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by Steve Furnagiev and Josh R. Stillwagon
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J.E.L. Code: F31
Keywords: Exchange rates; risk premia; survey data; IKE gap model; moving average; CVAR
Subjective Currency Risk Premia and Deviations from Moving Averages

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Abstract: This paper examines the empirical performance of an alternative model of the currency risk premium. The model predicts that the premium on foreign exchange will depend positively on the gap between the exchange rate and its benchmark value. In this paper, we relate the benchmark not to relative prices but to a moving average process in accord with technical analysis. The model is tested against a novel data set of traders’ exchange rate forecasts, from 1986:08 to 2013:09, to measure the subjective, ex ante premium. This eliminates the need for a joint hypothesis of rational expectations and enables more direct focus on risk behavior. Using the Cointegrated VAR (CVAR), strong support is found for this hypothesis, as the exchange rate’s deviation from a one-year moving average is significant at the 1% level and forms a stationary cointegrating relationship with the premium for the four USD exchange rates examined (against the Swiss franc, Japanese yen, British pound, and Canadian dollar).

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1 Introduction

Explaining predictable foreign exchange returns remains one of the central challenges in international finance, branded the excess returns puzzle. This puzzle stems from the ubiquitous rejection of traditional risk premium models founded on the rational expectations hypothesis (REH) and expected utility theory (EUT). The crux of the problem is that the putative risk variables, such as consumption and asset supplies, are insufficiently variable therefore requiring implausible degrees of risk aversion (Engel, 1996; Mark, 2001). These models are also inconsistent with frequent sign reversals in the premium, or alternating periods when the premium is positive or negative in value (Mark and Wu, 1998; Lewis, 1995). This rejection of REH models has led to numerous studies which attribute excess returns to systematic and persistent forecasting errors (Mark and Wu, 1998; Gourinchas and Tornell, 2004; Bacchetta, Mertens, and van Wincoop, 2009). These models predict that one could make predictable profits, even risk-adjusted profits, simply by betting against the forward rate, which if valid would constitute severe market inefficiency. It is possible though that the problem may lie, also or instead, with the specification of risk preferences. Psychologists have in fact uncovered substantial evidence that the predictions of EUT are inconsistent with the behavior of actual individuals towards risky gambles (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992).

One of the chief obstacles to fully surmounting this excess returns puzzle is the joint hypothesis nature of most testing. It cannot be discerned whether the rejection of REH and EUT models derives from violations of REH, an inadequate specification of risk preferences, or both. One strand of the literature has exploited survey data on traders’ forecasts to decompose ex post returns into an expected component – representing the risk premium – and an unexpected component – representing the forecast error. Synthesizing this body of literature finds evidence that excess returns arise from non-REH forecasting and a time-varying risk premium. While this suggests a need to find an alternative to REH, as much of the literature has pursued, very few studies have examined the determinants of the time-varying risk premium found in survey data to illuminate market participants’ risk behavior. The lone studies to do so use data spanning only to 1997 (Frydman and Goldberg, 2007; Frydman, Goldberg, and Stillwagon, 2013). Since then, volume in the foreign exchange market has exploded from $1.53 Trillion in 1998 to $5.34 Trillion in 2013 (Bureau of International Settlements, 2013), a common currency was implemented in the Euroarea, and the world has undergone its greatest economic crisis in nearly a century. Given all of these dramatic, transformational occurrences, a major contribution of this study is to update those

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2 Some appeal to irrationality, for example noise-trading (DeLong et al., 1990; Mark and Wu, 1998) or overconfidence (Burnside et al., 2011). Others however suggest non-REH forecasting to be rational, for example through rational inattention (Bacchetta and van Wincoop, 2005), ambiguity aversion (Gourinchas and Tornell, 2004; Hut, 2012), complexity (De Graauwe and Grimaldi, 2006), or imperfect knowledge (Frydman and Goldberg, 2007).
initial analyses of the survey data risk premium with an extra approximately 15 years of data.

The survey data characterize three-month ahead forecasts surveyed monthly by FX4Casts from August 1986 to September 2013, and cover the spot US dollar exchange rate against the Japanese yen, Swiss franc, British pound, and Canadian dollar. The survey-based forecasts are collected from nearly 50 major financial institutions, and according to the 2013 BIS triennial report, these four currency pairs account for over a third of all FX transactions. The breadth of the survey and currency cross-section in this case provides an expansive analysis of currency risk premia. The use of subjective expected returns enables more direct focus on risk behavior, circumventing the need for a joint hypothesis about expectations formation. Survey data allows for myriad forecasting strategies, whatever they may be, from fundamentalist to chartist approaches and the incorporation of non-economic news and central bank announcements, which are inherently difficult to model.

This paper suggests that the empirical troubles of canonical models derive in part from a misspecification of the risk premium. We test a new model of risk assessment and supplement it with technical analysis. The imperfect knowledge economics (IKE) gap model of risk, due to Frydman and Goldberg (2003, 2007), relates the equilibrium premium not to the volatility of returns, but rather to the gap between the exchange rate and its historical benchmark value. The intuition is that as a currency becomes further overvalued, those betting on a continued appreciation (bulls) will become more concerned about the potential for a reversal and the losses it would generate. Bears meanwhile will respond in the contrary way, becoming more confident in a reversal and less worried about a further appreciation. This is similar to one of the specifications of risk preferences employed by De Grauwe and Grimaldi (2006) in their heterogeneous agent model, where fundamentalists become less risk averse as the currency moves further away from the fundamental value. It is also similar in nature to the crash risk of Brunnermeier, Nagel, and Pedersen (2009) where returns to the carry trade are positive on average, but subject to negative skew (or crash risk). The gap model suggests that traders assess the potential for a crash ex ante by looking to the deviation between the exchange rate and benchmark values. Whereas De Grauwe and Grimaldi examined this through simulations, and Brunnermeier, Nagel and Pedersen did so with ex post returns (therefore subject to the REH joint hypothesis), we will conduct testing against a novel data set of ex ante returns.

