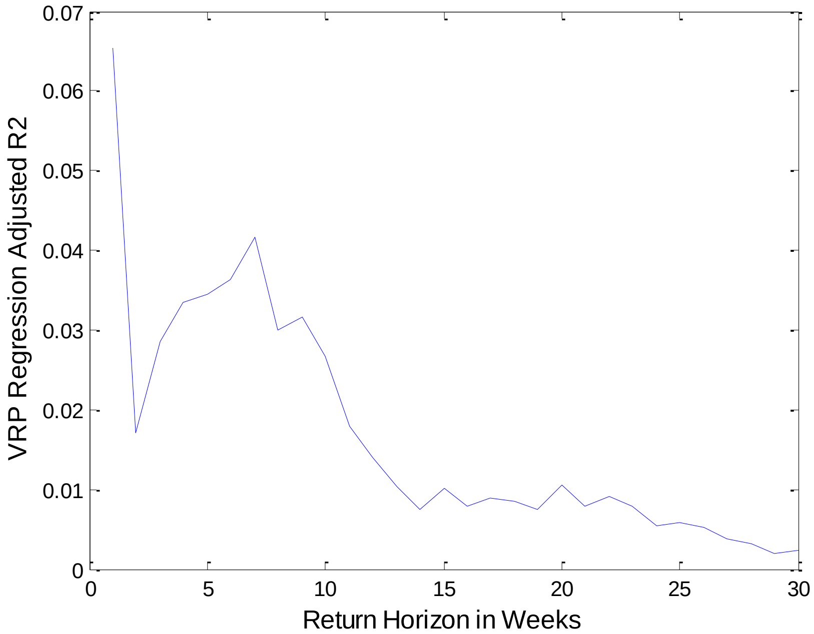


Figure 2 – Long-Term Regression Adjusted R^2



V.4 Out-of-sample Comparison with Random walk

In this section, I perform a pseudo-out-of-sample assessment of the predictors against a random walk benchmark using the framework of Diebold and Mariano (1995), as usual in the literature. It is worth mentioning, however, the comments of Diebold (2015) about the abuses of the Diebold-Mariano tests. Thus, this section should be viewed as an additional robustness test.

In this test, I use the weekly sample, since it has a longer period. The regressions are estimated based on a 3 to 5 years moving windows. The parameters estimated and the latest values of the variables at the end of the window are used to forecast one-week ahead returns. These forecasts are then compared with actual returns. The squared errors are used as penalty function, and a statistical test inspired on Diebold and Mariano (1995) is performed.

The regressions are the same of Table XI and XII, but now using a moving window of 3, 4 and 5 years rolled every week to estimate parameters. The return forecast is compared with the actual realization in the remaining years of the sample for each week. Then, the squared forecast errors are compared with those of a random walk forecast, i.e., a zero return forecast. The statistical inference is based on a time-series of the difference between the forecasted squared errors and random walk squared errors. This time-series is regressed on a constant. If this constant is statistically negative, the error of the regression is smaller than the random walk error, and so that variable shows a better predictive ability than the random walk.

Results can be seen on Table XIII. The Currency VRP regression, shown on the first column, has a MSE (mean squared error) always lower than the Random Walk, except for the European case using a three-year window. However, this better performance is statistically significant only for Emerging Markets and Latin America. For the four-year window, it is also statistically significant for the overall case.

In contrast, the other three variables – Interest Rate Differential, PPP and Lag returns – have always a higher MSE than the Random Walk when using 3 and 4 years windows (Panels A and B). In some cases, the random walk is even statistically better, especially for the PPP using three-year window.

Table XIII – Out-of-sample Tests against a Random Walk

Panel A - Three-Year Estimation Window										
Pooled Returns	**Differential MSE x 10^6 (Against Random Walk)**					**HH t-statistics (Against Random Walk)**				
	CVRP	**Δi**	**PPP**	**Lag Return**	**Full Model**	**CVRP**	**Δi**	**PPP**	**Lag Return**	**Full Model**
Overall	*-5,18*	2,19	1,62	0,56	-1,18	*-1,43*	*1,55*	***2,72***	0,71	-0,29
Developed	-2,23	2,24	3,19	0,98	5,44	-0,60	***1,98***	***1,93***	*1,14*	0,99
Emerging	-6,38	2,34	1,12	0,42	-2,44	***-1,73***	*1,31*	***2,03***	0,56	-0,58
Latin America	-17,90	1,76	1,36	0,55	-10,51	***-3,14***	*1,21*	***2,24***	0,62	***-2,21***
Asia-Pacific	-3,33	1,10	1,91	0,39	-0,95	*-1,05*	1,51	***5,77***	0,77	-0,42
Europe	1,39	4,60	1,21	1,20	9,74	0,41	***1,80***	0,68	0,93	*1,43*
Panel B - Four-Year Estimation Window										
Polled Returns	**Differential MSE (x 10^6)**					**HH t-statistics**				
	CVRP	**Δi**	**PPP**	**Lag Return**	**Full Model**	**CVRP**	**Δi**	**PPP**	**Lag Return**	**Full Model**
Overall	*-6,62*	1,19	1,34	0,57	-4,60	***-1,95***	*0,92*	*1,43*	0,30	-1,30
Developed	-5,00	1,70	0,59	0,68	-0,87	-1,49	*1,37*	*1,12*	*0,65*	0,44
Emerging	-7,43	1,02	1,32	0,52	-5,24	***-2,13***	*0,84*	*1,36*	0,24	-1,34
Latin America	-18,74	0,89	1,99	0,89	-15,01	***-3,01***	*1,17*	*0,76*	0,65	***-3,18***
Asia-Pacific	-4,15	0,97	1,07	0,26	-3,48	*-1,45*	1,31	***4,15***	0,31	-1,45
Europe	-0,89	2,83	0,90	1,14	0,73	-0,59	*1,23*	0,05	0,61	*0,51*
Panel C - Five-Year Estimation Window										
Pooled Returns	**Differential MSE (x 10^6)**					**HH t-statistics**				
	CVRP	**Δi**	**PPP**	**Lag Return**	**Full Model**	**CVRP**	**Δi**	**PPP**	**Lag Return**	**Full Model**
Overall	*-6,37*	0,03	0,07	-0,19	-4,69	*-1,49*	*0,93*	*1,16*	0,78	-1,06
Developed	-4,22	0,72	0,52	0,09	-3,23	-1,08	*1,31*	*0,24*	*1,03*	-0,15
Emerging	-7,46	-0,11	-0,38	-0,32	-6,03	***-1,68***	*0,75*	*1,17*	0,66	-1,17
Latin America	-10,47	-0,15	-0,46	0,01	-11,08	***-2,14***	*0,86*	***1,62***	1,03	***-2,07***
Asia-Pacific	-4,15	0,19	0,07	0,17	-4,54	*-1,06*	**1,65**	***2,21***	0,56	-1,17
Europe	-3,71	0,24	0,89	-0,41	-0,84	-0,25	*1,21*	0,23	1,02	*0,13*

