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# A Piece of the Puzzle: Can behavioral insights help understand currency returns?

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**A Piece of the Puzzle**

*Can behavioral insights help understand currency returns?*

By

Samuel D. Russell

A Thesis Submitted to the Department of Economics  
of Trinity College in Partial Fulfillment of the  
Requirements for the Bachelor of Science Degree

Economics 498-99

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## Abstract

This paper finds further evidence using a Cointegrated Vector Autoregression to support claims against the Uncovered Interest Rate Parity (UIP) *ex post*, referred to as the Forward Discount Anomaly (Fama, 1984). This anomaly suggests predictable profits simply from investing in a country with a higher interest rate. Potential explanations could be attributed to risk or deviations from the rational expectations hypothesis. UIP *ex ante* is tested using survey data. These results indicate a time-varying risk premium. Further it is found that this premium is related to the gap between the exchange rate and Purchasing-Power-Parity value. Additionally it is determined that investor expectations are consistent with some behavioral rules; extrapolative and adaptive expectations drive deviations from PPP which transitions to regressive expectations when the gap is very large.

## **Dedication**

I would like to dedicate this work to my Mom and Dad, whose support and guidance helped me make the most of my undergraduate career.

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## Introduction

The foreign exchange (FX) market continues to hold its puzzles. This is clear from the fact that our theories about the market have little or no predictive power. One such puzzle is the Foreign Discount Anomaly, which is the rejection of the Uncovered Interest Rate Parity (UIP) *ex post*. The Uncovered Interest Rate Parity is an equilibrium parity condition where differences in returns will equalize across the two countries. The Forward Discount Anomaly implies predictable profits can be gained by simply investing in the country with the higher interest rate. The issue may be that there is either some perceived risk that prevents full arbitrage or individuals are not forecasting according to the rational expectations hypothesis (REH) and are simply unaware of this regularity.

This paper seeks to provide further insight into currency returns in the foreign exchange market by utilizing observed investor expectations from survey data to see if investor expectations follow simple behavioral rules and an estimated vector autoregression model to determine if there is a risk premium. The sample of survey data shows consistency with investors' exchange rate expectations with simple behavioral rules formulated by Froot and Frankel (1987). The rejection of the Uncovered Interest Rate Parity *ex ante*, by the sample of survey data implies a significant premium. Further examination through the estimated Imperfect Knowledge Economics Gap Model shows its relation to the

gap between the currency's price and benchmark Purchasing-Power-Parity (PPP) value. This provides evidence in support of a risk premium and the theory that risk may matter. As investors evaluate potential investments based on the differential between the exchange rate and PPP value, consistent with the prospect theory based Imperfect Knowledge Economics Gap Model (Frydman and Goldberg, 2007). This model proposes that the risk premium co-moves with the real exchange rate, otherwise the 'gap' (the difference between the spot rate and underlying PPP value), and that investors perceive more risk the larger this gap. Therefore requiring a higher premium. The existence of the risk premium challenges previous assumptions of economic models in which agents do not consider risk when evaluating prospective investments.

### **Foreign Exchange Market**

The foreign exchange market is the world's largest market and the best example of perfect competition with many buyers and sellers free to enter and exit.

Trading generates large amounts of information that are quickly disseminated on asset prices and interest rates. These characteristics make the foreign exchange market an ideal testing ground for asset pricing theory. In view of the volume of trade increases and importance of the market, it is pertinent for investors to understand the factors involved in the market that influence exchange rates, affect fundamentals and drive returns.

Over the past several decades, there has been significant progress in exchange rate economics, one of the most challenging areas in economic research, especially for exchange rate determination in the long run (Taylor, 1995). In his 1995 paper, "The Economics of Exchange Rates" Mark Taylor surveys the progress made in understanding exchange rate determination. As new models developed, each incorporated a new dynamic of international financial markets.

Leading up to the 1970s, Taylor notes that the dominant model was the open Keynesian model, which developed into the Mundell-Fleming model. Robert Mundell and J. Marcus Fleming integrated asset markets and capital mobility (Taylor, 1995). The distinct feature of subsequent models developed in the 1970s was their basis in stock market equilibrium theories (Taylor, 1995). Subsequently the monetary approach developed, where supply and demand of money are determinants for relative prices that drive exchange rate changes. The monetary model, however, falls short: "the flexible-price monetary model (or its real interest differential variant) ceases to provide a good explanation of variations in exchange rate data: the estimated equations break down, providing poor fits, exhibiting incorrectly signed coefficients and failing general equation diagnostics (Frankel 1993b)" (Taylor, 1995). Other models were developed and tested from equilibrium and liquidity models, to portfolio balance models, each



with its own original contribution, and each with its own inadequacies in explaining market moments.

A benchmark for testing and comparing these models came from Richard Meese and Kenneth Rogoff, "In a landmark paper, Meese and Rogoff (1983a) compare the out-of-sample forecasts produced by various exchange rate models with forecasts produced by a random walk model, by the forward exchange rate, by a univariate regression of the spot rate, and by a vector autoregression" (Taylor, 1995). A random walk shows that the best estimate for the future exchange rate is whatever the exchange rate is currently. Meese and Rogoff showed that the other models were not able to outperform the random walk. This result has not been overturned by subsequent work.

Time passed and a new approach was developed in response to a particular anomaly. The market microstructure approach looks to understand what drives short run deviations away from fundamentals. "In this literature, researchers focus on the behavior of market agents and market characteristics rather than on the influence of macro fundamentals" (Taylor, 1995). This focus arose in response to the frequent movements of exchange rates that seemingly cannot be explained by the underlying fundamentals. These models state that movements may be driven by the influential expectations of analysts and how information is processed (Taylor, 1995).

Despite significant progress in economic research there is still even more ground that remains to be covered and explained. Achieving a better understanding of exchange rate determination becomes more important as the global community becomes more deeply connected. "In an increasingly interconnected world, the exchange rate is central to the economic performance of a country, and the policy options available should be adequate to the needs of promoting growth, price stability, and income equality" (Vernengo & Schönerwald da Silva, 2012). Among other things, exchange rates affect trade, employment and inflation. Understanding their fluctuations and how best to mitigate the risks they pose is key to countries' and international firms' growth.

Trade in the foreign exchange market is growing exponentially, implying that the number of forces acting on prices is growing as more people enter the market or are able to execute more trades through ever advancing technology. There is a strong belief in the international trading community that price patterns are repeatable and that people and their emotions drive these patterns. "All through time, people have basically acted and reacted the same way in the market as a result of: greed, fear, ignorance, and hope. That is why the numerical formations and patterns recur on a constant basis" (Livermore, 2006). The existence of these natural forces in financial markets has been discussed in a variety of economic literature. In his defense of a flexible exchange regime Milton

Friedman discusses the many merits of the regime as well as influential factors affecting price levels. "For many changes reflect natural changes in weather conditions and the like; others arise from the freedom of countless individuals to order their lives as they will, which it is our ultimate goal to preserve and widen; and yet others contain the seeds of progress and development" (Friedman, 1953). Similarly John Maynard Keynes noted similar forces: "Most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits — of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities" (Keynes, 1936). The foreign exchange market is large, with many participants and an extensive amount of information circulated to price assets. Understanding the natural forces that affect these transactions and their influence on investors' expectations could help provide insight into foreign exchange market anomalies.

### **Uncovered Interest Rate Parity**

This paper examines exchange rate behavior and returns between countries through the Uncovered Interest Rate Parity. This parity condition provides a simple framework for analyzing currency returns assuming that returns equalize through the process of arbitrage. Milton Friedman promotes the importance of

interest rates in the determination of international financial market conditions by arguing, “interest-rate changes have in the past played a particularly important role in adjustment to external changes, partly because they have been susceptible to direct influence by monetary authorities” (Friedman, 1953). UIP theory relates the change in the exchange rate to the level of the interest rate differential. Under UIP’s assumptions, returns across countries would equalize, as investors would continue to invest in the country with the higher interest rate with the corresponding exchange rate moving in a way to offset those returns over time.

The assumptions of UIP are perfect capital mobility, investor risk neutrality and that investor expectations are formed in accordance with the Rational Expectations Hypothesis (REH). Under free capital mobility, there will be an unimpeded capital flow driving the returns in the two currencies to equalize as it implies the interest rate at home will equal the interest rate abroad. Any slight deviation will be quickly arbitrated away. The next of these assumptions is that if one country’s returns are expected to be higher, the market agent’s only care about the point forecast of mean returns and not the risk associated with the other moments of the distribution. Finally, the impact of expectations being correct on average, up to a white noise error, will also drive *ex post* returns to equalize. These assumptions were derived to show that returns would equalize as the parity condition suggests. Individuals will continue to

invest in the country with the higher expected return until the returns between the two countries equalize. "If the risk-neutral markets hypothesis holds, then the expected foreign exchange gain from holding one currency rather than another (the expected exchange rate change) must be just offset by the opportunity cost of holding funds in this currency rather than the other (the interest rate differential)" (Taylor, 1995). To illustrate algebraically, UIP produces the following equation:

$$\Delta_k s_{t+k}^e = i_t - i_t^*$$

In the above equation,  $s_t$  is the logarithm of the spot exchange and superscript  $e$  denotes the expectation for the future value at period  $t+k$ . Maturity is reached at time  $k$ . Both  $i$  and  $i^*$  are the nominal interest rates for the domestic and foreign countries, respectively. Primarily, researchers have tested foreign exchange market efficiency through regression analysis of the spot and forward exchange rates (Taylor, 1995). Assuming the Covered Interest Parity holds<sup>1</sup>, so the interest

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<sup>1</sup>  $(i_t - i_t^*) - (f_t^{(k)} - s_t) = 0$  (Taylor, 1995)

In this parity condition, market participants, perhaps those looking to hedge against foreign exchange market risk, observe the following condition, re-written from above:

$$CD = \frac{F - s_t}{s_t} + \left( \frac{F - s_t}{s_t} \right) i^* + i^* - i,$$

Where CD is the covered differential, which establishes a strict relationship between the forward premium,  $\frac{F - s_t}{s_t}$ , and the interest rate differentials. Deviations from the covered differential could arise from transaction costs associated with investing in the foreign exchange market, margin requirements, government regulation or taxation, a risk premium, or the cost of gathering information.

rate differential is equal to the forward premium, the parameters for UIP can be tested through the following regression analysis (Taylor, 1995):

$$\Delta_k s_{t+k} = \alpha + \beta (f_t^{(k)} - s_t) + \eta_{t+k}$$

under rational expectations, the only difference between the expected change in exchange rate and the actual change in the exchange rate is the white noise forecast error. Instead of incorporating the interest rate differential, Mark Taylor describes the regression that estimates the coefficient of the difference between the logarithm of the forward rate for maturity,  $f_t^{(k)}$ , and the spot rate,  $s_t$ , for  $k$  periods. The interest differential can be substituted for the forward rate because of the covered differential, as previously noted, allowing for tests of market efficiency. The magnitude of the white noise error, if investors were forming REH expectations, would not be significant and the returns across countries would offset and equalize through arbitrage. "If investors are risk-neutral and have rational expectations, we should expect the slope parameter,  $\beta$ , to be equal to one and the disturbance term  $\eta_{t+k}$  – the rational expectations forecast error under the null hypothesis – to be uncorrelated with the information available at the time  $t$ " (Taylor, 1995). For example if the U.S. has a higher interest rate than

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Through the process of arbitrage, these price differentials are exploited and return back to equilibrium.

the U.K., the dollar should be expected to lose value relative to the pound sterling by that exact percentage difference.