Another contribution here is to relate the benchmark in Frydman and Goldberg (2003, 2007) to a moving average, as opposed to relative prices. Observation of actual trading practices demonstrates that the use of technical analysis is endemic (Cheung, Chinn, and Marsh, 2004; Gehrig and Menkoff, 2006). Its presence in economic modeling however is far more sparse (Frankel and Froot, 1990; DeLong et al., 1990). The recent exceptions typically rely on some variant of simple extrapolative expectations (De Grauwe

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3The survey data requires manually correcting for asynchronous reporting of the forecast and spot rate. See appendix for a complete listing of institutions and for details on the timing correction.
and Grimaldi, 2006; Hommes, 2006). While the use of survey data allows us to circumvent the need for a joint hypothesis about the point forecasts of expectations – be it perfect foresight, adaptive or extrapolative – we instead assume (and test whether) traders are looking to the deviation or gap between the exchange rate and its recent levels (captured through a moving average process) to assess the risk of their speculative positions.

The estimation that follows applies the Cointegrated Vector Autoregression (CVAR), or Johansen method (Johansen, 1996; Juselius, 2006), to address unit roots in the data and to examine the nature of the Granger causation. Identification of the CVAR is achieved by imposing the risk adjusted no arbitrage conditions of the gap theory. This paper finds strong evidence in support of the hypothesis that the ex ante risk premium co-moves positively with the deviation between the exchange rate and its moving average. This gap measure possesses the hypothesized positive sign and is significant in each sample at the 1% level, forming a stationary cointegrating relationship with the risk premium. This suggests that traders look to the gap between the exchange rate and its moving average (or recent levels more generally) to assess potential losses to their speculative positions. Exogenous shocks to interest rates appear to Granger cause swings in the exchange rate, and adjustment back to equilibrium occurs through two channels: risk and expectations. Take for instance a shock to the domestic interest rate. This will induce an appreciation of the domestic currency as investors adjust their portfolio towards the now higher return. This appreciation will continue until the gap grows sufficiently large that traders are no longer willing to increase their positions due to the perceived elevated risk of a reversal following the recent upswing. There is also evidence that traders will eventually expect partial or gradual reversals consistent with the Dornbusch overshooting model (1976).

2 Price Swings and Perceptions of Risk

Despite the fact that the standard models have not been tested against survey measures of the risk premium, there is reason from the outset to believe we may need an alternative. The standard models are founded upon expected utility theory (EUT), and there is much experimental evidence that the predictions of EUT are inconsistent with the behavior of actual individuals towards risky gambles (Kahneman and Tversky, 1979). Prospect theory uses these findings to develop a more accurate, descriptive theory of risk preferences.

Frydman and Goldberg (2003, 2007) adapt these insights to specify risk preferences in their model, where individuals receive much greater disutility from a loss than utility from an equal magnitude gain, with diminishing sensitivity in both domains. The risk premium for bulls and bears depends then on

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4Burnside et al. (2011) suggest that excess returns can be rationalized if “peso states”, i.e. losses from carry trades, are weighted more heavily.
their forecasts of the potential loss from their speculative positions.

There is an inherent difficulty in applying prospect theory to financial markets however. Even if we know individuals are loss averse, we have to say something about how they forecast the potential for loss in real world markets, where the probabilities are not given as they are in experiments. We need to connect the forecasted potential for loss to some observable fundamental variable(s). This additional difficulty accounts perhaps for prospect theory's rather limited application to financial markets, despite the great prominence of the theory itself.\(^5\)

The IKE gap model overcomes this difficulty by applying a lost insight of Keynes (1936), examined by Tobin (1958) and then largely overlooked by the discipline. In discussing liquidity preference, or the reason individuals may prefer to hold cash over interest bearing bonds, Keynes remarked:

\[
\text{unless reasons are believed to exist why future experience will be very different from past experience, a rate of interest \[\text{much lower than the benchmark rate},\] leaves more to fear than to hope, and offers, at the same time, a running yield which is only sufficient to offset a very small measure of fear \[\text{of capital loss}\] (Keynes, 1936, p.202).}
\]

Frydman and Goldberg draw from this and model the risk premium as a function of asset price swings. As the price increases, bulls will become more worried about the potential for and possible magnitude of a reversal, and will increase their forecast of the potential for loss. Consequently, they will demand a greater premium to increase or maintain their long positions all else equal. Meanwhile bears will become less concerned about a further movement away, lowering their forecasted potential loss and required premium. Both the effects for bulls and bears will act to increase the aggregate premium.\(^6\)

Keynes emphasized though that:

\[
\text{What matters is not the absolute level of } r \text{ but the degree of its divergence from what is considered a fairly safe level of } r.
\]

In determining what is a fairly safe level, Keynes felt individuals would rely on what is in truth a convention, of basing this assessment on the historical record and the recent past “\[\text{unless reasons are believed to exist why future experience will be very different from past experience}\]” and that following changes in the level of the asset price, eventually “having become accustomed to each successive reduction” the demand function of the public would adjust to viewing the recently prevailing level as safe. Consequently,

\(^5\)Benartzi and Thaler (1995) and Barberis, Huang, and Santos (2001) use aspects of prospect theory (PT). The latter for example supplements PT with the house-money effect of Thaler and Johnson (1990), though it does not incorporate the diminishing sensitivity of PT and combines it with risk aversion to produce limits to speculation.