This table shows results for an out-of-sample assessment. In a first step, four univariate models and one multivariate are estimated using a weekly rolling estimation window of 3, 4 and 5 years, respectively on Panels A, B and C. The univariate regressions are $R_t = \alpha + \beta_1 X_{t-1} + \varepsilon_t$ where R is the one-week currency return (positive for appreciation of the currency and negative for appreciation of the USD) and X is one of four variables: ATM Global Currency VRP, depreciation of the PPP over current exchange rate, and interest rate differentials (Δi) and Lagged weekly Currency returns. The multivariate model is $R_t = \alpha + \beta_1 CVRP_{t-1} + \beta_2 R_{t-1} + \beta_3 PPP_{t-1} + \beta_4 \Delta i_{t-1} + \varepsilon_t$. The dependent variable R is the average currency returns of all 30 currencies with equal weights; then the average returns of currencies with equal weights grouped by Developed / Emerging markets, and by region: Latin America, Europe and Asia-Pacific. Independent variables are an equally weighted average across all available currencies, for each variable. On the second step, the realization of the independent variables on the last day of the window is used to forecast the return R one week ahead. Then, a time-series of the squared difference between the forecasted returns and actual returns is built to represent squared errors of the model. The Random walk error is calculated as the squared returns. The differential Squared Errors time-series is built by subtracting the random walk squared error from the model's squared error time-series. This differential Squared Errors time-series is then regressed over a constant. The first five columns on the left show the point estimate of this regression, while the following five columns show the Hansen-Hodrick t-statistics, with 52 lags. The sample period is from February 2003 to December 2014. Returns are expressed in percentage points. The maturity of the options is one week. The realized volatility is calculated based on 5-minute log-returns with one-week windows.

If we consider the full multivariate model (equation 7), results are worse than the Currency VRP model alone. However, the full model is able to beat the Random Walk for the Latin America sample. Thus, it seems the other variables does not help the Currency VRP in prediction returns out-of-sample.

VI. Final Remarks

The empirical evidence throughout this paper provides support for a positive relationship of the currency VRP and future currency returns, i.e., a high VRP leads to future currency appreciation. The intuition is that, when risk aversion sentiment increases, the market quickly discounts the currency, and latter this discount is accrued, leading to currency positive returns over a month or even more time. Using the Global currency VRP (average VRP of all currencies) provides better results than regional or specific VRP, especially for emerging markets. Averaging across many currencies seems to reduce estimation error of individual currencies, giving robustness to the predictive ability. Future works may further investigate idiosyncratic and global factors of the VRP and currency returns.

The predictive ability of the VRP does not mean necessarily some sort of market inefficiency. The higher returns following a higher VRP can be seen as a compensation for a higher risk aversion, a higher perceived future risk, or both. Future studies can also evaluate the relationship of the currency VRP with other risk premium or risk aversion indicators in order to understand better the common motivations and co-movement among different risk sentiment drivers.

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VII. Appendix

This Appendix shows regressions using returns for each individual currency. Each table has an equivalent in the main text.

The overall picture using individual returns shows that over two thirds of the currencies can be forecasted by the Global Currency VRP. Regressions results using future individual currency returns as dependent variable and the Global Currency VRP based on ATM options as independent variable provided statistically significant positive coefficients for the returns of 22 of the 32 currencies in the first sample and 24 out of 30 in the second sample, even controlling for some traditional currency predictors.

Table A.I shows results currency by currency for regression (5) and it is the equivalent to Table IV of the main text. Both returns and VRP are from individual currencies. When using the backwards VRP, all but three currencies have coefficients significantly equal to zero. However, when we use the forward VRP, coefficients are mostly positive, and six of them are statistically greater than zero at 10% significance level. These positive coefficients are in line with the BTZ model prediction that a high (low) VRP leads to future positive (negative) returns.

The Adjusted R^2 of the forward approach is on average more than three times higher than the backward approach, although the values are low. For the forward VRP, adjusted R^2 is 3.11% on average, with developed markets having a higher average. The forward VRP adjusted R^2 is higher than the 1.07% found by BTZ for the S&P 500 using one-month returns, but lower than their results for 3-month returns.

It is interesting to point out that the so-called Commodities Currencies – AUD, CAD and NZD – have an adjusted R^2 for the forward VRP regressions higher than 7%, well above the average. The AUD point estimates for coefficients β_1 is around 0.24, meaning that every percentage point of the annual VRP increases future expected monthly returns in 0.24 percentage point.

Table A.II show the results with this Global Currency VRP and individual currency returns. The average adjusted R^2 is higher than those of Table A.I, for both forward (4.5% against 3.1%) and backward VRPs (1.1% against 0.9%). This improvement comes fundamentally for the Emerging Markets currencies, which increase from an average R^2

1.75% on Table A.I to 4.58% on Table A.II, for the forward VRP. For developed countries, the average R^2 remained almost the same, around 4.5%.

Regarding the sign and statistical significance of the coefficients, we have few changes to Table A.I. Now we have one more emerging market with predictability. Perhaps, this is an evidence that emerging currencies are more sensible to a global (systematic) VRP, while developed currencies have more idiosyncratic VRP sensibility.

Table A.I – Individual Volatility Risk Premium Regressions

Currency by Currency – Monthly Sample						
Individual Returns	Individual Volatility Risk Premium Model-Free, Backward			Individual Volatility Risk Premium Model-free, Forward		
	coefficient	t-statistics	adjusted R^2	coefficient	t-statistics	adjusted R^2
AUD	0,238	***1,65***	2,04	0,261	***2,47***	9,71
CAD	0,151	1,49	1,15	0,254	***2,15***	7,37
CHF	-0,190	-1,30	1,46	0,246	1,41	4,28
DKK	-0,043	-1,03	0,54	-0,018	-0,39	0,11
EUR	-0,116	-0,93	0,63	0,167	1,36	2,19
GBP	-0,222	-1,49	1,63	0,264	1,44	5,49
JPY	-0,116	-0,93	0,92	0,012	0,14	0,02
NOK	-0,060	-0,78	0,19	0,142	1,50	2,70
NZD	0,110	0,73	0,49	0,293	***2,62***	9,22
SEK	-0,028	-0,26	0,03	0,189	1,53	3,70
BRL	0,095	***2,77***	1,34	0,074	***1,83***	2,23
CLP	0,078	1,34	1,09	0,086	***1,97***	2,66
CZK	0,037	0,35	0,20	0,111	1,31	2,78
ILS	0,040	0,55	0,24	0,073	1,16	1,32
INR	0,066	1,30	0,67	0,031	0,63	0,28
MXN	0,018	0,30	0,10	0,032	0,66	0,79
MYR	-0,010	-0,30	0,05	-0,011	-0,32	0,07
PLN	-0,055	-0,41	0,36	0,065	0,51	0,87
TRY	0,025	0,32	0,09	0,107	1,54	3,15
ZAR	0,194	***3,31***	4,29	0,107	***2,29***	3,34
Mean			0,88			3,11
Dev Mean			0,91			4,48
EM Mean			0,84			1,75

This table shows results of the regression $R_{t,t+19} = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t$ using the individual VRP as regressor. The implied volatility used for the VRP calculation uses the model-free approach. On panel A, dependent variable R is the individual monthly (20 business days) returns of 20 currencies against the US Dollar. Only estimates for VRP coefficients are shown. Columns 1 to 3 show the point estimates, t-statistic and Adjusted R^2 for the individual Volatility Risk Premium calculated backwards. Columns 4 to 6 show the point estimates, t-statistic and Adjusted R^2 for the individual Volatility Risk Premium calculated forwards. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY) and South African Rand (ZAR). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days. The maturity of the options is one month.