There are many financial anomalies<sup>2</sup> that remain unexplained in international macroeconomics. Froot and Thaler discuss anomalies, defined as, “an empirical result qualifies as an anomaly if it is difficult to ‘rationalize’, or if implausible assumptions are necessary to explain it within the paradigm” (Froot and Thaler, 1990). The focus of this paper is the Forward Discount Anomaly, a major puzzle in international macroeconomics. This puzzle arises because returns do not tend to equalize across countries, as implied by the rejection of the Uncovered Interest Parity theory *ex post* and the efficient markets hypothesis assumptions. For the condition to hold, the  $\beta$  coefficient should equal unity and the  $\alpha$  intercept, zero. In fact the estimated  $\hat{\beta}$  is found, in previous estimated models, to be not only consistently less than one but often negative, implying that simply investing in the country with the higher interest rate would yield predictable profits. An alarming market inefficiency. In his 1984 paper, “Forward and Spot Exchange Rates”, Eugene F. Fama investigated the degree to which forward exchange rates are able to forecast future spot exchange rates. Fama (1984) also examines whether forward rates have time varying premiums. By

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<sup>2</sup> Other puzzles discussed in Obstfeld and Rogoff (2001): home-bias-in-trade puzzle, the Feldstein-Horioka puzzle, home-bias portfolio puzzle, the consumption correlations puzzle, the Purchasing-Power-Parity puzzle and the exchange rate disconnect puzzle

testing a model for combined measurement of the two components of forward rates, the variation in the premium and expected future spot rate, Fama finds support that both aspects vary through time. “More startling are the conclusions that (a) most of the variation in forward rates is variation in the premiums, and (b) the premium and expected future spot rate components of forward rate are negatively correlated” (Fama, 1984). He estimated the following regression:

$$S_{t+1} - S_t = \alpha_2 + \beta_2(F_t - S_t) + \varepsilon_{2,t+1}.$$

Where,  $S_{t+1} - S_t$  is the difference between the future and current spot rate. Then,  $F_t - S_t$  is the current forward-spot differential. This model is estimated to see if there is any predictive success of the forward-spot differential with the future change in the spot rate. Fama observes negative values for  $\hat{\beta}_2$ , which is consistent with previous literature’s estimates. The failure of estimated models to produce an estimated value of 1.0, suggested by an efficient market hypothesis, pushes economists to revise assumptions and look for explanations.

As observed by Pierre-Olivier Gourinchas and Aaron Tornell, “Accordingly, the forward premium is always a biased predictor of future depreciation; the bias can be so severe as to lead to negative coefficients in the ‘Fama’ regression” (Gourinchas and Tornell, 2004). Froot and Thaler summarize the evidence against UIP *ex post*, “a very large literature has tested the unbiasedness hypothesis and found that the coefficient  $\beta$  is reliably less than one.



In fact,  $\beta$  is frequently estimated to be less than zero" (Froot and Thaler 1990).

The question presented by UIP's rejection *ex post* is why aren't investors exploiting these opportunities until they disappear? The expected utility theory based REH models have also been rejected (Capital Asset Pricing Model (CAPM) and Consumption CAPM). This anomaly represents an inability to explain price movements in the world's largest and arguably most competitive market, a major challenge to economic theory. Possible explanations have been suggested, for instance a time varying risk premium in the forward rate (Fama, 1984) but require further investigation.

As Charles Engel shows in his 1996 survey of the Forward Discount Anomaly and risk premium, the estimated  $\beta$  coefficient for UIP is not 1, as hypothesized. Engel reports on the previous research by Hodrick (1987)<sup>3</sup> where the future exchange rate is negatively related to the forward discount. The corresponding  $\beta$  coefficient is often less than 1, and most often found to be negative. Engel also surveys models and test procedures for the risk premiums. These models include the CAPM, latent variable model and portfolio-balance models of risk premiums. Engel defines the risk premium:

$$rp_t^{re} = f_t - E_t(s_{t+1})$$

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<sup>3</sup> Most notable seminal studies on forward and spot exchange rates: Fama 1984 and Bilson 1978

where,  $rp_t^{re}$ , is the foreign exchange risk premium. This implies that under risk neutrality, agents will drive  $f$ , the log of the forward exchange rate, to equality with expectations of the future spot rate,  $E(st+1)$ . If this were the case, under rational expectations expected profits would be zero (Engel, 1996). Regression results show this is not the case, and that there are seemingly unexploited opportunities for profit in the foreign exchange market, otherwise known as the Forward Discount Anomaly.

### **Behavioral Economics**

Through the pioneering work of behavioral economics, we are allowed a deeper understanding of asset prices and their deviation from fundamental benchmark values. Barberis and Thaler discuss some of these advances in their *Survey of Behavioral Finance*, concluding that “these papers are important existence proofs, showing that it is possible to think coherently about asset pricing while incorporating salient aspects of human behavior” (Barberis and Thaler, 2003). Just as an asset pricing approach helps to understand currency movements, so too does behavioral finance provide insight into asset prices and the human forces that drive the movements in those prices.

Behavioral economics studies the cognitive and emotional factors in economic decision making. The application of behavioral economics to explain some financial phenomena is known as behavioral finance. “Behavioral finance

argues that some financial phenomena can plausibly be understood using models in which some agents are not fully rational” (Barberis and Thaler, 2003). Many of the observations of human behavior that provide foundations for models in behavioral finance are derived from the experimental findings of cognitive psychology. Despite the inability of previous economic models to explain certain persistent phenomena, there has been reluctance to incorporate such findings into economic research. Nicholas Barberis and Richard Thaler list reasons for hesitation in their survey of behavioral finance:

Economists are sometimes wary of this body of experimental evidence because they believe (i) that people, through reputation will learn their way out of biases; (ii) that experts in a field, such as traders in an investment bank will make fewer errors; and (iii) that with more powerful incentives, the effects will disappear. (Barberis and Thaler, 2003)

Many of the discoveries of behavioral finance over the past few years, have been tentatively applied to stock markets, with results that are promising.

Behavioral finance could add clarity to foreign exchange markets by incorporating more accurate descriptions of human behavior than previous models. “Economists once thought behavior was either rational or impossible to formalize” (Barberis and Thaler, 2003). Through the findings of cognitive

psychology and the pioneering work of psychologists and behavioral economists alike, it is now evident that these processes are possible to understand and that previous models can be enhanced by incorporating assumptions that more accurately depict real human behavior. It is widely accepted that investors' expectations influence international financial market outcomes. Assumptions and formulas that more aptly describe their behavior therefore seems a first and crucial step towards better economic understanding.

Applying a behavioral finance framework to the foreign exchange market, Paul DeGrauwe and Marianna Grimaldi (2006) construct simple and complex behavioral rules to illustrate their foreign exchange market observations and how investors form their expectations. "Agents are aware of the exceptional complexity of the world in which they live. They will therefore follow a different forecasting strategy than the one the rational expectations model assumes, in which individual agents can store and process all relevant information in their brain." (DeGrauwe and Grimaldi, 2006). In accordance with psychological literature, they propose that agents use simplifying heuristics, commonly described as anomalies of human behavior, taking in small parts of an overly large and complex world to formulate their expectations. They discuss two discoveries of cognitive psychology in their survey of behavioral finance before constructing their own model from their own separate observations. The first

being “framing”, where individuals’ decisions are affected by the way choices are presented (Kahneman and Tversky, 1981). The second anomaly mentioned is prospect theory (Kahneman and Tversky, 1979). Prospect theory shows that, in contrast to the expected utility theory, utility of gains and disutility of losses are derived from changes in financial wealth and not the overall level. Where the disutility of a loss is greater than the utility of an equivalent gain. Prospect theory will be discussed in more detail later in this paper. DeGrauwe and Grimaldi propose that when agents are forming their expectations in complex markets they use simple forecasting rules. Agents base their decision on what rule to use by comparing the profitability of *ex post* returns. These heuristics do not guarantee optimal results but afford the agent a way of using experience-based techniques to solve problems and make decisions in the face of complexity. With this understanding, they propose simple forecasting rules and a formula for how investors choose between the methods. When approaching complex informational problems, agents will sift through the information with experienced based techniques to come to a decision of how to act in the market.

### **Explanations**

This paper is an investigation into why UIP does not hold *ex post*, and further examines possible explanations where the differences in returns could be explained by a varying risk premium or if investors are forming expectations in

accord with simple behavioral rules. In approaching the Forward Discount Anomaly, three questions must be considered: Is there a time-varying risk premium? If so what explains it? Lastly how can we characterize expectations about the exchange rate? This paper examines the Forward Discount Anomaly from the approach that there may be a risk premium and/or investors may be forming non-REH expectations. The first possible explanation challenges UIP's assumption of risk neutrality.

UIP assumes individuals will invest in the higher expected return country, and do not care about risk or the other moments of the return distribution. Investors are apparently leaving opportunities for profit unexploited in the foreign exchange market. This behavior is in contrast to the assumption of risk neutrality. It therefore seems possible that these potentially more profitable investments may be considered riskier and therefore less attractive as investors would require a higher premium for holding that asset.

The second possible explanation is with the assumption of rational expectations, where individuals' forecast errors are just a white-noise error or they are forecasting in a way with perfect foresight. This would allow economists to represent expected changes in the exchange rate with the actual future change in the exchange rate.

In their paper, Jeffrey Frankel and Kenneth Froot (1989) use survey data to measure exchange rate expectations. Their research looks to answer two questions, “how best to describe the survey expectations formation; and whether investors’ expectations are unbiased forecasts of the actual spot exchange rate process” (Frankel and Froot, 1990). As they investigate the answer to these two questions, Frankel and Froot offer a way to test rational expectations: “The simplest possible test of rational expectations is to see if expectations are unconditionally biased, if investors systematically overpredict or underpredict the future spot rate” (Frankel and Froot, 1989). As evidenced in the 70s and 80s investors consistently under then over predicted the future value of foreign currencies relative to the US dollar. This observation emphasizes the need to consider different explanations over time.