\(^6\)De Grauwe and Grimaldi (2006) use a similar specification of the risk premium in some variants of their behavioral model, where fundamental traders become less risk averse the further the exchange rate has moved away from its fundamental value. It is also similar to Brunnermeier, Nagel, and Pedersen (2009) view that excess returns are related to “downside” crash risk, here with the elaboration that individuals assess this risk by looking to the “gap” from benchmark values.
after an increase in the exchange rate for example, the effect on the premium will be temporary, gradually subsiding as individuals become accustomed to this higher valuation and begin to view it as the “new normal”. This type of dynamic can be captured by measuring the gap as the deviation from a moving average, as this study will do. Surveys of FX participants reveal that the use of technical analysis is ubiquitous (Cheung, Chinn, and Marsh, 2004; Gehrig and Menkoff, 2006). Despite this, such behavior is largely absent from exchange rate modeling.

The equilibrium condition implies an equilibrium between the premium and gap, which Frydman and Goldberg refer to as Uncertainty-adjusted UIP (UAUIP). Assuming a moving average for the benchmark, we have:

\[
s_{t+1|t} - s_t + i_t^{us} - i_t = \sigma(s_t - s_{MA,t-1}) + \rho_t
\]

The log exchange rate \( s_t \) is written here in terms of the domestic price of foreign currency. The left hand side represents the expected excess return, defined as the difference between the expected foreign and domestic returns. The expected foreign return is the foreign interest rate \( i_t^{us} \) plus any additional expected gain or loss arising from a change in the exchange rate \( s_{t+1|t} - s_t \), while the return on a domestic asset is simply the home interest rate \( i_t \). According to the simpler uncovered interest parity (UIP) condition, the expected foreign and home returns should offset each other in equilibrium. More generally, the expected excess return in equilibrium should be offset, or by definition equal to, a risk premium.

UAUIP posits that this risk premium is a function of the gap between the exchange rate and its benchmark value. A larger gap \( s_t - s_{MA,t-1} \) in this case requires a higher expected excess return in equilibrium. Alternatively, if there is an increase in the expected excess foreign exchange return, the foreign currency will appreciate, until it is far enough from recent levels to deter further speculative arbitrage. In other words, if for example \( i_t^{us} \) increases, \( s_t \) will be bid up through arbitrage until \( s_t - s_{MA,t-1} \) has grown sufficiently large to offset the expected excess returns, and to restore risk-adjusted equilibrium. Therefore we have a conception of endogenous risk, which provides limits to arbitrage at least in the near time. Eventually however, investors would grow accustomed to this new higher level and again be willing to arbitrage against the interest rate differentials. This behavior could account for the gradual exchange rate swings commonly documented, for example as described by the phenomena of delayed overshooting (Eichenbaum and Evans 1995) which would translate into predictable excess returns – i.e. the well-known forward discount anomaly of Bilson (1981) and Fama (1984).

The coefficient \( \sigma \) is derived from the underlying optimization problem, and is a reduced-form representation of how individuals map from the gap to the potential for loss; subsumed in \( \sigma \) are preference parameters and a weighting function between bulls and bears that are assumed constant. Other forms

\footnote{Exceptions incorporating chartist behavior include Frankel and Froot (1990) and De Graauwe and Grimaldi (2006).}

\footnote{For further details on the derivation of the model see (Frydman and Goldberg, 2007, 2013).}
of exogenous changes in the risk premium, for example related to government finances or changes in risk appetite, will be captured in $\rho_t$, representing the risk premium if the exchange rate is at a relevant moving average benchmark.

3 Data

The most novel component of the dataset is the survey forecast data from FX4Casts, $s^e_{t+1|t}$, which is provided monthly from 1986:08 to 2013:09. The forecasts are collected from nearly 50 major financial institutions (see appendix for a complete listing) and report their three-month ahead exchange rate forecasts. The aggregate forecast is reported as the geometric mean of the individual forecasts, to mitigate the influence of outliers. The spot exchange rate $s_t$ is manually collected to better coincide with the timing of the forecast reporting. The interest rates are three month Treasury bill rates to align with the forecast horizon. The information set is comprised of $x'_t = [s^e_{t+1|t} - s_t, i_t, i^{us}_t, gap_t]$ which denote respectively the expected change in the spot exchange rate (as measured by survey data), the domestic and foreign interest rates, and the gap which is measured as the difference between the exchange rate and its 12-month moving average $gap_t = s_t - s^MA_{t-1}$ where $s^MA_{t-1}=(s_{t-1} + s_{t-2} + \ldots + s_{t-12})/12$.

Interestingly, one year is the same time frame of evaluation which Barberis, Huang, and Santos (2001) found to be of relevance in their application of prospect theory to equity markets.