Table A.II – Global Volatility Risk Premium Regressions

Currency by Currency – Monthly Sample						
Individual Returns	**Global Volatility Risk Premium Model-Free, Backward**			**Global Volatility Risk Premium Model-Free, Forward**		
	coefficient	**t-statistics**	**adjusted R^2**	**coefficient**	**t-statistics**	**adjusted R^2**
AUD	0,303	***1,64***	2,70	0,311	***2,16***	7,98
CAD	0,125	1,52	1,05	0,204	***2,16***	7,88
CHF	-0,103	-0,62	0,45	0,117	0,96	1,63
DKK	-0,020	-0,13	0,02	0,115	1,13	1,89
EUR	-0,023	-0,15	0,03	0,115	1,12	1,87
GBP	-0,092	-0,73	0,52	0,164	1,14	4,68
JPY	0,024	0,19	0,03	-0,091	-1,08	1,35
NOK	0,067	0,59	0,19	0,248	***2,19***	7,45
NZD	0,147	0,63	0,66	0,257	1,50	5,66
SEK	-0,031	-0,20	0,04	0,203	1,46	4,25
BRL	0,219	1,40	1,32	0,313	***2,77***	7,61
CLP	0,383	***3,53***	5,79	0,325	***3,55***	11,70
CZK	-0,152	-0,70	0,63	0,123	0,70	1,16
ILS	-0,146	-1,26	1,63	0,082	0,74	1,44
INR	0,145	***1,67***	1,41	0,126	***1,91***	3,00
MXN	0,062	0,37	0,16	0,168	1,14	3,37
MYR	0,016	0,21	0,03	0,092	1,59	3,34
PLN	-0,173	-0,62	0,66	0,163	0,69	1,63
TRY	0,119	0,81	0,51	0,232	1,46	5,43
ZAR	0,422	***2,59***	4,44	0,320	***2,19***	7,16
Mean			1,12			4,52
Dev Mean			0,57			4,47
EM Mean			1,66			4,58

This table shows results of the regression $R_{t,t+19} = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t$ using the global VRP (mean of all 20 VRP) as independent variable. The implied volatility used for the VRP calculation uses the model-free approach. On panel A, dependent variable R is the individual monthly (20 business days) returns of 20 currencies. On Panel B, dependent variable R is the equally weighted average returns of all 20 currencies, developed markets, emerging markets, Latin America, Asia-Pacific and Europe. Only estimates for VRP coefficients are shown. Columns 1 to 3 show the point estimates, t-statistic and Adjusted R^2 for the Volatility Risk Premium calculated backwards, and averaged across all currencies. Columns 4 to 6 show the point estimates, t-statistic and Adjusted R^2 for Volatility Risk Premium calculated forwards, and averaged across all currencies. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY) and South African Rand (ZAR). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days. The maturity of the options is one month.

Table A.III provides results for individual currencies equivalent to Table VI, which uses only ATM options. It uses individual currency returns as dependent variable. The independent variable is the individual VRP on the first three columns and the global VRP on the last three columns. Only the forward VRP approach is considered. For the individual VRP, the average adjusted R^2 is 2.65%, and five currencies have statistically significant β_1 coefficients.

For the Global VRP, results are very strong: only six currencies do not have statistically significant coefficients. From these six currencies, five are European. Thirteen currencies have statistically positive VRP coefficients. One statistically negative coefficient is found, for the Japanese Yen. In fact, the market considers the Japanese Yen a safe haven currency as documented in Botman et al (2013). One mechanism that can explain this behavior relates to carry trade. The yen is a common funding currency on carry trade operations. When risk sentiment increases investors sell the risky asset leg of the carry trade and buy back the Yen, pushing a Yen appreciation.

It is worth noting that, for emerging markets currencies, there is no doubt of the sign of the VRP coefficient: it is positive. Again, the improvement of going from individual VRP to a global VRP is much better from Emerging markets than for developed.

On table A.IV, the first two columns show the coefficients for the currency global VRP using model-free and ATM volatilities respectively. These regressions are the same of Tables V and VI, but now there are 12 more emerging markets currencies. Considering these additional currencies, respectively 11 and 20 coefficients are statistically significant for model-free and ATM volatilities. All these point estimates are positive, except for the Yen, which is statistically negative at 1% using the ATM volatility VRP.

The Equity VRP has also several significant coefficients: 14 out of 32. All point estimates are positive, again except for the Yen. Aloosh (2013) also finds positive coefficients for the equity VRP predicting currencies. The lag returns coefficients have lowest number of significant coefficients, with only two significant coefficients, one showing positive and the other negative autocorrelation. The PPP has the largest number of significant coefficients with 21 out 32 positive and significant. The positive estimates make sense since it means undervalued currencies tend to appreciate in the following month. The better results of PPP are led by European countries.

The interest rate differential shows negative coefficients in most of the cases, but with only four are statistically significant, all of them from developed countries. This negative signal is consistent with the UIP, since currencies with higher interest rates tend to depreciate in the following month. However, statistical evidence for the UIP in this univariate case is weak. Recall that empirical literature usually rejects the UIP (see Engel 1996 for an overview).

Table A.III – ATM Volatility Risk Premium Regressions

Currency by Currency – Monthly Sample						
Individual Returns	Individual Volatility Risk Premium ATM, Forward			Global Volatility Risk Premium ATM, Forward		
	coefficient	t-statistics	adjusted R^2	coefficient	t-statistics	adjusted R^2
AUD	0,183	***1,65***	4,31	0,313	***1,75***	4,67
CAD	0,283	***2,07***	5,36	0,258	***2,29***	7,24
CHF	0,321	1,64	5,47	0,136	1,01	1,25
DKK	-0,019	-0,26	0,05	0,116	0,87	1,10
EUR	0,230	1,07	1,96	0,116	0,86	1,10
GBP	0,367	***1,73***	6,64	0,303	***1,91***	9,18
JPY	-0,080	-0,73	0,64	-0,230	***-3,96***	5,02
NOK	0,126	0,89	1,28	0,335	***2,22***	7,83
NZD	0,276	***2,51***	6,63	0,368	***2,48***	6,69
SEK	0,243	1,55	3,44	0,303	***2,03***	5,43
BRL	0,095	***2,42***	2,25	0,418	***2,99***	7,82
CLP	0,094	1,31	1,38	0,344	***2,20***	7,55
CZK	0,134	1,48	2,62	0,212	1,37	1,98
ILS	0,131	1,07	2,32	0,208	***2,14***	5,38
INR	0,061	0,54	0,47	0,171	***1,94***	3,17
MXN	0,076	1,54	2,26	0,314	***2,12***	6,74
MYR	0,077	0,94	0,83	0,132	***2,44***	3,90
PLN	0,150	1,23	2,46	0,370	***1,87***	4,85
TRY	0,115	1,42	1,93	0,310	1,47	5,61
ZAR	0,056	1,14	0,66	0,273	1,26	3,01
Mean			2,65			4,98
Dev Mean			3,58			4,95
EM Mean			1,72			5,00