Frankel and Froot (1989) then examine another puzzle: why the gap between the forward discount and expected rate of depreciation in the survey data is so large. They offer two possible explanations: the gap is a risk premium or investor expectations are heterogeneous. Frankel and Froot (1990) state that in order for the difference to be a risk premium, there has to be two requirements, “(a) that assets denominated in other currencies were perceived in the early 1980’s as riskier than assets denominated in dollars, and (b) that investors are highly risk averse” (Frankel and Froot, 1990). While Frankel and Froot (1989)

conclude that they are unable to find the existence of a premium while pooling across exchange rates, later studies that don't replicate this exact form of analysis do. If these conditions are met, modeling the changing risk preferences becomes a first and crucial step to better understanding investor behavior and their subsequent influences in financial markets.

### **Risk: Re-examined**

#### **Prospect Theory**

To look at the former of the two explanations, this paper uses a model that incorporates the experimental findings of Daniel Kahneman and the late Amos Tversky (1979). In their paper, Barberis and Thaler note the significance of the work of Kahneman and Tversky:

Thanks largely to the work of cognitive psychologists such as Daniel Kahneman and Amos Tversky, we now have a long list of robust empirical findings that catalogue some of the ways in which actual humans form expectations and make choices. There has also been progress in writing down formal models of these processes, with prospect theory being the most notable. (Barberis and Thaler, 2003).

Kahneman and Tversky found that individuals' risk preferences are quite different from the standard theory. What matters is not the level of wealth with



diminishing returns, rather the change in wealth with a much greater disutility from a loss than utility from an equal magnitude gain with diminishing sensitivity to both. Through prospect theory Daniel Kahneman and Amos Tversky have shown that individuals' risk preferences are not stagnant, but rather subject to change relevant to recent experiences.

In establishing the basis for prospect theory Kahneman and Tversky offer a critique of the assumptions of expected utility theory, providing many instances in which experiment participants violate the framework. Expected utility theory suggests that probabilities weight the utility of outcomes.

Kahneman and Tversky coin the name of effects that cause participants to act in a specific way – often in stark contrast of what the expected utility theory would hypothesize. The first of these effects, they label the Certainty Effect, where people will often place greater significance on outcomes that are considered certain when compared with outcomes that are only considered possible.

Experiment participants were given monetary values and degrees of certainty that they would receive either value in a given option. For instance:

Problem 1: Choose between

- A. 2,500 with probability .33,
- 2,400 with probability .66,
- 0 with probability .01;

B. 2,400 with certainty.

They found that 82 percent of participants opted for the option that was certain. These choice problems are similar to other well-known counter-examples of the expected utility theory. Maurice Allais first presented these counter-examples in 1953 (Kahneman and Tversky, 1979). These problems capture varying degrees of risk preferences. Experiment participants choose options with the lesser monetary value with certainty rather than the greater value but also greater risk. Kahneman and Tversky are able to capture these behaviors into the framework of their prospect theory.

Curious about the effect opposite signs but equal magnitudes would have on outcomes of the same problems, Kahneman and Tversky gave outcomes the opposite sign and again posed the problems to experiments participants. Like the previous experiments, these new choices yielded interesting results. They found that given the same probabilities but the opposite value for each outcome experiment participants will take the greater magnitude loss with probability over the lesser value loss with certainty. The results from their experiment show that risk averse behavior becomes risk seeking, as participants are more willing to try their odds with a greater loss that is merely probable than a loss of lesser value but certainty. This anomaly was named, the Reflection Effect (Kahneman and Tversky, 1979). This behavior violates expected utility theory by showing

that agent risk preferences vary depending on how the choices are presented and do not choose the greater monetary value option with consistency.

Offering a general description of the phases involved in prospect theory Kahneman and Tversky (1979) describe the following processes involved in making decisions. The first phase is the editing phase and involves the initial analysis of choices being considered. This analysis is then followed by the evaluation phase, where the best prospect is chosen. The editing phase serves the purpose of simplifying the prospects being considered through three different steps: coding, combination, segregation and cancellation. Coding involves a reference point and states individuals look at final outcomes from decisions as gains and losses rather than the final level of wealth. Combination involves combining probabilities of matching outcomes. Segregation separates components of each prospect with varying degrees of risk. Cancellation is where agents ignore aspects of prospective choices. This last process simplifies the choice but often biases the subject towards one prospect or another because they may have overlooked certain elements of either prospect. "Many anomalies of preference result from the editing of prospects. For example, the inconsistencies associated with the isolation effect result from the cancellation of common components. Some intransitivities of choice are explained by a simplification that eliminates small differences between prospects" (Kahneman and Tversky, 1979).

A direct result of many of these operations is that agents will often demonstrate inconsistent preferences.

The evidence against expected utility theory spurs the formulation of prospect theory. The basic equation of this theory:

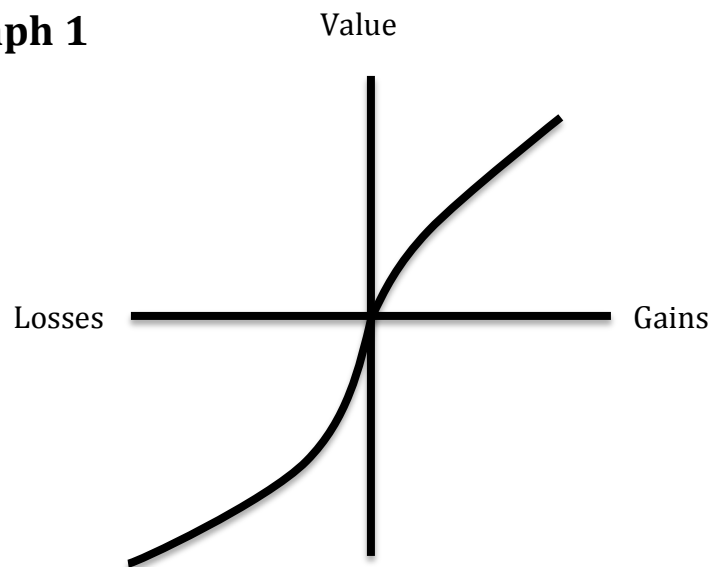
$$V(x) = \begin{cases} x^\alpha & \text{if } x \geq 0 \\ -\lambda(-x)^\beta & \text{if } x < 0 \end{cases}$$

(Tversky and Kahneman, 1992). This piecewise linear function is Kahneman and Tversky's value function that shows algebraically: loss aversion and diminishing sensitivity to subsequent gains and losses (Tversky and Kahneman, 1992). *Graph 1* shows the movements in this value function, as gains are listed in the top equation and losses in the bottom equation. The  $\lambda$  coefficient differentiates the effect of losses from gains, as the loss curve is steeper at points for equal magnitude gains. This function is the quantitative description of their data from the experiments run. "An essential feature of the present theory is that the carriers of value are changes in wealth or welfare, rather than final states" (Kahneman and Tversky, 1979). This component of the theory is illustrated through the value function and provides the reasoning for the value function's features. They are based on movements away from the reference point, are generally concave for gains and convex for losses, and the losses slope is steeper than the slope for gains. The shape of the value function was derived from an experiment where participants' preference for risky choices given probabilities

for given outcomes show that 82% of participants prefer a 25% chance of obtaining \$4,000 or a 25% of obtaining \$2,000 over a 25% of gaining \$6,000.

Consistent with the reflection effect previously mentioned participants preferred a 25% chance for a loss of \$6,000 to losses of \$4,000 or \$2,000 both with a 25% probability.

**Graph 1**



Kahneman and Tversky offer the following summary of the value function, “we have proposed the value function is (i) defined on deviations from the reference point; (ii) generally concave for gains and commonly convex for losses; (iii) steeper for losses than for gains” (Kahneman and Tversky, 1979). The value function, highlighting that individuals are risk averse with gains and risk seeking with losses - where gains and losses are compared to a reference point - is then coupled with the next aspect of prospect theory: the weighting function. This

function attributes weights to the value of the results. Decision weights are not simply probabilities associated with outcomes. "Decision weights measure the impact of events on the desirability of prospects, and not merely the perceived likelihood of these events" (Kahneman and Tversky, 1979). One observed aspect of the weighting function is that given probabilities with a fixed ratio, decision weights are nearer to one with low probabilities.

It is important to note the validity of experimental data. "By default, the method of hypothetical choices emerges as the simplest procedure by which a large number of theoretical questions can be investigated" (Kahneman, 2013). Kahneman and Tversky repeat experiments from their earlier years with Israeli subjects, in the Israeli army, later with University students. The results in both cases were almost identical. The experimental method relies on several assumptions: "that people often know how they would behave in actual situational choice, and on further assumption that the subjects have no special reason to disguise their true preferences" (Kahneman and Tversky, 1979). The experiments have reasonable accuracy in predicting people's true preferences. Since the experimental data shows repeated violations of the expected utility theory, it therefore provides significant evidence that a new way of modeling market agents' risk preferences should be considered.