At this point it is useful to examine some of the basic comovements between our measures of the gap and premium for the four USD exchange rates examined (against the British pound, Canadian dollar, Japanese yen, and Swiss franc). Figure 1 examines the behavior of the spot exchange rate and its 12-month moving average. Recall that it is the difference between the two series in this figure which defines our gap measure (on the right y-axis in each panel), plotted against our measure of the premium based on survey data in Figure 2.

We can certainly discern a fair amount of positive co-movement between the expected excess return and the deviation between the spot rate and its 12-month moving average. There are of course some large aberrations, particularly during the zenith of the 2008 financial crisis for the BP/USD and CAD/USD, consistent with flight to quality effects leading to USD appreciation outside of expected returns. In other words, we are observing changes in the exogenous risk premium $\rho_t$, as opposed to changes in expected returns leading to endogenous changes in the risk premium through the gap. This flight to quality effect does not occur, at least to the same degree, for the JY and CHF, which likely were also viewed as safe haven currencies. We do however see Swiss franc appreciation and yen depreciation in the years following the financial crisis, outside of expected returns, consistent with the Swiss National Bank’s intervention.

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9The basic, qualitative results on cointegration and the positive and significant sign of the gap are robust to using 6 or 18 month moving averages as well.
Figure 1: The Spot Exchange Rate and its 12-month Moving Average.

Caption: Clockwise from upper left - BP/USD, CHF/USD, JY/USD and CAD/USD. The logged spot rate is featured in red, with its 12-month moving average in blue.

Figure 2: The Premium and Gap from Moving Average.

Caption: Clockwise from upper left are the BP/USD, CHF/USD, JY/USD and CAD/USD. Expected excess returns are featured in red and on the left y-axes, with deviations from the 12-month moving average in blue on the right y-axes in each panel.
and Japan’s turn to more expansionary policy under Abenomics. In addition to these large shocks outside of the UAUIP relationship, we see some sluggish or gradual adjustment of the exchange rate following changes in expected excess returns. The error-correction framework is ideal for examining this type of long-run equilibrium adjustment following shocks from multiple sources. It also looks like there are periods of literally years where the premium and gap are primarily either positive or negative in value. This persistence also motivates the need for a cointegration analysis.

4 Identification Approach

The estimation is conducted in the cointegrated vector autoregression (CVAR), also referred to as the Johansen method (1991; 1996). The CVAR model extends the error-correction model of Engle and Granger (1987) to allow for a systems approach with multiple, simultaneous cointegrating relations. The data is ordered in terms of the levels of persistence. The ECM for a VAR(2) model, i.e. including two lags, can be represented generically as:

$$\Delta x_t = \Gamma \Delta x_{t-1} + \Pi x_{t-1} + \mu_t + \varepsilon_t$$

The matrix is just a Granger causal reformulation of the covariances in the data, while $\Gamma$ represents the coefficients of the short-run dynamics. $\mu_t$ represents the deterministic components of the model (constant, trends, mean shifts, etc.), and $\varepsilon_t$ is an i.i.d. Gaussian error term.

If the variables in the information set are integrated of order 1, I(1), the unit roots or common stochastic trends imply that the matrix $\Pi$ is not full rank. When the matrix is reduced rank, it can be decomposed into an $\alpha$ and a $\beta^\prime$ vector. The $\beta^\prime$ vector describes the linear combinations of the variables which become stationary and can be interpreted as representing an equilibrium between the variables. The $\alpha$ vector meanwhile describes the error-correction mechanism indicating which variables are endogenous and adjust back to equilibrium following shocks, and the rate at which they do so. The CVAR is designed to allow the data to “speak freely” in terms of the rank (number of relationships in the information set), and the pulling and pushing forces of the system (which variables are error-correcting and which are weakly exogenous driving the equilibrium), rather than constraining the data from the outset with untested assumptions concerning the rank and causality.

A well-defined CVAR is one that satisfies the distributional assumptions of the underlying econometric theory. Ensuring this is the case often takes the form of controlling for outliers and structural breaks with the use of dummy variables and deterministic shifts respectively. A large number of significant outliers

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11 This term “speak freely” comes from Hoover, Johansen, and Juselius (2008). See also Hendry and Mizon (1993) for more on the general-to-specific methodology of the CVAR.
greater than 3.5 following the rule of thumb of Juselius (2006)) are present in each sample (listed in the appendix). We do however assess the sensitivity of our results by comparing them to estimates without the chosen dummy variables. It can be seen in the appendix that the basic qualitative results are still maintained for three of four samples, even in the absence of dummy variables for the largest outliers (Section 7.5).

The rank of the II matrix r, or number of cointegrating relations, can be determined using the trace test of Johansen (1991) and by looking at the large roots of the companion matrix. Results for the trace test and the roots of the companion matrix are displayed in the appendix. As is common, the criteria for rank decision are at times in conflict, with a choice of two often selected by the trace test. It is worth noting however that the rank test occurs under the joint hypothesis of no economic null. Intuition suggests, however, three sources of exogenous shocks: two would arise from the interest rates of each country ($i_t^{us}$ and $i_t^{it}$), which could be interpreted as shocks from monetary policy, and a third source would derive from autonomous changes in expectations $s_{t+1|t} - s_t$ that may be related to expectations about future interest rates or currency intervention. Appealing to the roots of the system does in fact support the intuition for three exogenous trends. The near unity roots, with moduli of approximately .85 or more following the rule of thumb in Juselius (2006), represent the p-r common stochastic trends where p is the number of variables included in the information set (here four). Consequently, we select a rank of one for each model.12