This table shows results of the regression $R_{t,t+19} = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t$ where the VRP is calculated using at-the-money (ATM) volatilities. On panel A, dependent variable R is the individual monthly (20 business days) returns of 20 currencies. On Panel B, dependent variable R is the equally weighted average returns of all 20 currencies, developed markets, emerging markets, Latin America, Asia-Pacific and Europe. Only estimates for VRP coefficients are shown. All results consider the Volatility Risk Premium calculated using the forward approach. Columns 1 to 3 show the point estimates, t-statistic and Adjusted R^2 for the individual Volatility Risk Premium. Columns 4 to 6 show the point estimates, t-statistic and Adjusted R^2 for the average Volatility Risk Premium calculated across all currencies. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY) and South African Rand (ZAR). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days. The maturity of the options is one month.

Table A.IV – Univariate Regressions of Control Variables

Currency by Currency – Monthly Sample

Indiv. Returns	Coefficients						Adjusted R^2					
	MF CVRP	ATM CVRP	Equity VRP	Δi	PPP	Lag Ret	MF CVRP	ATM CVRP	Equity VRP	Δi	PPP	Lag Ret
AUD	0,31**	0,31*	0,06	-0,49	0,04	0,11	**8,0**	4,7	2,1	1,3	3,9	1,1
CAD	0,20**	0,26**	0,05*	-0,44	0,11*	-0,12	**7,9**	7,2	3,7	0,5	5,4	1,5
CHF	0,12	0,14	0,06	-0,77	0,23*	-0,15*	1,6	1,3	2,5	1,1	**8,3**	2,2
DKK	0,12	0,12	0,04	-0,08	0,13**	-0,05	1,9	1,1	1,6	0,1	**4,7**	0,3
EUR	0,12	0,12	0,04	-0,58	0,35***	-0,05	1,9	1,1	1,6	1,5	**10,6**	0,3
GBP	0,16	0,30*	0,10**	-1,06**	0,19**	0,06	4,7	9,2	**11,6**	8,8	7,7	0,4
JPY	-0,09	-0,23***	-0,04	-0,70**	0,03	0,01	1,4	5,0	1,6	**5,8**	0,6	0,0
NOK	0,25**	0,34**	0,09**	-0,74	0,17***	0,03	7,5	**7,8**	6,5	3,6	6,3	0,1
NZD	0,26	0,37**	0,08	-1,15***	0,02	-0,03	5,7	6,7	3,1	**10,0**	2,7	0,1
SEK	0,20	0,30**	0,08*	-0,77*	0,13**	-0,02	4,2	5,4	4,7	3,1	**5,9**	0,0
BRL	0,31***	0,42***	0,09**	-0,09	0,05**	0,12	7,6	**7,8**	4,1	0,3	4,8	1,6
CLP	0,32***	0,34**	0,08**	0,25	0,04	0,10	**11,7**	7,5	4,9	0,6	2,7	0,9
CZK	0,12	0,21	0,06	-0,23	0,09**	-0,02	1,2	2,0	2,0	0,2	**6,2**	0,0
ILS	0,08	0,21**	0,06*	-0,29	0,08*	-0,02	1,4	**5,4**	4,9	1,2	3,4	0,0
INR	0,13*	0,17*	0,03*	-0,06	0,03**	0,01	3,0	3,2	1,4	0,4	**5,6**	0,0
MXN	0,17	0,31**	0,07**	-0,16	0,09*	0,08	3,4	6,7	4,2	0,3	**9,4**	0,6
MYR	0,09	0,13**	0,03	-0,04	0,01	0,00	3,3	**3,9**	1,9	0,1	1,3	0,0
PLN	0,16	0,37*	0,10	-0,42	0,06*	0,07	1,6	4,8	4,0	1,0	**4,9**	0,5
TRY	0,23	0,31	0,07	0,03	0,04	0,03	5,4	**5,6**	3,6	0,1	4,5	0,1
ZAR	0,32**	0,27	0,06	0,18	0,03*	0,04	**7,2**	3,0	1,6	0,7	4,2	0,1
BGN	0,12	0,12	0,04	-0,05	0,11***	-0,05	1,9	1,1	1,6	0,1	**13,6**	0,3
COP	0,11	0,08	0,01	-0,15	0,03	0,13	1,4	0,4	0,1	0,5	**3,8**	1,7
HUF	0,11	0,08	0,01	0,12	0,10**	0,13	1,4	0,4	0,1	0,6	**8,7**	1,7
IDR	0,35*	0,47**	0,10	0,19	0,01	0,07	17,2	**17,6**	8,3	0,9	2,5	0,5
ISK	0,35*	0,42	0,14*	-0,14	0,11***	0,02	7,7	6,4	7,2	1,6	**10,7**	0,1
KRW	0,34**	0,43***	0,09**	0,00	0,05	-0,06	**10,8**	9,9	4,6	0,0	3,9	0,4
PEN	0,05	0,09***	0,02*	-0,11	0,01	0,16*	1,4	**2,7**	1,7	0,7	2,4	2,6
PHP	0,05	0,08*	0,02*	-0,03	0,02	0,06	1,7	1,9	1,5	0,1	**3,2**	0,3
RON	0,08*	0,11**	0,03	0,03	0,01	0,02	**3,0**	3,0	2,1	0,1	0,7	0,1
RUB	0,08	0,19	0,05	-0,08	0,06***	0,01	0,7	2,1	1,9	0,6	**8,9**	0,0
SGD	0,00	0,16	0,06*	-0,05	0,06***	0,17	0,0	1,7	3,0	1,1	**9,3**	2,7
THB	0,09	0,12**	0,03*	0,11	0,03*	-0,05	3,6	**4,1**	3,8	0,2	3,3	0,3

*This table shows results of the univariate regressions $R_{t,t+19} = \alpha + \beta_1 X_{t-1} + \varepsilon_t$ where R is the one-month currency return (positive for appreciation of the currency and negative for appreciation of the USD) and X is one of six variables: model-free Global Currency Volatility Risk Premium (MF CVRP), at-the-money Global Currency Volatility Risk Premium (ATM CVRP), Lagged one-month, Equity (S&P 500) VRP, depreciation of the PPP over current exchange rate, and interest rate differentials (Δi). The regression is estimated for individual monthly returns of 32 currencies as dependent variable. Columns 1 to 6 show the point estimates for regressions with each variable, while columns 7 to 12 show the adjusted R^2. Coefficients significantly different from zero at 10%, 5% and 10% are marked with *, ** and ***, respectively. The implied volatility used for the currency VRPs calculation uses the model-free approach. The Equity VRP uses the VIX index as implied volatility. Both equity and currency VRPs use the forward approach. Options used for calculations have one-month expiration. Equity VRP uses daily returns, while Currency VRP uses 30-minutes returns, both for one-month moving window. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Bulgarian Lev (BGN), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), South Korean Won (KRW), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs and interest rates are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days.*

Table A.V show results for individual currency returns as depended variable, and four independent variables: at-the-money Global Currency Volatility Risk Premium (ATM CVRP), PPP and interest rate differentials (Δi) and lagged returns. This is equivalent of Table VIII of the main text, but with individual returns instead of grouped returns. The Currency VRP and PPP coefficient results show a similar picture of the univariate case. The currency VRP has now three more coefficients statistically positive, totaling 22 out of 32. Results are weaker for the interest rate differential, where only four currencies with negative significant coefficients. Lagged returns now have more coefficients with significance, all with negative coefficients, indicating a conditional negative autocorrelation.