The equity premium puzzle offers a similar dilemma as the Forward Discount Anomaly. "The core of the equity premium puzzle is that even though stocks appear to be an attractive asset – they have high average returns and a low covariance with consumption growth – investors appear very unwilling to hold them. In particular, they appear to demand a substantial risk premium in order to hold the market supply" (Barberis and Thaler, 2003). Progress was made with this puzzle by replacing the assumptions of expected utility theory with loss aversion and assuming REH by Nicholas Barberis, Ming Huang and Tano Santos. "We study asset prices in an economy where investors derive direct utility not only from consumption but also from fluctuations in the value of their financial wealth. They are loss averse over these fluctuations, and the degree of loss aversion depends on their prior investment performance" (Barberis et al., 2001). In their paper they advocate a different approach to thinking about the aggregate stock market. This approach is influenced by prospect theory and provides fruitful explanations to the high mean, excess volatility and predictability of stock returns coupled with a low correlation of consumption growth that is observed in financial puzzles. In some instances this effect is attributed to the house money effect, where agents display more risk seeking behavior with money they have won or recently gained. People are more willing to hold specific assets because of the higher expected rate of return. This effect,

however, is contradicted by survey data (Frydman and Goldberg, 2007). In their model, Barberis et al. (2001), models dividend growth in the following way:

$$\log\left(\frac{D_{t+1}}{D_t}\right) = g_D + \sigma_D \epsilon_{t+1}$$

Then in an effort to maximize consumption, the specification preferences are modeled in accordance to some standard features of asset pricing models.

$$E\left[\sum_{t=0}^{\infty} \left(\rho^t \frac{C_t^{1-\gamma}}{1-\gamma} + b_t \rho^{t+1} v(X_{t+1}, S_t, z_t)\right)\right]$$

Their first term illustrates utility over consumption,  $C_t$ . Power utility is incorporated in the model and  $\rho$  represents the time discount factor. The curvature of the utility function is maintained with  $\gamma > 0$ . The second term defines utility derived from fluctuations in financial wealth.  $X_{t+1}$  gives the gain or loss experienced by the investor from current,  $t$ , to  $t+1$ .  $s_t$  is the variable showing the investor's asset holdings considered risky at time  $t$ .  $z_t$  measures gains and losses before time  $t$ , as a proportion of  $s_t$ . These variables allow Barberis et al. (2001) to show investor's prior performance and the subsequent effect on risk preferences. One of the most salient aspects of the model is the evaluation of assets. This provides the reference point, which is the basis for fluctuations in financial wealth and therefore provides utility or disutility for gains and losses respectively. Barberis et al. (2001) have the following framework for their model:

$$X_{t+1} = S_t R_{t+1} - S_t R_{f,t}$$



this illustrates how investors are disappointed if their returns don't match the riskless return in any given economy. "Our results suggest that a model which relies on loss aversion alone cannot provide a complete description of aggregate stock market behavior" (Barberis et al., 2001). Such a model would fall short in explaining volatility. In their model economy where investors receive utility from fluctuations of financial wealth, risk preferences are based on prior investment performance, and loss aversion overall has traction with historical data of asset prices. This progress in the aggregate stock market for understanding returns with prospect theory based models shows the potential for similar progress to be made in understanding currency returns. Similar to the work of Benartzi and Thaler (1995), their model provides an alternative to the consumption-based approach and incorporates "prospect-type utility". The success of Benartzi and Thaler gives rise to the implications of a formal pricing model incorporating prospect theory and providing further insight into average returns.

### **Imperfect Knowledge Economics – Gap model**

The model this paper applies to explain the risk premium is Roman Frydman and Michael Goldberg's Imperfect Knowledge Economics gap model. "The other aggregate regularity that we model involves the market risk premium – the anticipated excess return that market participants in the aggregate require in

order to hold the available supply of the risky asset” (Frydman and Goldberg, 2010). Here the risk premium is related to how far the exchange rate moves in one direction or the other relative to its benchmark of Purchasing-Power-Parity (PPP).

John Maynard Keynes in *The General Theory of Employment, Interest and Money*, gives rise to the nature of speculators and the factors influencing their behavior, “what matters is not the absolute level of [the interest rate]  $r$  but the degree of its divergence from what is considered a fairly safe [benchmark] level of  $r$ , having regard to those calculations of probability which are being relied on” (Keynes, 1936). These ideas provide the foundation for Frydman and Goldberg’s gap model. “Keynes discussion of the importance of benchmark levels as anchors for asset price swings suggests that market participants look to the gap between the asset price and its benchmark value in forecasting the potential unit loss from speculation” (Frydman and Goldberg, 2003). Asset price evaluation in reference to the underlying benchmark value typifies investor behavior. The larger the gap, the greater the premium the investor will seek to hold the risky asset, as the potential for loss is greater.

In their paper, Frydman and Goldberg observe that the risk premium co-moves with PPP. “Frydman and Goldberg (2007) and Stillwagon (2010) undertake more formal statistical analysis using parametric and nonparametric

procedures and find a positive relationship between the premium and the gap in the three largest currency markets” (Frydman and Goldberg, 2010). PPP is the level of relative prices that the exchange rate reverts back to over long horizons. They alternate risk perceptions from the standard utility theory and incorporate Tversky and Kahneman’s prospect theory.

Prospect theory states that individuals’ risk preferences vary, similar to the endogenous prospect theory in the IKE model. Kahneman and Tversky (1992) modeled agents’ aversion to loss is from a proposed utility function, below is the endogenous prospect theory:

$$V(\Delta W) = \begin{cases} (W|ar^g|)^\alpha \\ -\lambda(W|ar^l|)^\beta \end{cases}$$

This utility function contains dynamics that illustrate individuals as loss averse and that disutility from losses is greater than utility from equal magnitude gains. Gains and losses are shown by  $r^g$  and  $r^l$  respectively. The  $\lambda$  coefficient is the functions constant. The utility function is derived from agents’ open stock positions and represents fluctuations in financial wealth. This is important as this paper weighs the potential of each plausible explanation separately.

By utilizing the prospect theory based IKE model, allowing for structural change, and through the use of survey data, eliminating the need to specify REH expectations, this paper is able to further determine whether or not investors are forming forecasts characterized by simple behavioral rules. “But we use an

extension of their original formulation, which we call endogenous prospect theory, that recognizes that outcomes cannot be represented with an overarching probability distribution" (Frydman and Goldberg, 2010). These behaviors have implications for individuals' perceptions of risk and how they will invest in the face of varying degrees of risk. The intuition is that, if the dollar is overvalued relative to PPP, individuals investing in the dollar demand a higher expected return to compensate for the risk that the exchange rate may reverse back towards PPP. "There is, however a serious problem with using the forward discount as the measure of the expected change in the exchange rate, in that the two may not be equal. The gap that may separate the forward discount and expected depreciation is generally interpreted as a risk premium" (Frankel and Froot, 1990). This is in contrast to standard models where volatility provides the perceived level of risk. "Purchasing Power Parity (PPP) has variously been viewed as a theory of exchange rate determination, as a short- or long-run equilibrium condition, and as an efficient arbitrage condition in either goods or asset markets (Officer 1976; Frenkel 1976, 1978; Rudiger Dornbusch 1987a)" (Taylor, 1995). The IKE model was developed specifically to look at risk. "We show that opening a mathematical model to non-routine change and imperfect knowledge on the part of economists enables us to incorporate both fundamental variables (such as earnings and interest rates), on which rational expectations

(REH) theorists focus, and psychological and social considerations (such as confidence and conventions), which behavioral economists emphasize, without presuming obvious irrationality on the part of market participants” (Frydman and Goldberg, 2010). In their paper *Opening Models of Asset Prices and Risk to Non-Routine Change*, Frydman and Goldberg develop the microfoundations for an Imperfect Knowledge Economics model, “an IKE model that can account for the long-swings nature of fluctuations in asset prices and risk – and for the connection between the two – without presuming that individuals forego obvious profits opportunities” (Frydman and Goldberg, 2010). The further overvalued a currency is from PPP the greater perceived potential for loss.

### **Behavioral Rules: Representation Examined**

#### **Characterizations of expectations**

When constructing economic models, assumptions must be made to simplify the modeling process. Given the empirical difficulties of UIP we must also take into consideration the theory’s assumptions and how well they describe market conditions and participants’ behavior. UIP assumes that in international financial market agents form rational expectations, are risk neutral, and there is free capital mobility. At the time of development, these assumptions may have seemed like accurate descriptors of actual market conditions. Like the assumptions in other macroeconomic models, financial market participants are

presented as rational, calculating and logical individuals to the extent that they will make decisions regarding their finances in their best interest. Until recently these assumptions were acceptable and considered the best way to model agents' behavior when faced with the complexity and uncertainty of the foreign exchange market. As John Maynard Keynes noted regarding uncertainty:

Or, again, the expectation of life is only slightly uncertain. Even the weather is only moderately uncertain. The sense in which I am using the term is that in which the prospect of a European war is uncertain, or the price of copper and the rate of interest twenty years hence, or the obsolescence of a new invention, or the position of private wealth-owners in the social system in 1970. About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know. Nevertheless, the necessity for action and for decision compels us as practical men to do our best to overlook this awkward fact and to behave exactly as we should if we had behind us a good Benthamite calculation of a series of prospective advantages and disadvantages, each multiplied by its appropriate probability, waiting to be summed." Where there is so much uncertainty what are we to do? But use the knowledge that we have to navigate the complexities of life and

progress, as we are destined to do. We therefore assume that other individuals act accordingly and use the knowledge and understanding they have and that presented to them by others to similarly navigate the uncertainty present in their own life.

(Keynes, 1936)

Ignoring the importance of uncertainty led to simplifying assumptions of agent behavior. Economics differentiates itself from other social sciences in the assumptions it makes about agents. Kenneth Froot and Richard Thaler note this, “most (all?) behavior can be explained by assuming that agents have stable, well-defined preferences and make rational choices consistent with those preferences in markets that (eventually) clear” (Froot and Thaler, 1990). Observing agent behavior within the market, prior to making assumptions about how they act, will help better understand their preferences, how they are forming their expectations and inevitably, assumptions more closely resembling that observed behavior. “Investors could even be rational, and yet make repeated mistakes of the kind detected here, if the true model of the spot process is evolving over time” (Frankel and Froot, 1989) It is difficult to say what constitutes rational behavior or not as there is no metric for how forecasters should be forming their

expectations.<sup>4</sup> This issue of structural change is another component of the Imperfect Knowledge Economics, where we have observed that past events are necessarily an accurate predictor of future events. Frankel and Froot examined differences in investors' expectations as they consistently under predicted in the 70s and over predicted in the 80s.

The second possible explanation for the Forward Discount Anomaly that is examined in this paper looks to see if investors are forming expectations that follow specific behavioral rules.

Another suggested explanation of anomalous exchange rate movements is the widespread influence of foreign exchange analysts who do not base their predictions on economic theory-the fundamentals-but on the identification of supposedly recurring patterns in graphs of exchange rate movements-i.e., "technical" or "chart" analysts (Charles Goodhart 1988; Frankel and Froot 1990a, 1990b; Allen and Taylor 1990). Questionnaire surveys conducted by the Group of Thirty (1985) and Taylor and Allen (1992) reveal that extremely high proportions of traders employ technical or chartist

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<sup>4</sup> These behavioral rules may be rational ways to produce unbiased forecasts with minimum variance. Froot and Frankel (1989) examine these expectations to determine if there is bias.



analysis, especially when fore-casting over shorter horizons  
(Taylor, 1995).