5 Testing for a Long-run Relationship between the Premium and Gap

Given the reduced rank restriction, the CVAR method allows us to test for hypothesized equilibrium relationships in the form of identifying, and over-identifying, restrictions on the $\beta'$ matrix. Identification and over-identification are achieved by imposing r-1 and r restrictions, respectively, on the cointegrating relationships. Here we impose two restrictions consistent with the no risk-adjusted arbitrage conditions of the gap theory. The first is a set of equal and opposite coefficients on foreign and domestic interest rates. The second imposes equality between the expected change in the log exchange rate and the foreign interest rate differential. These restrictions lead to the expected excess return on foreign exchange of $s_{t+1|t} - s_t + i_t^{us} - i_t$, wherein over-identification is achieved and both the standard errors and stationarity of the relationships can be estimated. There is a free coefficient on the gap variable hypothesized to be positive. $\rho_t$ represents the risk premium on foreign exchange if the gap is zero. This is captured primarily in the deterministic components which are sample dependent as described in the results. In some it is well approximated as a constant, in others it requires a mean shift, or broken trend. Other omitted risk

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12 The choice of rank = 1 can further be supported by the graphs of the cointegrating relationships. In each sample a possible, or candidate, second cointegrating relationship appears less stationary on the margin.
factors are further captured in the error term $\varepsilon_t$ which should be stationary if cointegration is present. The error term also captures measurement error in the survey data.

Restricted cointegrating relationships for all four data series are displayed in Table 1. It is worth noting, for proper interpretation of the coefficients, that the nature of the endogeneity for the system is determined within the CVAR. Thus all variables are initially treated as possible left hand side variables with only the error term on the right.

\[(s_{t+1}^e - s_t) + i_t^* - i_t - \sigma(gap_t) - \rho_t = \varepsilon_t \quad (3)\]

Table 1: Restricted Cointegrating Relationships – $\beta'$ matrix

<table>
<thead>
<tr>
<th></th>
<th>$(\Delta s^e + i^m - i)$</th>
<th>$s - s^M_{t,12}$</th>
<th>Constant</th>
<th>Trend</th>
<th>T(94:08)</th>
<th>C(04:01)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP/USD (1 1 -1)</td>
<td>-0.850</td>
<td>-0.010</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.320</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[-8.687]</td>
<td>[-1.923]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAD/USD (1 1 -1)</td>
<td>-0.069</td>
<td>0.007</td>
<td>-</td>
<td>-</td>
<td>-0.004</td>
<td>0.795</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[-4.208]</td>
<td>[8.891]</td>
<td></td>
<td></td>
<td>[-2.783]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JY/USD (1 1 -1)</td>
<td>-0.083</td>
<td>-</td>
<td>0.0004</td>
<td>-0.003</td>
<td>-</td>
<td>0.956</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[-2.887]</td>
<td>[3.940]</td>
<td></td>
<td></td>
<td>[-2.807]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHF/USD (1 1 -1)</td>
<td>-0.312</td>
<td>-0.006</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.649</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[-6.132]</td>
<td>[-1.963]</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

t-values in brackets. p-value for likelihood ratio test of the restricted model relative to unrestricted. T(94:08) and C(04:01) represent breaks in the trend and constant terms, in 1994:08 and 2004:01 respectively.

The primary testable implication derived from Equation 1 is the hypothesis that expected excess returns form an equilibrium relationship with a gap term, which itself proxies for a risk premium. The second primary hypothesis, which alludes to the behavioral implications of how participants perceive current levels as safe relative to a benchmark, posits that the gap measure of risk should enter positively into the equilibrium relationship. Recall that a participant who recognizes the tendency for reversals in swings becomes more conscious of upswings the larger and sharper they become. Table 1 shows that both hypotheses of UAUIP are satisfied within the data. In all four exchange rate series we find an economically and statistically significant risk premium using a 12-month moving average gap measure. The LR test of the over-identifying restrictions, represented by the p-values, are not rejected implying a stationary cointegration relationship which can be interpreted as an equilibrium relationship. The estimated p-values range from 0.320 to 0.956; strongly affirming of the cointegration null.

Although the basic qualitative results are robust across samples (namely the positive and significant sign of the gap and the stationarity of the resulting relationship with the premium) there is some notable variation across samples in terms of the deterministics and gap coefficient magnitudes. The CHF/USD and BP/USD are well-specified with simply a constant to represent the exogenous risk premium (implying the exogenous influences have been stationary if not constant). The CAD however requires a mean shift.
and the JY/USD a broken trend. This suggests that fluctuations in exogenous premium have been most 
significant in those samples particularly the latter. These may stem from trade effects, Canada being 
a commodity currency and Japan having run persistent trade surpluses. Japan’s results may also be 
connected to their unique experience over the last quarter century with a prolonged liquidity trap and 

Those two samples with the most evidence of extraneous influences on the premium also have the 
smallest estimated gap effects. The BP/USD has the largest effect, suggesting a 1% increase in the 
deviation from the moving average is associated with approximately a .85% increase in the premium. 
This contrasts with .31%, .8%, and .7% for the CHF, JY and CAD. It is worth noting that the estimates 
for the BP/USD and CHF/USD are much closer in the sensitivity analysis excluding dummy variables. 
A pattern seems to emerge in any event though where the largest gap coefficient estimates are associated 
with the two samples where the expected change in the exchange rate has the least evidence of error-
correction as seen in the following section.