Regarding the adjusted R^2, there are some commodities currencies like Canada and New Zealand with the highest values: above 20%. The predictive ability of Currency VRP seems good outside Europe. From the nine currencies that does not have statistically significant VRP coefficients, seven are European. Perhaps an explanation for this weak result in Europe is that the Euro is a reference for these currencies and not the US Dollar. In some cases, the existence of exchange rate regimes with floors against the Euro (like Swiss Franc and Czech Koruna) may cluster results towards the Euro case, which is not significant. Thus, further studies using exchange rates against the Euro is needed to uncover the low predictability of European currencies.

Table A.VI starts to show results for the weekly sample. In this set of regressions, equivalent to Table X of the main text, again there is support a positive relationship between VRP and future currency returns, and ATM volatilities providing better results than the model-free approach. When changing from the individual VRP (Table IX of the main text) to Global VRP (Table A.VI), the predictive power decreases for AUD, GBP and JPY, and increase for CAD, CHF and EUR.

Table VII shows univariate regressions for control variables with the weekly sample, and is equivalent to Table XI of the main text. Coefficients for the Global currency VRP and PPP are statistically significant at 10% for most of the currencies, while interest rate differential and lagged returns show very few significant coefficients. In the vast majority of the currencies, the Global currency VRP provide the highest adjusted R^2.

Table A.VIII shows currency by currency results for a multivariate model using the Global Currency VRP and three control variables: PPP, Lagged Returns and interest rate differentials. It is equivalent to Table XII of the main text, and confirms findings of Section IV, with 24 out of 30 Global currency VRP coefficients being statistically positive. The PPP has also many statistically positive coefficients: 22 out of 30. The interest rate differential has again negative coefficients, but with just a few having statistical significance. Regarding lagged returns, results are mixed. The Australian, New Zealand Brazilian and other commodities currencies show the highest Adjusted R^2.

Finally, Table A.IX shows results for the out-of-sample assessment using individual currency returns instead of grouped returns, and it is analogous to the Panel B of Table XIII, so that an estimation window of 4 years is used. While in the grouped returns evaluation the Latin American and Emerging Markets currencies perform better, when we turn to individual returns currencies from developed markets shows stronger results. Nine out of ten developed currencies have lower MSE for the VRP model than a Random Walk, with five of them statistically significant. On the other hand, for Emerging Markets currencies only half of the currencies are able to beat the Random Walk. This is consistent with a view that the idiosyncratic component of Emerging Markets is hard to forecast, while the common component is easier. For developed markets, an individual analysis seems to provide better results

Table A.V – Regressions with Control Variables

Currency by Currency – Monthly Sample

Individual Returns	Coefficients				t-statistics				Adjusted R^2
	Currency VRP - ATM	*Δi*	PPP	Lag Return	Currency VRP - ATM	*Δi*	PPP	Lag Return	
AUD	0,39	-0,05	0,05	-0,01	***2,20***	-0,09	***1,77***	-0,04	10,8
CAD	0,45	-0,65	0,09	-0,32	***2,93***	-1,57	1,41	***-2,81***	22,0
CHF	0,23	-0,54	0,21	-0,14	***1,76***	-1,19	1,61	***-1,78***	12,7
DKK	0,14	0,25	0,14	-0,05	1,07	0,56	***1,73***	-0,53	6,4
EUR	0,16	-0,12	0,35	-0,01	1,21	-0,21	***2,83***	-0,12	12,8
GBP	0,28	-0,44	0,11	-0,08	***1,71***	-0,78	1,34	-0,90	16,0
JPY	-0,19	-0,57	0,00	-0,08	***-3,61***	***-2,46***	0,04	-0,70	8,8
NOK	0,39	-0,52	0,17	-0,11	***2,77***	-1,50	***3,36***	-1,17	17,6
NZD	0,44	-1,20	0,03	-0,21	***2,81***	***-2,90***	***1,69***	***-2,37***	22,7
SEK	0,35	-0,45	0,11	-0,11	***2,28***	-1,22	***1,71***	-1,26	13,1
BRL	0,47	-0,05	0,06	0,00	***3,41***	-0,44	***3,00***	0,04	14,9
CLP	0,41	0,12	0,05	-0,03	***2,86***	0,28	***3,74***	-0,36	12,8
CZK	0,19	-0,01	0,09	-0,01	1,31	-0,02	***2,00***	-0,10	7,7
ILS	0,24	-0,31	0,06	-0,08	***2,03***	-1,60	1,24	-0,83	10,2
INR	0,20	-0,05	0,03	-0,04	***2,73***	-0,91	***2,57***	-0,53	9,7
MXN	0,26	-0,38	0,09	0,01	***2,40***	-1,17	***2,03***	0,19	16,0
MYR	0,17	-0,02	0,02	-0,08	***2,88***	-0,12	0,98	-0,85	6,5
PLN	0,33	-0,74	0,06	0,00	1,59	***-2,68***	***1,91***	0,02	11,3
TRY	0,37	0,08	0,04	-0,10	***1,81***	0,79	1,51	-1,20	10,5
ZAR	0,43	-0,02	0,04	-0,08	***1,77***	-0,13	***2,19***	-0,79	9,5
BGN	0,18	0,01	0,11	-0,02	1,40	0,04	***3,99***	-0,19	16,0
COP	0,13	-0,78	0,07	0,10	1,09	***-2,07***	***3,49***	0,92	13,3
HUF	0,08	-0,06	0,12	0,18	0,65	-0,48	***2,90***	1,45	12,9
IDR	0,55	0,07	0,01	-0,12	***2,28***	0,29	1,62	-0,68	23,5
ISK	0,49	-0,14	0,11	-0,12	***1,84***	-1,11	***3,08***	-0,77	19,4
KRW	0,66	-0,14	0,05	-0,28	***5,24***	-0,70	1,47	***-2,05***	21,2
PEN	0,09	0,04	0,02	0,15	***2,02***	0,27	1,52	1,54	7,8
PHP	0,09	-0,01	0,02	0,01	***1,79***	-0,11	1,50	0,09	6,1
RON	0,14	-0,02	0,01	-0,05	***2,33***	-0,19	1,06	-0,39	4,5
RUB	0,13	-0,02	0,06	0,01	1,04	-0,14	***2,59***	0,09	10,1
SGD	0,02	-0,06	0,07	0,17	0,10	-1,44	***4,47***	1,31	14,7
THB	0,15	0,15	0,04	-0,14	***2,51***	0,51	***1,82***	-1,17	10,6