These techniques can be very influential on market movements as discussed earlier where the market may demonstrate self-fulfilling expectations. For instance if market agents expect a currency's depreciation and act as if that will be reality, it is likely the currency will depreciate as a result. "The question of what mechanism investors use to form expectations is of interest independent of the question of whether these mechanisms are rational, that is, whether they coincide with the mathematical expectation of the actual spot process" (Frankel and Froot, 1989). They offer three different rules to illustrate different ways that expectations are formed: adaptive, regressive and extrapolative expectations. The adaptive technique implies that investors are adjusting their expectations for the next period based on whether they under or overestimated the current period. The regressive technique takes more of a fundamentalist approach, where investors expect values to return to their fundamental or benchmark value. "The Trend is your friend', as they say on the trading floor" (James, 2003). This common saying on the trading floor most aptly describes the extrapolative expectations where the previous trend is extended to next period. If the currency has been depreciating, investors will expect it to continue to depreciate, where the expected change as being related to the past change. Also, commonly

described as bandwagon expectations. Specific behavioral rules could be illustrating how traders generate their point forecasts of returns. This paper uses survey data to test whether the behavioral rules are consistent with traders' forecasts, both at an aggregate and disaggregated level.

## Methods

### Survey data

Until recently survey data has not been available for economists to incorporate into their research because it had not been compiled. There have now been a fair number of survey data studies. Previous empirical work has operated on the assumption that the rational expectations hypothesis is true for all tests of UIP and other risk premium models. "A problem with much of the empirical work on possible rationalizations of the rejection of the simple, risk neutral efficient markets hypothesis, is that in testing one leg of the joint hypothesis, researchers typically have assumed that the other leg is true" (Taylor, 1995). Survey data provides insight into investor expectations and behaviors in financial markets that would be hard sought through other means. "In general, the overall conclusion that emerges from survey data studies appears to be that *both* risk aversion *and* departures from rational expectations are responsible for rejection of the simple efficient markets hypothesis" (Taylor, 1995). Through survey data,

this paper is able to test for a risk premium without assuming REH. By using historical exchange rate, interest rate, and survey data from 1982-2000, it is possible to look at these two explanations (risk and non-REH forecasting) for the Forward Discount Anomaly individually. Utilizing survey data Frankel and Froot describe investors' expectations formation through a simple model. With Frankel and Froot's framework, modeling investors' expectations with survey data from Money Market Services International, testing whether investors form non-REH expectations becomes possible.

### **Cointegrated VAR Model**

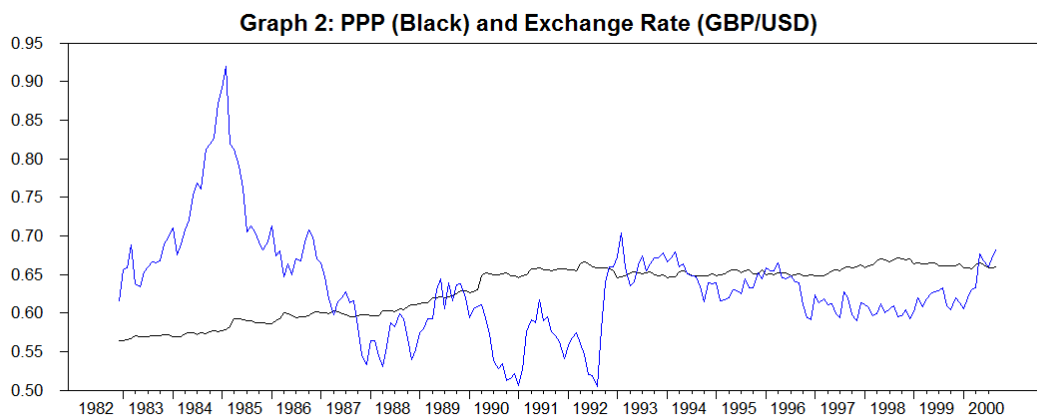
A cointegrated vector auto regression (VAR) model was estimated to obtain the results analyzed by this paper. A cointegrated VAR model has variables that are non-stationary, in that they follow a random walk, but can still be combined in a linear way to form a stationary relationship. This relationship can be interpreted as equilibrium. As stated by Katarina Juselius (2006), ". . . the VAR model is essentially a reformulation of the covariances of the data. The question is whether it can be interpreted in terms of rational economic behavior, and if so, whether it could be used as a 'design experiment' when data are collected by passive observation" (Juselius, 2006). In addition to the VAR model's capabilities of testing more than one potential relationship, the model can be modified in a manner that allows for a statistically 'well-behaved' model (Juselius, 2006). For

analyzing the hypothesizes that this paper presents, the estimation of a VAR model provides for the greatest flexibility for deriving results and therefore more reliable results from which valuable conclusions can be drawn.

Cointegration is the process of combining two or more non-stationary variables so that together they become stationary. "Cointegration implies that certain linear combinations of the variables of the vector process are integrated of lower order than the process itself" (Juselius, 2006). This suggests that the only difference could be white noise error as the cointegrated variables are influenced by the same shocks. "Thus, if the non-stationarity of one variable corresponds to the non-stationarity of another variable, then there exists a linear combination between them that becomes stationary" (Juselius, 2006). Therefore equilibrium between two variables is established (co-integrating equilibrium), as two or more variables that have common stochastic trends, will move together in the long run. Katarina Juselius further states that these long-run economic relationships are of a "steady-state" and "therefore of considerable economic interest" (Juselius, 2006). Within the foreign exchange market, this has significant implications for the current state of the volatile system, as there is an observed tendency of exchange rates to regress back to the fundamental values over the long run.

## Sample

The period: 1982-2000 provides for interesting analysis, as exchange rates were exceptionally volatile for the dollar was extremely overvalued in the early 80s and was then persistently undervalued relative to its benchmark PPP value from the mid 80s onward. *See Graph 2*



The use of survey data of investors' forecasts is an instrumental aspect of this research, allowing investors' behaviors to be observed through their exchange rate expectations and allowing various hypotheses about how they form their expectations to be tested individually. The question becomes whether agents are not investing in the country with the higher interest rate because of some notion of risk, or because they don't have perfect foresight and if not, then what rule best describes how they are forming their expectations?

## Description of Results

### Test UIP *ex post*

This paper tests the Uncovered Interest Parity *ex post* to find consistency with previous empirical research for the sample of Pound Sterling/U.S. Dollar exchange rate for the period of 1982-2000. The following regression was estimated using the Cointegrated Vector Autoregression:

Table 1: UIP <i>ex post</i> - Rejected				
Bartlett Correction: CHiSqr		0.132[0.716]		
Variables	Change in Exchange Rate	U.S. short term interest rate from the prior month (lagged once)	U.K. short term interest rate from the prior month (lagged once)	Constant
<b>Beta Coefficient</b>	1.000	-2.422	2.422	-0.005
<b>t-value</b>	n/a	-1.964	1.964	-1.420
<b>Alpha Coefficient</b>	-0.922	0	0.001	n/a
<b>t-value</b>	-9.982	0.144	0.996	n/a

$$s_t - s_{t-1} = \gamma + \beta(i_{t-1} - i_{t-1}^*) + \varepsilon_t$$

$s_t$  is the current spot exchange rate. While,  $s_{t-1}$  is the previous period's spot rate.

The intercept is included through the  $\gamma$  value. In the later IKE Gap Model and

tests of UIP *ex ante*, the following variables will also be included:  $s_{t+1|t}^e$  is the

future expected exchange rate. The current spot rate,  $s_t$ , and interest rate

differential  $i^* - i$ . In testing UIP *ex post*, the interest rates ( $i_{t-1} - i_{t-1}^*$ ), domestic

and foreign, were imposed to have the same coefficient. Through the VAR

model, a system of equations, multiple endogenous variables are allowed simultaneously.

In this research only one cointegrating relationship has been found. The Roots of Companion Matrix helped in determining the rank of one so there were 2 near unit roots in this system of three variables. UIP predicts a coefficient of one so the interest rates differential is offset by a future change in the exchange rate on average. Further, in this estimated model, there was not a need for intervention dummy variables to account for significant economic or political events.

The rejection of UIP *ex post* confirmed what previous research found and gives rise to the Forward Discount Anomaly, since both interest rates were imposed to have the same coefficient. The estimated coefficient of  $\beta$ , - 2.242, was found to be significant with a t-value of -1.964. This finding is consistent with previous literature's rejection of the UIP *ex post*, as the theory's conditions require a  $\gamma$  of 0 and a  $\beta$  at unity.

### Testing UIP *ex ante*

Table 2: UIP <i>ex ante</i> - Rejected	
Bartlett Correction: CHiSqr	8.451[0.038]

Next, UIP *ex ante* is tested with survey data. If rejected, this would imply a premium but if upheld would show that expected returns equalize. Rejection suggests that the Forward Discount Anomaly exists just because investors

systematically mis-forecast. Therefore a gross market inefficiency. The following regression model was estimated:

$$s_{t+1|t}^e - s_t = i - i^*$$

Using cointegrated vector autoregression this paper rejects UIP *ex ante* with the survey data where difference in the future expected exchange rate with the current spot rate should be offset by the interest rate differential  $i - i^*$ . Rejection of UIP *ex ante* suggests a premium and provides sufficient evidence for investigating a model that re-evaluates how market agents perceive risk. With a sufficiently small p-value of 0.038 this allows for the rejection of the Cointegration or stationarity hypothesis. This estimated model would then suggest that there is a risk premium. This premium could therefore partially account for the Forward Discount Anomaly, as investors are less likely to invest in the country with higher interest rate due to greater risk associated with that investment. Without this counter balancing effect driving down the exchange rate to offset the interest rate differential, returns therefore do not equalize.

### **Imperfect Knowledge Economics: Gap model**

The estimated equation contains the risk premium, which includes: the future expected exchange rate, U.S. and U.K. interest rates, as the left hand side variables of the model. These results show the extent of error correction through



the alpha coefficient, where the variables are adjusting back to equilibrium.

These values need to be significant to make up for the disequilibrium.