5.1 Error-Correction: The Pulling Forces

There are several tests that combine to tell the story of endogeneity. First and foremost is the error 
correction component, displayed in Table 2. The error-correction documents which variables significantly 
adjust and how quickly they do so following shocks which create disequilibrium from the long-run rela-
tionships estimated in Table 1. Recall that the $\alpha$ vector is one of the decomposed components of $\Pi$ in 
Equation 2. If $\alpha\beta'$ < 0 for a given variable, it implies equilibrium correction. 
A significant coefficient also grants the respective variable the interpretation of being endogenous 
within the cointegrating relationship, while describing the proportion of the disequilibrium it makes up, 
or corrects for, within each (monthly) period. For example, in the CHF/USD sample we see significant 
error-correction in the gap, which means the gap makes up roughly 33% of the disequilibrium in each 
sample, while the expected change in the exchange rate corrects for another 20%. The adjustment of the 
gap is consistent with our endogenous model of risk, where a higher expected return leads to appreciation 
relative to recent levels which eventually deters further arbitrage. The adjustment of expectations implies 
some degree of expected mean reversion, though much less so in the BP/USD, which also helps to restore 
equilibrium (by lowering expected excess returns). This appears consistent with the overshooting model 
of Dornbusch (1976) where the exchange rate appreciates so much it is then expected to depreciate.

The combined adjustment factors for the CHF/USD sample imply a half-life of the disequilibrium 
of roughly one month, compared to estimates assuming PPP is the equilibrium value for the exchange 
rate which find half-lives in the range of approximately 3-5 years (Rogoff, 1996). This is a drastic 
improvement in characterizing foreign exchange market equilibrium as it relates to explaining observed 
exchange rate movements, compared to viewing PPP as the equilibrium. The JY/USD and BP/USD
Table 2: Error Correction – $\alpha$ matrix

<table>
<thead>
<tr>
<th></th>
<th>$\Delta s^e$</th>
<th>$\Delta (i^{us})$</th>
<th>$\Delta (i)$</th>
<th>$\Delta (s - s_{12}^{MA})$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BP/USD</strong></td>
<td>-0.043</td>
<td>0.0003</td>
<td>0.001</td>
<td>0.234</td>
</tr>
<tr>
<td></td>
<td>[-2.266]</td>
<td>[0.672]</td>
<td>[2.407]</td>
<td>[8.227]</td>
</tr>
<tr>
<td><strong>CAD/USD</strong></td>
<td>-0.790</td>
<td>-0.004</td>
<td>0.006</td>
<td>0.275</td>
</tr>
<tr>
<td></td>
<td>[-14.476]</td>
<td>[-1.648]</td>
<td>[2.042]</td>
<td>[2.756]</td>
</tr>
<tr>
<td><strong>JY/USD</strong></td>
<td>-0.462</td>
<td>-0.002</td>
<td>-0.003</td>
<td>0.243</td>
</tr>
<tr>
<td></td>
<td>[-8.809]</td>
<td>[-1.845]</td>
<td>[-3.652]</td>
<td>[2.758]</td>
</tr>
<tr>
<td><strong>CHF/USD</strong></td>
<td>-0.200</td>
<td>0.0003</td>
<td>-0.003</td>
<td>0.335</td>
</tr>
<tr>
<td></td>
<td>[-4.835]</td>
<td>[0.290]</td>
<td>[-2.844]</td>
<td>[5.089]</td>
</tr>
</tbody>
</table>

$t$-values in brackets.

series also suggest half-lives of between one to two months, and the CAD/USD less than one month. We do observe statistically significant movements away from equilibrium by the Swiss and Japanese interest rates, but they are of a very minute magnitude in both cases (-0.003).

To complement the results of the error correction components, Table 3 displays the results for tests of weak exogeneity. A variable is weakly exogenous if it is not adjusting to the error component of the cointegrating relationship. We can test for weak exogeneity of an individual variable by imposing a zero restriction on the alpha coefficient that corresponds with that variable. Table 3 suggests that different interest rates show signs of being weakly exogenous in all four data series. The null of weak exogeneity cannot be strongly rejected for the U.S. interest rate in any series, but is rejected for the foreign interest rate in the BP, JY and CHF samples. In addition, the expected change in the exchange rate also shows signs of exogeneity in the BP sample, which may portray a “Peso problem” type effect stemming from the UK’s fixed exchange rate under the European Monetary System, which eventually collapsed under speculative attacks in 1992. The exogenous interest rates in the US in particular embody a “leader follower” dynamic of monetary policy which seems sensible given the US role as the world reserve currency and largest economy. These results are nonetheless suggestive that interest rates and to a lesser extent an expectations component are responsible for much of the driving action within the system. This is a dynamic that coincides well with the choice of three common stochastic trends implied by a rank of one.
Table 3: Test for weak exogeneity

<table>
<thead>
<tr>
<th></th>
<th>(\Delta s^c)</th>
<th>(\Delta(i_{us}))</th>
<th>(\Delta(i))</th>
<th>(\Delta(s - s_{MA}^{12}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP/USD</td>
<td>1.991</td>
<td>0.376</td>
<td>6.565</td>
<td>37.488</td>
</tr>
<tr>
<td></td>
<td>[0.158]</td>
<td>[0.539]</td>
<td>[0.010]</td>
<td>[0.000]</td>
</tr>
<tr>
<td>CAD/USD</td>
<td>127.512</td>
<td>2.614</td>
<td>3.265</td>
<td>6.459</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td>[0.106]</td>
<td>[0.071]</td>
<td>[0.011]</td>
</tr>
<tr>
<td>JY/USD</td>
<td>49.992</td>
<td>2.763</td>
<td>10.633</td>
<td>4.389</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td>[0.096]</td>
<td>[0.001]</td>
<td>[0.036]</td>
</tr>
<tr>
<td>CHF/USD</td>
<td>14.372</td>
<td>0.002</td>
<td>6.834</td>
<td>15.203</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td>[0.969]</td>
<td>[0.009]</td>
<td>[0.000]</td>
</tr>
</tbody>
</table>

p-values in brackets. Null-hypothesis of weak exogeneity for individual variable.