*This table shows results of the multivariate regressions $R_{t,t+19} = \alpha + \beta_1 \boldsymbol{X_{t-1}} + \varepsilon_t$ where R is the one-month currency return (positive for appreciation of the currency and negative for appreciation of the USD) and **X** is a vector of four variables: at-the-money Global Currency Volatility Risk Premium (ATM CVRP), depreciation of the PPP over current exchange rate, and interest rate differentials (Δi). The regression is estimated for individual monthly returns of 32 currencies as dependent variable. Columns 1 to 6 show the point estimates for regressions with each variable, while columns 7 to 12 show the adjusted R^2. Coefficients significantly different from zero at 10%, 5% and 10% are marked with *, ** and ***, respectively. The implied volatility used for the currency VRPs calculation uses the model-free approach. VRP uses the forward approach. Options used for calculations have one-month expiration. Realized volatility is based on 30-minutes returns with one-month moving window. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Zloty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Bulgarian Lev (BGN), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), South Korean Won (KRW), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). The t-statistics are calculated using Hansen-Hodrick HAC with 21 lags. The sample period is from October 2007 to August 2014, with 1809 daily observations. VRPs and interest rates are expressed on an annualized basis in percentage points. Returns are expressed in percentage points for 20 business days.*

Table A.VI – Global VRP Regressions

Currency by Currency - Weekly Sample						
Individual Returns	Global Volatility Risk Premium Model Free, Forward			Global Volatility Risk Premium ATM, Forward		
	coefficient	t-statistics	adjusted R^2	coefficient	t-statistics	adjusted R^2
AUD	0,163	***2,96***	6,19	0,461	***3,18***	16,33
CAD	0,068	***3,54***	2,20	0,208	***2,81***	6,83
CHF	0,000	-0,01	0,00	0,037	0,78	0,17
EUR	0,015	0,67	0,10	0,088	***1,98***	1,18
GBP	0,014	0,79	0,09	0,120	***2,31***	2,31
JPY	-0,053	***-1,89***	1,19	-0,184	***-3,58***	4,76
DKK	0,014	0,65	0,09	0,088	***1,99***	1,16
NOK	0,036	1,23	0,38	0,184	***3,24***	3,33
NZD	0,110	***2,51***	2,74	0,354	***3,62***	9,41
SEK	0,008	0,26	0,02	0,105	***1,79***	1,05
BRL	0,121	***1,95***	3,10	0,357	***2,97***	8,88
CLP	0,111	***4,16***	4,07	0,287	***2,93***	8,99
COP	0,076	***2,98***	1,95	0,213	***3,22***	5,11
CZK	-0,003	-0,11	0,00	0,081	1,40	0,58
HUF	0,038	1,29	0,26	0,213	***2,74***	2,69
IDR	-0,001	-0,02	0,00	0,094	***2,25***	1,88
ILS	0,009	0,38	0,05	0,080	1,15	1,21
ISK	-0,061	-0,69	0,62	-0,032	-0,26	0,06
INR	0,030	***2,07***	0,81	0,123	***3,06***	4,49
MXN	0,085	***2,20***	2,88	0,276	***2,58***	9,94
MYR	0,019	1,12	0,53	0,081	***2,32***	3,21
PEN	0,013	1,57	0,39	0,041	***2,03***	1,23
PHP	0,016	1,09	0,36	0,090	***2,75***	3,66
PLN	0,052	1,13	0,52	0,284	***3,03***	5,21
RON	-0,003	-0,09	0,00	0,111	***2,51***	1,18
RUB	0,004	0,12	0,01	0,110	***2,54***	1,46
SGD	0,023	1,63	0,87	0,083	***3,05***	3,75
THB	-0,014	-1,52	0,32	-0,006	-0,26	0,02
TRY	0,085	***3,94***	1,68	0,309	***4,43***	7,42
ZAR	0,128	***4,55***	2,47	0,348	***3,79***	6,04
Mean			1,13			4,12
Dev Mean			1,30			4,65
EM Mean			1,04			3,85

This table shows results of the regression $R_t = \alpha + \beta_1 VRP_{t-1} + \varepsilon_t$. VRP is the Global Currency Volatility Risk Premium and is calculated as the average VRP of six currencies: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Euro (EUR), Japanese Yen (JPY) and Swiss Franc (CHF). The VRP is calculated using the forward approach. The Returns (R) are calculated on a weekly basis and expressed in percentage points. Dependent variables are the individual weekly returns of 30 currencies: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Zloty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). Constant coefficients estimates are omitted. Columns 1 to 3 show the point estimates, t-statistic and Adjusted R^2 for the Global Currency Volatility Risk Premium calculated using ATM volatilities. Columns 4 to 6 show the point estimates, t-statistic and Adjusted R^2 for the Global Currency Volatility Risk Premium calculated using model-free volatilities. The t-statistics are calculated using Hansen-Hodrick HAC with 2 lags. The sample period is from February 2003 to December 2014, with 622 weekly non-overlapping. VRPs are expressed on an annualized basis in percentage points. The maturity of the options is one week. The realized volatility is calculated based on 5-minute log-returns with one-week windows.

Table A.VII –Regressions with Control Variables

Indiv. Returns	Coefficients				Adjusted R^2			
	ATM CVRP	Δi	PPP	Lag Ret	ATM CVRP	Δi	PPP	Lag Ret
Currency by Currency - Weekly Sample								
AUD	0,46***	-0,01	0,012***	-0,03	**16,3**	0,0	1,0	0,1
CAD	0,21***	-0,01	0,015***	0,00	**6,8**	0,0	1,4	0,0
CHF	0,04	-0,01	0,033*	-0,01	0,2	0,0	**1,2**	0,0
EUR	0,09**	-0,03	0,018*	0,03	**1,2**	0,1	0,6	0,1
GBP	0,12**	-0,05	0,017***	-0,01	**2,3**	0,1	0,8	0,0
JPY	-0,18***	-0,02	0,000	-0,07	**4,8**	0,1	0,0	0,4
DKK	0,09**	-0,02	0,024**	0,02	**1,2**	0,0	0,9	0,1
NOK	0,18***	-0,06	0,027**	-0,03	**3,3**	0,3	0,8	0,1
NZD	0,35***	-0,18**	0,017**	-0,02	**9,4**	0,8	1,1	0,1
SEK	0,10*	-0,03	0,028**	-0,02	1,0	0,1	**1,1**	0,0
BRL	0,36***	0,03*	0,003***	-0,09	**8,9**	0,5	1,3	0,8
CLP	0,29***	0,00	0,006***	-0,05	**9,0**	0,0	1,0	0,2
COP	0,21***	0,00	0,002***	-0,04	**5,1**	0,0	0,7	0,1
CZK	0,08	-0,04	0,007**	0,04	0,6	0,1	**0,8**	0,1
HUF	0,21***	0,05	0,010**	-0,01	**2,7**	0,3	0,8	0,0
IDR	0,09**	0,03	0,001	0,21***	1,9	0,2	0,3	**4,2**
ILS	0,08	0,01	0,005**	-0,08*	**1,2**	0,0	0,4	0,6
ISK	-0,03	-0,06	0,010	-0,07	0,1	**0,6**	0,5	0,5
INR	0,12***	-0,03**	0,003***	0,14***	**4,5**	1,0	1,3	1,8
MXN	0,28***	0,06*	0,015**	-0,02	**9,9**	0,3	1,3	0,0
MYR	0,08**	-0,03*	0,001	0,01	**3,2**	0,5	0,1	0,0
PEN	0,04**	-0,01	0,001*	0,09	**1,2**	0,1	0,4	0,7
PHP	0,09***	-0,02	0,000	0,00	**3,7**	0,2	0,1	0,0
PLN	0,28***	-0,05	0,008*	-0,05	**5,2**	0,2	0,7	0,2
RON	0,11**	0,00	0,002*	-0,02	**1,2**	0,0	0,3	0,0
RUB	0,11**	-0,03***	0,002***	0,05	1,5	**1,7**	0,6	0,2
SGD	0,08***	0,00	0,002	0,05	**3,8**	0,0	0,4	0,3
THB	-0,01	-0,04*	0,001*	0,04	0,0	**0,6**	0,5	0,2
TRY	0,31***	0,02*	0,005*	0,00	**7,4**	0,7	1,0	0,0
ZAR	0,35***	0,06	0,011***	-0,04	**6,0**	0,3	1,5	0,2