<b>Table 3: IKE Gap Model</b>					
<b>Bartlett Correction: CHISqr</b>		0.638[0.727]			
<b>Variables</b>	<b>Exchange Rate</b>	<b>U.S. 10 year government bond</b>	<b>U.K. 10 year government bond</b>	<b>GAP</b>	<b>Constant</b>
<b>Beta Coefficient</b>	1.000	1.000	-1.000	1.892	0.002
<b>t-values</b>	n/a	n/a	n/a	2.329	2.284
<b>Alpha Coefficient</b>	-0.443	-0.006	-0.001	-0.001	n/a
<b>t-values</b>	-6.485	-2.539	-0.566	-0.406	n/a

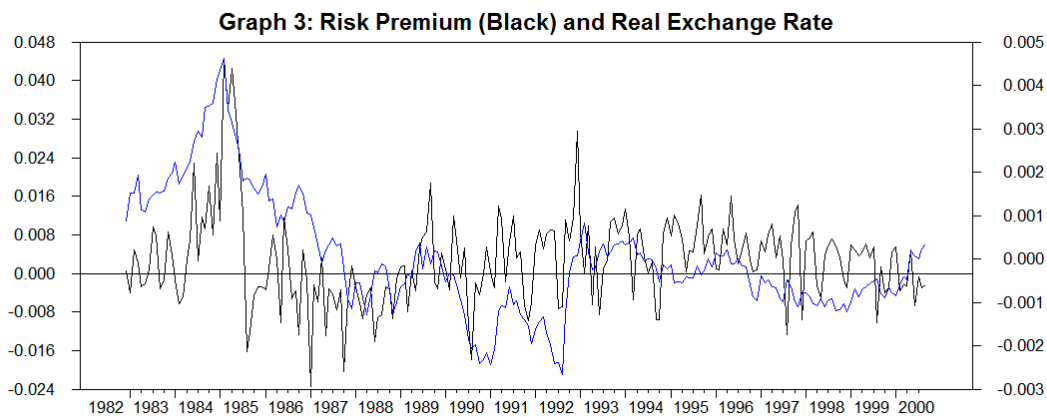
With the confirmation of the possibility of a risk premium, in accordance with the beliefs of Keynes that gave rise to the Imperfect Knowledge Economics Gap Model of Frydman and Goldberg, the following regression is estimated to determine the validity of the IKE Gap model given the sample.

$$s_{t+1|t}^e - s_t + i^* - i = \beta(s_t - s_t^{ppp})$$

The cointegrated vector autoregression yields a beta coefficient for the gap:  $(s_t - s_t^{ppp})$  of 1.892, significant with a t-value of 2.329. Where,  $s_{t+1|t}^e$  is the future expected exchange rate. The current spot rate,  $s_t$ , the interest rate differential  $i^* - i$  and Purchasing-Power-Parity,  $s_t^{ppp}$ . This estimation has a p-value of 0.727, we therefore do not reject the stationarity hypothesis. The Gap Model was normalized on the expected change in the exchange rate and imposed an equal coefficient restriction. As previously mentioned the risk premium is defined as the expected excess returns series. Suggested by Frydman and Goldberg, this

series shows the real exchange rate to co-move with a measure of the risk premium. Looking at the data visually allows us to see this relationship as predicted by the Imperfect Knowledge Economics gap model. The graph below shows that the risk premium tends to move positively with this real exchange rate (See *Graph 3*).

*Graph 3*



*In black is the measure of the risk premium based in part on survey data. It moves in a positive manner with the difference between the exchange rate and its benchmark value of PPP.*

The spot exchange rate has an alpha coefficient of -0.443 and a significant t-value, therefore making up for 44% of the disequilibrium in each period. The U.S. interest rates are precisely estimated but very small while the U.K. interest rates are insignificant. The U.S. interest rates' alpha coefficients are not large enough to contribute significantly in making up the disequilibrium. When the

exchange rate is overvalued relative to PPP, individuals investing in it become worried about an eventual reversal and require a higher expected return to maintain their position in that currency. This seems to make sense since there is a tendency for exchange rates to mean revert back to PPP over very long horizons.

The IKE Gap Model gains further support from this paper as the estimate for GAP coefficient and overall model are found to be significant. The estimated regression shows that expected effect of varying degrees of risk, derived from a gap between the PPP value and current spot exchange rate, may lead to investment and profit opportunities foregone. These realized risks in the prospective investment may have an effect on investor decisions and therefore become a plausible explanation for the Forward Discount Anomaly.

### **Expectations**

As the Forward Discount Anomaly seems to suggest investors forego obvious profits. The existence of a risk premium may partially explain this behavior. The next potential explanation that this paper examines is if investors are forming expectations consistent with simple behavioral rules. If investors utilize these rules they may be simplifying overly complex investment decisions as suggested by DeGrauwe and Grimaldi and Frankel and Froot. These processes involved may comprise the final decision and lead to a non-optimal outcome.

Emphasizing the need to understand what is influencing investor behavior and

why they may forego profits. Analysis of survey data confirms consistency with investor expectations and simple behavioral rules formulated by Froot and Frankel (1989).

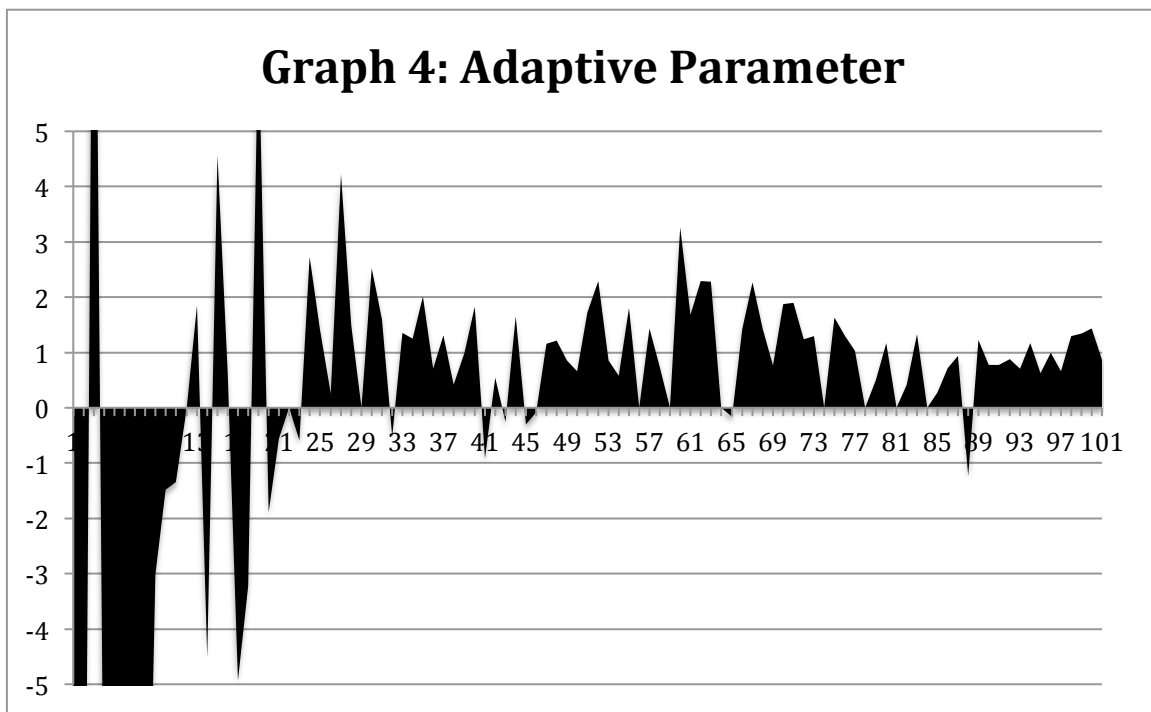
### **Adaptive**

One of the behavioral rules discussed by Frankel and Froot in their 1989 paper is the adaptive expectation formed by investors. Adaptive expectations modifies projections of the expected future spot rate through a process using the weighted average of the current spot rate and the lagged expected rate:

$$s_{t+1|t}^e = (1 - \gamma_1)s_t + \gamma_1 s_{t|t-1}^e.$$

where the future expected exchange rate,  $s_{t+1|t}^e$ , is formulated adaptively. This technique implies that investors are adjusting their expectations for the next period based on whether they under or overestimated the current period. The value of  $\gamma_1$  is expected to be between 0 and 1, indicating that the expectations are inelastic. This paper's results, provide strong support that individuals are adjusting in what looks like an adaptive fashion, so if they underestimate the exchange rate, they increase their expectation for the next period. Though at times it appears to also be extrapolative, so their expectation increases more than one to compensate for the forecast error (suggesting investors expect a trending exchange rate).

The estimate of the adaptive parameter is the expected exchange rate divided by the forecast error. Sorting this value, the adaptive parameter  $a$ , by the absolute value of the forecast error's magnitude, it is apparent that the adaptive technique was used for the vast majority of estimates. Only where the error was small did it appear that other techniques were used. *See Graph 4*



This graphical analysis shows a clear depiction that investors are forming their expectations adaptively. When looking at the correlation between the independent variables, this paper found that a correlation of .95 between the forecast error and expected change in the exchange rate, which further validates the conclusion that investors are forming expectations consistent with simple behavioral rules; in particular the adaptive technique.

This technique could indicate various implications for market movements. Psychological literature talks of conservatism in approaching markets that may make investors reluctant to over extend their expectations even when they are systematically under or over forecasting. This hesitation may indicate extreme loss aversion in financial markets by investors and their continuing inability to correctly forecast may make them reluctant to commit further. This would be in accordance with the value function of Kahneman and Tversky's prospect theory.

Systematic mis-forecasting and other possible explanations could account for this inability and foregone profits in international financial markets. Finding consistency with behavioral rules provides greater insight and understanding into how investors are forming their expectations, given the market uncertainty they face.

### **Regressive**

Another technique outlined by Frankel and Froot is the regressive technique where investors' expectations are regressive back to PPP, consistent with standard theory. This regressive technique has also been coined the "fundamentalist approach" where investors expected underlying fundamental values to drive asset prices and implies a negative correlation between the expected rate and real exchange rate. Rudiger Dornbusch was a proponent of

this technique; it suggests that values and prices converge on long-run equilibriums (Frankel and Froot, 1989).