5.2 Common Stochastic Trends: The Pushing Forces

Lastly, the alpha vector associated with error correction has a dual component, \(\alpha_\perp\), in the moving average representation of the CVAR. Dual because \(\alpha_\perp\) details the common stochastic trends or “pushing forces” that drive the equilibrium, which complement the “pulling” forces of the error correction back to equilibrium. Table 4 displays the \(p-r\), here 4-1=3, common stochastic trends of the system. We can see that the three trends derive from the two interest rates and autonomous fluctuations in expected changes in the exchange rate. Again these may be related to anticipations of future changes in the interest rates. There are some significant impacts from the gap term as well which would be associated with exogenous changes in the risk premium. The significant gap trends primarily coincide with the common stochastic trend from the expected change in the exchange rate, suggesting these autonomous expectational effects, outside of contemporaneous interest rates, stem in part from anticipations of changing risk attitudes. There is also evidence that the gap enters significantly in the trends associated with the UK and Swiss interest rates, which are both major financial centers, and with the trends for both interest rates in the yen sample, which likely reflects its prominent role in the carry trade.
6 Conclusion

This paper finds support for its main hypothesis that expected excess foreign exchange returns are offset by a risk premium associated with the deviation between the exchange rate and its recent levels, proxied here by a moving average. When expected excess returns increase, for example from a rise in one country’s interest rate, this leads to appreciation of that currency until it has appreciated so much relative to its recent levels that investors are deterred from further arbitrage. Eventually however, this new valuation is seen as safer, leading to further appreciation of the currency. This may account for the previously documented “delayed overshooting” phenomena (Eichenbaum and Evans, 1995), and the predictability of excess returns. There is also evidence however that expectations partially adjust, though the magnitude is small for the BP/USD, suggesting participants eventually expect mean reversion after an appreciation, similar to the Dornbusch (1976) overshooting hypothesis.

This narrative represents an endogenous form of risk which limits swings, as opposed to exogenous
changes in the risk premia which drives swings in the exchange rate. This study also provides direction for future research on the source of exogenous changes in the premium. A basic examination of the expected excess returns and the gap suggest that the exogenous changes in the premium have been primarily associated with flights to quality surrounding the financial crisis. There also appears to be a significant effect of currency intervention towards the end of the Swiss franc and yen samples as one might suspect. The results of this paper, which suggest a connection between price swings from recent levels and perceived risk, could complement a wide range of other exchange rate modeling approaches, from traditional models of risk to those which explain excess returns through market microstructure or various forms of non-REH forecasting. All of these could potentially benefit from appending a gap risk effect.
References


7 Appendix

7.1 Tables

Table 5: Trace Test

<table>
<thead>
<tr>
<th>p-r / rank (r)</th>
<th>4 / 0</th>
<th>3 / 1</th>
<th>2 / 2</th>
<th>1 / 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP/USD</td>
<td>0.000</td>
<td>0.002</td>
<td>0.487</td>
<td>0.487</td>
</tr>
<tr>
<td>CAD/USD</td>
<td>0.000</td>
<td>0.002</td>
<td>0.604</td>
<td>0.668</td>
</tr>
<tr>
<td>JY/USD</td>
<td>0.000</td>
<td>0.002</td>
<td>0.265</td>
<td>0.451</td>
</tr>
<tr>
<td>CHF/USD</td>
<td>0.000</td>
<td>0.001</td>
<td>0.016</td>
<td>0.750</td>
</tr>
</tbody>
</table>

Reported p-values for likelihood ratio test, with null hypothesis of rank r, H(r), against the alternative of full rank, H(p).

Table 6: Roots of companion matrix

<table>
<thead>
<tr>
<th>Modulus, H(r=4)</th>
<th>BP/USD</th>
<th>CAD/USD</th>
<th>JY/USD</th>
<th>CHF/USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root1</td>
<td>0.987</td>
<td>0.983</td>
<td>0.979</td>
<td>0.987</td>
</tr>
<tr>
<td>Root2</td>
<td>0.987</td>
<td>0.983</td>
<td>0.979</td>
<td>0.987</td>
</tr>
<tr>
<td>Root3</td>
<td>0.845</td>
<td>0.896</td>
<td>0.883</td>
<td>0.849</td>
</tr>
<tr>
<td>Root4</td>
<td>0.705</td>
<td>0.564</td>
<td>0.766</td>
<td>0.747</td>
</tr>
<tr>
<td>Root5</td>
<td>0.548</td>
<td>0.380</td>
<td>0.468</td>
<td>0.451</td>
</tr>
<tr>
<td>Root6</td>
<td>0.368</td>
<td>0.331</td>
<td>0.363</td>
<td>0.373</td>
</tr>
<tr>
<td>Root7</td>
<td>0.184</td>
<td>0.207</td>
<td>0.319</td>
<td>0.161</td>
</tr>
<tr>
<td>Root8</td>
<td>0.184</td>
<td>0.207</td>
<td>0.100</td>
<td>0.124</td>
</tr>
</tbody>
</table>