*This table shows results of the univariate regressions $R_t = \alpha + \beta_1 X_{t-1} + \varepsilon_t$ where R is the one-week currency return (positive for appreciation of the currency and negative for appreciation of the USD) and X is one of four variables: ATM Global Currency VRP, depreciation of the PPP over current exchange rate, and interest rate differentials (Δi) and Lagged weekly Currency returns. The regression is estimated for individual monthly returns of 30 currencies as dependent variable. Columns 1 to 4 show the point estimates for regressions with each variable, while columns 5 to 8 show the adjusted R^2. Coefficients significantly different from zero at 10%, 5% and 10% are marked with *, ** and ***, respectively. The implied volatility used for the currency VRPs calculation are the model-free. Currency VRPs use the forward approach. Options used for calculations have one-month expiration. Equity VRP uses daily returns, while Currency VRP uses 30-minutes returns, both for one-month moving window. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). The t-statistics are calculated using Hansen-Hodrick HAC with 2 lags. The sample period is from February 2003 to December 2014, with 622 weekly non-overlapping. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points. The maturity of the options is one week. The realized volatility is calculated based on 5-minute log-returns with one-week windows.*

Table A.VIII –Regressions with Control Variables

Currency by Currency - Weekly Sample									
Individual Returns	**Coefficients**				**t-statistics**				**Adjusted R^2**
	Currency VRP - ATM	***Δi***	**PPP**	**Lag Return**	**Currency VRP - ATM**	***Δi***	**PPP**	**Lag Return**	
AUD	0,477	0,028	0,017	-0,028	***3,29***	0,47	***3,59***	-0,36	18,5
CAD	0,220	-0,084	0,019	-0,017	***3,00***	-1,56	***4,29***	-0,33	9,0
CHF	0,042	0,072	0,044	0,005	0,80	1,20	***1,88***	0,09	1,7
EUR	0,081	-0,027	0,016	0,027	***1,78***	-0,47	***1,64***	0,61	1,7
GBP	0,116	-0,023	0,015	-0,009	***2,19***	-0,43	***2,83***	-0,18	3,0
JPY	-0,184	-0,002	-0,002	-0,068	***-3,59***	-0,07	-0,29	-1,30	5,2
DKK	0,084	-0,015	0,023	0,024	***1,88***	-0,24	***2,12***	0,54	2,0
NOK	0,187	-0,058	0,024	-0,028	***3,37***	-1,19	***1,79***	-0,69	4,5
NZD	0,354	-0,207	0,025	-0,025	***3,64***	***-2,61***	***3,05***	-0,57	12,1
SEK	0,110	-0,032	0,028	-0,014	***1,85***	-0,71	***1,84***	-0,30	2,3
BRL	0,378	-0,013	0,005	-0,106	***3,12***	-0,36	***2,33***	-1,63	12,1
CLP	0,298	-0,026	0,007	-0,040	***3,02***	-0,91	***3,17***	-0,63	10,8
COP	0,227	-0,027	0,003	-0,034	***3,43***	-0,68	***3,51***	-0,39	6,6
CZK	0,087	-0,034	0,007	0,033	1,55	-0,65	***2,16***	0,68	1,6
HUF	0,203	0,032	0,008	-0,019	***2,71***	0,93	1,51	-0,36	3,4
IDR	0,114	0,014	0,001	0,221	***2,66***	0,34	***1,85***	***3,55***	7,3
ILS	0,086	0,003	0,006	-0,077	1,23	0,11	***1,84***	***-1,80***	2,4
ISK	-0,024	-0,064	0,011	-0,069	-0,24	-1,24	1,63	-0,96	1,8
INR	0,134	-0,030	0,002	0,132	***3,25***	***-1,67***	***1,93***	***2,57***	8,5
MXN	0,270	0,042	0,004	-0,018	***2,51***	1,11	0,70	-0,31	10,4
MYR	0,088	-0,041	0,000	0,007	***2,46***	***-2,15***	0,36	0,10	4,2
PEN	0,046	0,004	0,002	0,082	***2,27***	0,12	***1,86***	1,30	2,6
PHP	0,096	-0,038	0,001	-0,010	***2,90***	***-2,16***	***2,32***	-0,22	4,7
PLN	0,292	-0,109	0,009	-0,058	***3,15***	***-2,09***	***1,94***	-0,80	6,9
RON	0,116	-0,019	0,003	-0,025	***2,57***	-0,83	1,60	-0,59	1,8
RUB	0,143	-0,036	0,002	0,021	***3,35***	***-3,50***	***3,28***	0,19	4,5
SGD	0,087	0,003	0,004	0,056	***3,11***	0,09	***1,86***	1,07	4,8
THB	0,001	-0,027	0,001	0,037	0,03	-0,83	0,60	0,58	0,8
TRY	0,322	0,021	0,001	-0,026	***4,95***	1,59	0,42	-0,47	8,8
ZAR	0,350	-0,026	0,012	-0,051	***3,96***	-0,46	***2,67***	-0,88	7,8