$$s_{t+1}^e = (1 - \vartheta)s_t + \vartheta\bar{s}_t$$

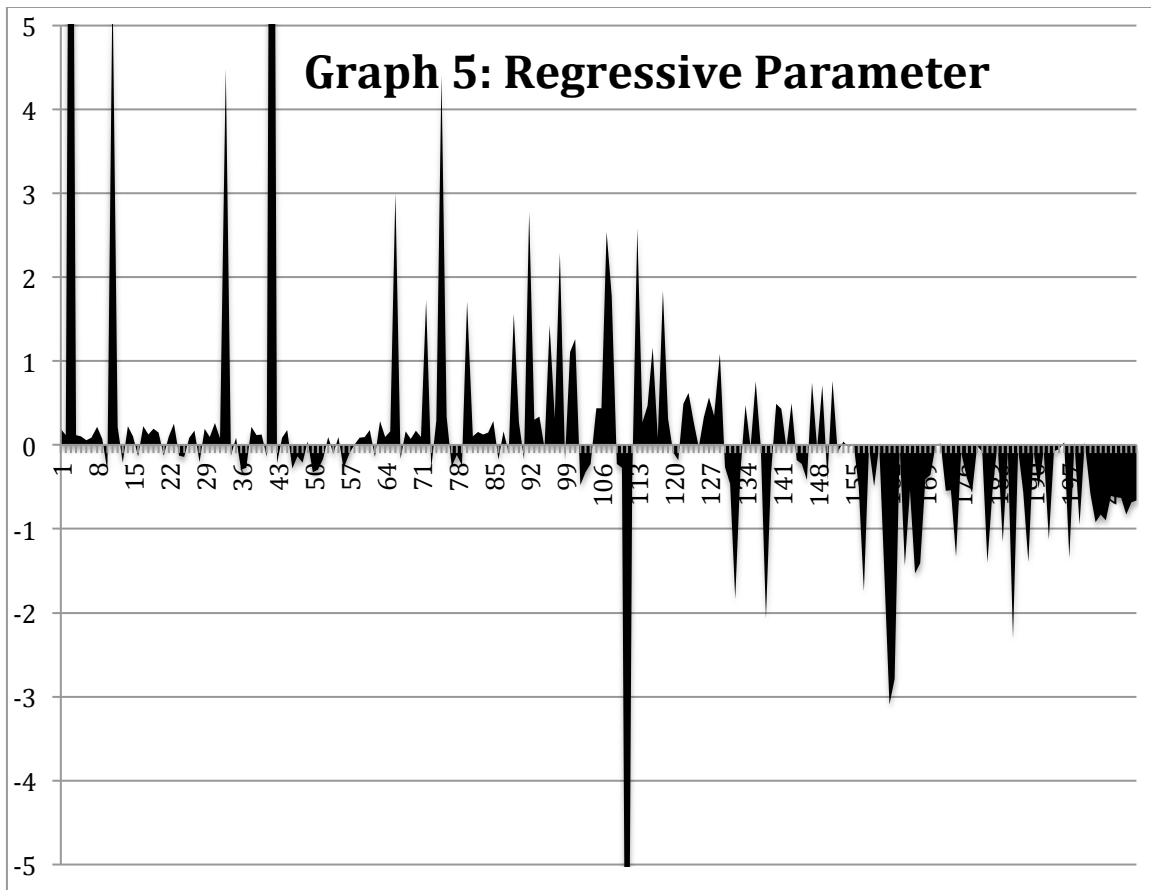
where  $\bar{s}_t$  is the long run equilibrium and  $\vartheta$  is the speed at which regression is expected to occur. When observing the survey data it only appears to be true that when the gap is very large in absolute value terms. This paper models the below regressive technique:

$$\Delta s_{t+1}^e = c(s_t - s^{PPP})$$

illustrating Purchasing-Power-Parity as  $s^{PPP}$ . Investors' expectations grow more regressive as they expect there to be movement back to fundamental values.

Therefore as the real exchange rate,  $s_t - s^{PPP}$  grows; investors expect the future exchange rate to move back to the benchmark PPP value. This is shown in *Graph*

5.



This graph shows the regressive parameter,  $c$ , sorted by the size of the gap. The regressive parameter is the expected change in the exchange rate over the real exchange rate (the current spot minus the PPP value). The graph shows that as the gap between the exchange rate and the benchmark value at PPP grows, investors become more regressive. Through sorting by the absolute value of the gap we were able to see that investors' behavior became increasingly regressive, as the gap grew larger. Additional, analysis shows that the correlation between dependent variables for the formation of regressive techniques is 36%. There is, however, 100% correlation between the expected change in the exchange rate



and the real exchange rate when the gap is sufficiently large. The regressive techniques effectiveness is when the gap is large, but overall agents expect a further movement away from fundamentals.

### **Extrapolative**

The third behavioral rule that was tested to see if was implemented on the aggregate level in the survey data from MMSI, was the extrapolative technique.

This is the technique illustrated by Frankel and Froot:

$$\Delta s_{t+1}^e = -g\Delta s_t$$

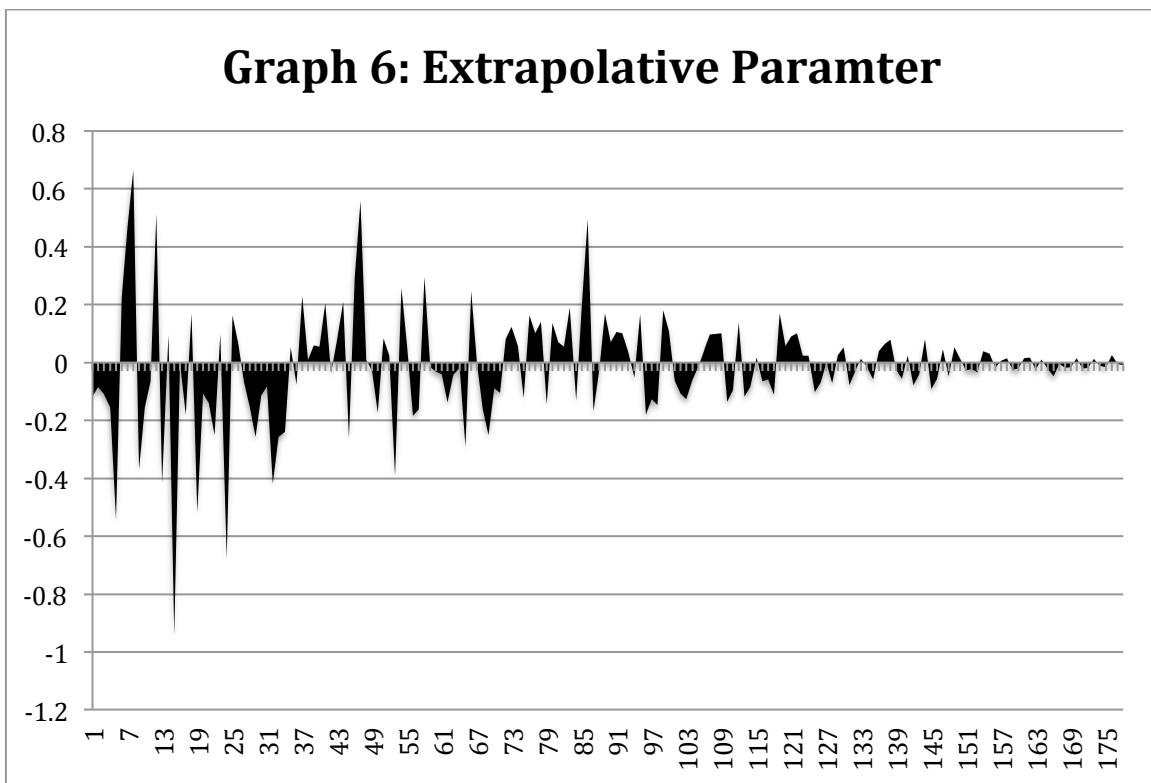
where investors are shown to have static expectations if  $g=0$ , but otherwise  $g$  is hypothesized to be less than zero. The above model is similar to what DeGrauwe and Grimaldi (2006) specify to model chartists, who are suggested to use an extrapolative technique:

$$E_{c,t}(\Delta s_{t+1}) = \beta\Delta s_t$$

where the  $\beta$  coefficient is the degree to which they extrapolate the expected change for the future expected exchange rate. The extrapolative technique proposes that investors expect change in the future expected exchange rate,  $s_{t+1}^e$ , to be the most recent observed change of the spot exchange rate,  $s_t$ . These investors are described as chartists and often display bandwagon expectations. This behavioral rule had the lowest correlation of the three rules -0.037. The correlation was calculated from the variables of the difference between the

survey data of investor's expectation for the future exchange rate with the actual spot rate at that time period and the actual change from current to future spot rate. For the sample of aggregate survey data, investors' expectations were not consistent with the extrapolative technique, and therefore it does not seem to characterize their behavior well.

The graph below (*Graph 6*), shows no real consistency in one direction or another for the extrapolative parameter for one month intervals. Also for three, six, nine and twelve-month intervals were found to be inconsistent as well. *Graph 6* shows the extrapolative parameter,  $g$ , sorted by the absolute value of the actual change in the exchange rate.



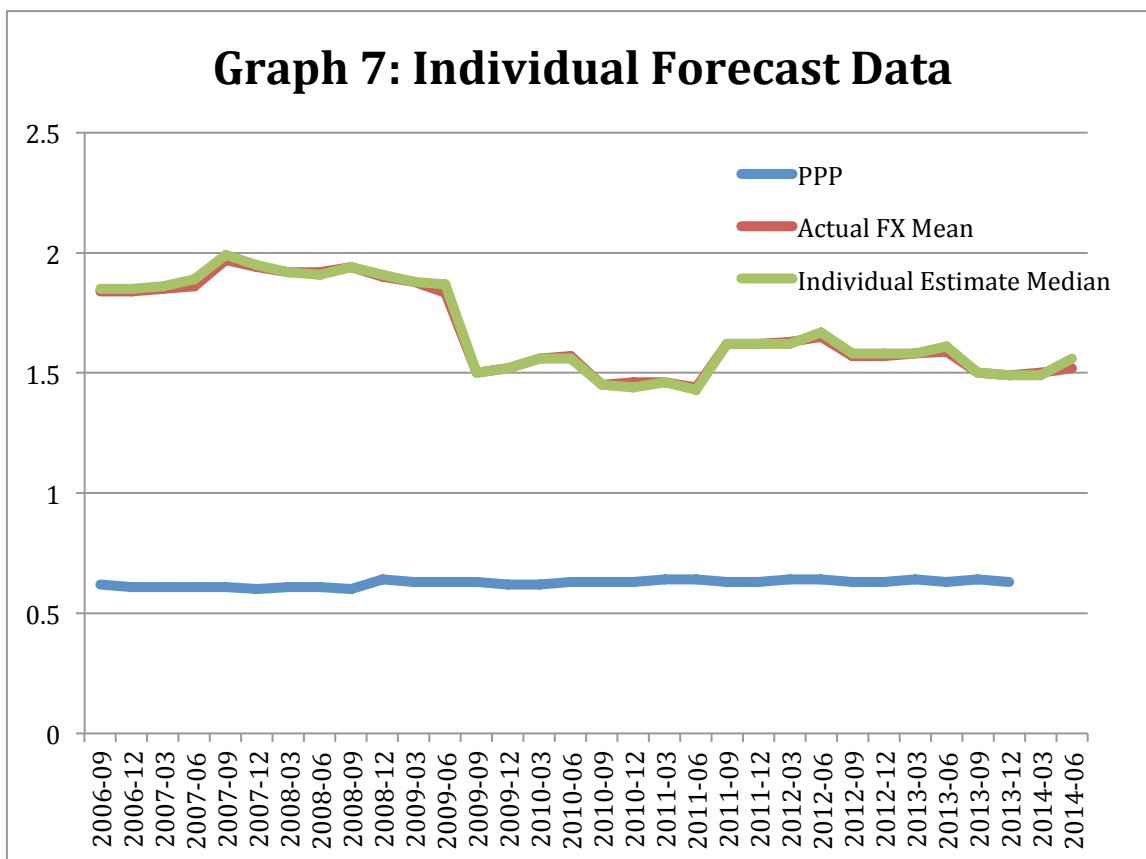
The extrapolative technique does not appear to be implemented by investors according to the sample examined. This technique is thought to also be the most disruptive of the three in the foreign exchange market:

The finding that a high proportion of foreign exchange market participants deliberately use analytical techniques that ignore macro fundamentals (i.e. 'technical or 'chartist' analysis) especially over shorter horizons . . . underscores the importance of allowing for the interaction of diverse forces in the short run determination of exchange rates (Flood and Taylor, 1996)

Flood and Taylor (1996) were compelled by the findings in survey data that showed investors having heterogeneous expectations that are consistent with behavioral rules. Employing simple behavioral rules for dealing with the complexity of markets seems a reasonable approach.