7.2 Contributors to FX4casts Consensus Forecasts


FX4casts (associated with Forecasts Unlimited) distributes their compilation of forecasts on the last Friday of each month. The corresponding spot rate they report is for the day prior. The survey questionnaires however are disseminated on the Wednesday of the week prior and responses are collected
from Wednesday-Monday with most of the responses coming in on Friday. The spot rate reported then
significantly lags that observed when the respondents are forming their forecasts. We correct for this by
manually using the spot rate from the second to last Friday of the month to better accord with the timing
of the forecast reporting. The results are robust to using the Wednesday or Thursday prior as well.

7.3 Dummy Variables

The model for the Swiss franc has dummy variables accounting for significant outliers in 1991:02, 1988:01,
1990:01, 2008:11, 1989:05, 1992:03, and 2007:08. The model for the British pound has dummy variables in
2008:03, 2008:09, 2008:10, 2008:12, 2009:05. The model for the Japanese Yen has dummy variables in

7.4 Multivariate Tests for Non-Stationarity

Table 7: Test for individual stationarity

<table>
<thead>
<tr>
<th></th>
<th>(r=1), DGF = 3, 5%CV = 7.815</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\Delta s^c)</td>
</tr>
<tr>
<td>BP/USD</td>
<td>37.978</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
</tr>
<tr>
<td>CAD/USD</td>
<td>40.71</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
</tr>
<tr>
<td>JY/USD</td>
<td>4.572</td>
</tr>
<tr>
<td></td>
<td>[0.206]</td>
</tr>
<tr>
<td>CHF/USD</td>
<td>19.326</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
</tr>
</tbody>
</table>

p-values in brackets. Null-hypothesis of stationarity for individual variable.
### 7.5 Sensitivity Analysis excluding Dummy Variables

#### Table 8: Restricted Cointegrating Relationships – \( \beta \) matrix

<table>
<thead>
<tr>
<th>Currency</th>
<th>( \Delta s^e + i^{us} - i )</th>
<th>( s - s_{12}^{MA} )</th>
<th>Constant</th>
<th>Trend</th>
<th>T(94:08)</th>
<th>C(04:01)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP/USD</td>
<td>-0.271</td>
<td>-0.0003</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.634</td>
</tr>
<tr>
<td></td>
<td>[-4.234]</td>
<td>[-0.105]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAD/USD</td>
<td>-0.003</td>
<td>0.006</td>
<td>-</td>
<td>-</td>
<td>-0.0002</td>
<td>-</td>
<td>0.670</td>
</tr>
<tr>
<td></td>
<td>[-0.138]</td>
<td>[5.892]</td>
<td></td>
<td></td>
<td>[-0.082]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JY/USD</td>
<td>-0.107</td>
<td>-</td>
<td>0.0004</td>
<td>-</td>
<td>-0.0003</td>
<td>-</td>
<td>0.633</td>
</tr>
<tr>
<td></td>
<td>[-3.222]</td>
<td>[3.234]</td>
<td></td>
<td></td>
<td>[-2.252]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHF/USD</td>
<td>-0.232</td>
<td>-0.006</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.542</td>
</tr>
<tr>
<td></td>
<td>[-4.445]</td>
<td>[-1.791]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* t-values in brackets. p-value for likelihood ratio test of the restricted model relative to unrestricted. Results estimated without dummy variable to assess sensitivity. T(94:08) and C(04:01) represent breaks in the trend and constant terms, in 1994:08 and 2004:01 respectively.

#### Table 9: Error Correction – \( \alpha \) matrix

<table>
<thead>
<tr>
<th>Currency</th>
<th>( \Delta s^e )</th>
<th>( \Delta(i^{us}) )</th>
<th>( \Delta(i) )</th>
<th>( \Delta(s - s_{12}^{MA}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP/USD</td>
<td>-0.219</td>
<td>0.001</td>
<td>0.003</td>
<td>0.252</td>
</tr>
<tr>
<td></td>
<td>[-5.158]</td>
<td>[0.611]</td>
<td>[1.340]</td>
<td>[3.787]</td>
</tr>
<tr>
<td>CAD/USD</td>
<td>-0.706</td>
<td>-0.004</td>
<td>0.005</td>
<td>0.215</td>
</tr>
<tr>
<td></td>
<td>[-9.996]</td>
<td>[-1.348]</td>
<td>[1.063]</td>
<td>[1.699]</td>
</tr>
<tr>
<td>JY/USD</td>
<td>-0.453</td>
<td>0.0003</td>
<td>-0.003</td>
<td>0.262</td>
</tr>
<tr>
<td></td>
<td>[-8.026]</td>
<td>[0.235]</td>
<td>[-3.450]</td>
<td>[2.914]</td>
</tr>
<tr>
<td>CHF/USD</td>
<td>-0.271</td>
<td>0.001</td>
<td>-0.002</td>
<td>0.284</td>
</tr>
<tr>
<td></td>
<td>[-5.556]</td>
<td>[0.620]</td>
<td>[-1.343]</td>
<td>[3.923]</td>
</tr>
</tbody>
</table>

* t-values in brackets. Results estimated without dummy variable to assess sensitivity.