This table shows results of the regression $R_t = \alpha + \beta_1 CVRP_{t-1} + \beta_2 R_{t-1} + \beta_3 PPP_{t-1} + \beta_4 \Delta i_{t-1} + \varepsilon_t$ where R is the weekly currency return (positive for appreciation of the currency and negative for appreciation of the USD), CVRP is the at-the-money Global Currency Volatility Risk Premium, PPP is depreciation of the Purchase Power Parity over current exchange rate, and Δi is the interest rate differential against the USD interest rate. The regression is estimated for individual weekly returns of 30 currencies as dependent variables. The first four data columns show the coefficients of the four independent variables. The following four columns show the respective t-statistics, and the last column show the Adjusted R^2. The currencies are: Australian dollar (AUD), British Pound (GBP), Canadian Dollar (CAD), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), New Zealand dollar (NZD), Norwegian Krone (NOK), Swedish Krona (SEK), Swiss Franc (CHF), Brazilian Real (BRL), Chilean Peso (CLP), Czech Koruna (CZK), Malaysian Ringgit (MYR), Mexican Peso (MXN), Israeli Shekel (ILS), Indian Rupee (INR), Polish Złoty (PLN), Turkish Lira (TRY), South African Rand (ZAR), Colombian Peso (COP), Hungarian Florint (HUF), Indonesian Rupiah (IDR), Icelandic Króna (ISK), Peruvian Sol (PEN), Philippine Peso (PHP), Romanian Leu (RON), Russian Ruble (RUB), Singapore Dollar (SGD) and Thai Baht (THB). The t-statistics are calculated using Hansen-Hodrick HAC with 2 lags. The sample period is from February 2003 to December 2014, with 622 weekly non-overlapping. VRPs are expressed on an annualized basis in percentage points. Returns are expressed in percentage points. The maturity of the options is one week. The realized volatility is calculated based on 5-minute log-returns with one-week windows.

Table A.IX – Out-of-sample Tests against a Random Walk

Individual Returns	Differential MSE x 10^6 (Against Random Walk)					HH t-statistics (Against Random Walk)				
	CVRP	*Δi*	PPP	Lag Return	Full Model	CVRP	*Δi*	PPP	Lag Return	Full Model
AUD	*-67,67*	5,08	3,39	27,17	-57,03	***-2,40***	**3,08**	1,19	**2,12**	**-2,53**
CAD	-13,29	1,97	2,08	5,50	-6,50	**-4,05**	1,50	0,74	**2,08**	**2,25**
CHF	3,86	3,21	2,40	2,80	11,16	**8,30**	**-3,04**	1,08	**7,01**	**6,31**
DKK	-0,11	1,50	0,97	2,60	3,31	-0,07	**2,14**	0,57	**2,21**	**-2,45**
EUR	*-1,74*	0,48	6,36	3,33	13,71	*-1,09*	**1,66**	**3,88**	**2,72**	**4,66**
GBP	-10,84	1,05	3,09	0,79	2,70	**-18,24**	0,93	-1,48	0,91	**-2,31**
JPY	-0,08	2,88	0,76	2,56	3,21	-0,05	**3,37**	0,53	**2,18**	**3,84**
NOK	-10,05	2,08	1,38	2,87	0,94	**-4,14**	0,70	0,43	**1,73**	-0,22
NZD	*-23,41*	-2,65	1,35	5,94	-23,63	***-6,26***	**1,98**	-0,67	**3,40**	**5,39**
SEK	2,84	2,88	2,60	3,83	9,45	-0,77	**-18,84**	**-1,76**	**4,01**	**-1,74**
BRL	-44,70	2,73	2,50	12,43	-27,81	**-2,69**	1,44	**-1,84**	**2,00**	-1,43
CLP	-29,61	7,10	4,06	8,32	-15,55	**-1,84**	**2,43**	**2,81**	**13,32**	-0,98
CZK	*-9,19*	4,88	4,85	9,52	5,65	***-5,08***	**-3,38**	**-4,48**	**2,97**	1,50
ILS	5,09	4,45	3,42	5,13	14,51	**1,97**	**2,54**	**-2,21**	**2,14**	**-2,21**
INR	-5,17	7,40	1,67	10,63	4,54	-1,20	**2,21**	0,34	**1,79**	1,59
MXN	-2,23	2,84	0,60	-5,68	10,84	**-2,24**	**2,10**	-0,55	**13,65**	**-2,13**
MYR	*4,25*	1,91	3,56	1,11	13,56	***1,90***	**-3,26**	**6,09**	1,40	**2,40**
PLN	40,27	7,56	30,37	27,20	93,64	**2,16**	**5,87**	**2,20**	**2,20**	**2,26**
TRY	-6,32	1,12	-1,90	-0,87	-1,51	**-9,43**	0,63	**-2,90**	1,25	-0,55
ZAR	-21,95	1,40	0,36	14,27	-12,08	**-6,06**	1,12	-0,20	**2,31**	**2,91**
BGN	*-2,25*	0,60	2,66	1,59	1,75	***2,24***	0,87	**5,87**	**5,00**	**-1,80**
COP	0,03	1,38	1,01	1,43	5,71	-0,16	**2,52**	**1,92**	**1,77**	1,61
HUF	-1,56	1,28	2,71	1,68	1,48	0,94	1,54	**1,72**	**5,76**	-0,99
IDR	-19,22	7,55	0,38	11,26	-6,98	**6,96**	**-14,11**	0,26	**2,02**	-0,94
ISK	*1,55*	2,33	-0,59	5,04	-1,00	*0,83*	1,58	**1,90**	**1,77**	-0,66
KRW	-11,58	0,44	8,06	8,23	1,50	-1,51	-0,59	1,49	**3,11**	0,18
PEN	-1,82	0,72	0,92	0,63	3,34	**5,32**	**-10,86**	**6,12**	**4,18**	**3,23**
PHP	0,82	0,59	0,48	0,95	1,76	**4,08**	**-9,97**	**5,72**	**2,22**	0,98
RON	*-25,51*	1,67	0,59	7,30	-10,91	***-4,43***	1,13	0,37	1,64	**-2,65**
RUB	-30,56	7,41	20,53	9,66	4,82	**6,43**	1,55	**4,03**	**1,98**	**-2,63**

This table shows results for an out-of-sample assessment. In a first step, four univariate models and one multivariate are estimated using a weekly rolling estimation window of 4 years. The univariate regressions are $R_t = \alpha + \beta_1 X_{t-1} + \varepsilon_t$ *where R is the one-week currency return (positive for appreciation of the currency and negative for appreciation of the USD) and X is one of four variables: ATM Global Currency VRP, depreciation of the PPP over current exchange rate, and interest rate differentials (Δi) and Lagged weekly Currency returns. The multivariate (full) model is* $R_t = \alpha + \beta_1 CVRP_{t-1} + \beta_2 R_{t-1} + \beta_3 PPP_{t-1} + \beta_4 \Delta i_{t-1} + \varepsilon_t$*. The dependent variable R is the individual currency returns against US Dollar. On the second step, the realization of the independent variables on the last day of the window is used to forecast the return R one week ahead. Then, a time-series of the squared difference between the forecasted returns and actual returns is built to represent squared errors of the model. The Random walk error is calculated as the squared returns. The differential Squared Errors time-series is built by subtracting the random walk squared error from the model's squared error time-series. This differential Squared Errors time-series is then regressed over a constant. The first five columns on the left show the point estimate of this regression, while the following five columns show the Hansen-Hodrick t-statistics, with 52 lags. The sample period is from February 2003 to December 2014. Returns are expressed in percentage points. The maturity of the options is one week. The realized volatility is calculated based on 5-minute log-returns with one-week windows.*