This research looked for consistency between the survey data and the rules underlying three particular techniques: adaptive, extrapolative and regressive. The results showed that investors for our sample were best described by the adaptive expectations at a 95% correlation. But when the gap between the underlying fundamentals and the spot exchange rate is large, investors were 100% regressive. Showing consistency between simple behavioral rules and this sample of survey data.

Along with the aggregate survey data from MMSI, *Bloomberg* has collected individual survey data for a number of banks (Credit Suisse Group, Morgan Stanley, UBS to name a few). The survey of expectations for the individual banks suggest that from the third quarter of 2006 to the second quarter of 2014 banks are showing very regressive expectations. The average of the calculated PPP value for this period is 0.6253 and the average actual exchange rate is 1.688. With a sufficiently large gap between the benchmark and spot exchange rate, this is consistent with the aggregate data, as now individual banks appear to be utilizing a regressive technique during a period with a large 'gap'.



The above graph (*Graph 7*) shows the median estimate of 29 banks that submitted their quarterly estimates to *Bloomberg* compared with the quarter average exchange rate and PPP value. The calculated average of the correlation for the regressive techniques variables was -98.8%. Similar to the aggregate data, the individual forecasts of 29 banks (a few the major players in the foreign exchange market) are also consistent with simple behavioral rules at this time period, which shows a large gap between the PPP value and exchange rate.

Frankel and Froot's (1989) paper suggests avenues for future economic research. "We believe that heterogeneous expectations and their role in determining market dynamics are important areas for future research" (Frankel and Froot, 1989). They also state that, "If expectations are heterogeneous, then the forward discount that is determined in market equilibrium could be a convex combination of regressive expectations and other forecasts that are closer to static expectations" (Frankel and Froot, 1987). Frankel and Froot (1987) claim that people utilize different techniques at the same time. The results from this paper show situations where investors are 100% regressive with a large gap but most other times adaptive, and sometimes extrapolatively adaptive.

The consistency with behavioral rules provides greater insight into investor behavior. This understanding helps to provide a piece of the puzzle in trying to determine what drives currency returns and why investors behave the

way they do. The Forward Discount Anomaly and extreme volatility in the short run remains unexplained and it is only a matter of incorporating the right elements to gain further insight. This paper presents further evidence in support of adjusting current assumptions and incorporating more salient characterizations of human behavior. Further, through a cointegrated vector autoregression, the estimated model shows that there is a risk premium related to the gap, as investors require more for holding higher risk assets.

The findings of this paper emphasize the need for new techniques for evaluating market outcomes that better incorporate investor behavior, their perceptions on risk and the simplifying techniques they employ in the face of complexity and uncertainty.

## **Conclusion**

There are many anomalies that persist in macroeconomics, challenging economic theory. These puzzles expose economic theories' inability to accurately depicted market outcomes. The Forward Discount Anomaly is one such puzzle that persists in the foreign exchange market. Gaining insight into the foreign exchange market is crucial as international agents hope to navigate uncertainty presented by fluctuating exchange rates. This paper provides evidence that suggests that there is a premium in the foreign exchange market. Regression

analysis supports the IKE Gap model that further implies that it may be a risk premium associated with a large gap between the PPP value and spot rate. This contradicts an assumption that is used in the Uncovered Interest Rate Parity theory where investors are believed to be risk neutral and when evaluating potential investments they will go for the higher return regardless of risk. In addition, survey data shows that investors' expectations are consistent with certain behavioral rules. This paper's findings provide one more piece of the puzzle and urges the need to re-evaluate assumptions used in current economic modeling. Especially those models based on expected utility theory proposing economic agents as calculating individuals, who use all the given information available and have consistent risk preferences. In an increasingly globalized community more accurate modeling can reduce uncertainty by providing insight into foreign exchange market conditions, thereby, providing firms and policy makers a better understanding of what drives currency returns. Allowing international agents to effectively mitigate risks inherent in international exchange.

## **Contribution**

The results presented in this research will provide further insight into currency returns and moments in the foreign exchange market through the investigation

of investors' expectations. Findings showed consistency with simple behavioral rules. While there must be further investigation into possible bias in these methods, investor adherence to simple rules is one of many pieces needed to progress and construct better rules illustrating agents' expectation formation. Further, this paper provides support for the prospect theory based Imperfect Knowledge Gap Model and the need to seek alternative assumptions for individuals' risk preferences rather than assuming risk neutrality.

### **Student Acknowledgement of Original Work**

This paper represents my own work according to Trinity College's regulations.



## Appendix

### MODEL SUMMARY: UIP *ex post*

Sample: 1983:01 to 2000:09 (213 observations)  
 Effective Sample: 1983:03 to 2000:09 (211 observations)  
 Obs. - No. of variables: 193  
 System variables: DSPOT LAGIUS LAGIUK  
 Constant/Trend: Restricted Constant  
 No. of Centered Seasonals: 12  
 Lags in VAR: 2

The unrestricted estimates:

BETA(transposed)

	DSPOT	LAGIUS	LAGIUK	CONSTANT
Beta(1)	-43.686	128.308	-104.105	0.070
Beta(2)	1.897	631.284	-501.231	0.091
Beta(3)	-0.483	-406.526	-167.543	3.512

ALPHA

	Alpha(1)	Alpha(2)	Alpha(3)
DDSPOT	0.021 (9.980)	-0.000 (-0.191)	0.000 (0.229)
DLAGIU	-0.000 (-0.234)	0.000 (1.157)	0.000 (2.489)
DLAGIU	-0.000 (-0.976)	0.000 (3.544)	-0.000 (-0.378)

PI

	DSPOT	LAGIUS	LAGIUK	CONSTANT
DDSPOT	-0.923 (-9.981)	2.256 (1.400)	-2.076 (-1.823)	0.003 (0.422)
DLAGIU	0.000 (0.256)	-0.005 (-0.409)	-0.016 (-1.806)	0.000 (2.514)
DLAGIU	0.001 (1.133)	0.056 (2.975)	-0.040 (-2.992)	-0.000 (-0.305)

Log-Likelihood = 4181.765

RESIDUAL ANALYSIS

Residual S.E. and Cross-Correlations

	DDSPOT	DLAGIUS	DLAGIUK
	0.0307196	0.0002315	0.0003591
DDSPOT	1.000		

DLAGIUS	0.042	1.000	
DLAGIUK	-0.162	0.183	1.000

LOG( Sigma )	=	-39.638
Information Criteria: SC	=	-38.268
H-Q	=	-38.779
Trace Correlation	=	0.302

#### Tests for Autocorrelation

Ljung-Box(52):	ChiSqr(450)	=	653.427	[0.000]
LM(1):	ChiSqr(9)	=	15.543	[0.077]
LM(2):	ChiSqr(9)	=	6.445	[0.695]

Test for Normality:	ChiSqr(6)	=	80.433	[0.000]
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#### Test for ARCH:

LM(1):	ChiSqr(36)	=	149.873	[0.000]
LM(2):	ChiSqr(72)	=	259.625	[0.000]

#### Univariate Statistics

	Mean	Std.Dev	Skewness	Kurtosis	Maximum	Minimum
DDSPOT	0.000	0.031	0.317	5.405	0.141	-0.117
DLAGIUS	-0.000	0.000	-0.044	4.165	0.001	-0.001
DLAGIUK	-0.000	0.000	0.329	5.782	0.001	-0.001

	ARCH(2)	Normality	R-Squared
DDSPOT	9.906 [0.007]	33.652 [0.000]	0.505
DLAGIUS	31.070 [0.000]	12.495 [0.002]	0.194
DLAGIUK	11.784 [0.003]	41.595 [0.000]	0.193

**The Roots of Companion matrix helps to determine the rank, which shows how many cointegrating relationships there are between the variables, and allows for an easy calculation of the unit root. Further it helped in the selection of a system with rank  $r$  and  $p$  variables has  $p-r$  near unit roots.**

#### The Roots of the COMPANION MATRIX // Model: H(0)

	Real	Imaginary	Modulus	Argument
Root1	1.000	0.000	1.000	0.000
Root2	1.000	0.000	1.000	0.000
Root3	1.000	0.000	1.000	0.000
Root4	-0.462	0.000	0.462	3.142
Root5	0.271	0.040	0.274	0.148

Root6 0.271 -0.040 0.274 -0.148

The Roots of the COMPANION MATRIX // Model: H(1)

	Real	Imaginary	Modulus	Argument
Root1	1.000	0.000	1.000	0.000
Root2	1.000	-0.000	1.000	-0.000
Root3	0.290	0.118	0.313	0.386
Root4	0.290	-0.118	0.313	-0.386
Root5	0.116	-0.000	0.116	-0.000
Root6	-0.078	0.000	0.078	3.142

The Roots of the COMPANION MATRIX // Model: H(2)

	Real	Imaginary	Modulus	Argument
Root1	1.000	0.000	1.000	0.000
Root2	0.966	0.000	0.966	0.000
Root3	0.281	-0.158	0.322	-0.511
Root4	0.281	0.158	0.322	0.511
Root5	0.110	0.000	0.110	0.000
Root6	-0.078	0.000	0.078	3.142

The Roots of the COMPANION MATRIX // Model: H(3)

	Real	Imaginary	Modulus	Argument
Root1	0.976	-0.037	0.977	-0.038
Root2	0.976	0.037	0.977	0.038
Root3	0.281	-0.169	0.328	-0.542
Root4	0.281	0.169	0.328	0.542
Root5	0.07I(1)-ANALYSIS			

p-r	r	Eig.Value	Trace	Trace*	Frac95	P-Value	P-Value*
3	0	0.323	101.675	99.176	35.070	0.000	0.000
2	1	0.058	19.375	18.990	20.164	0.065	0.073
1	2	0.032	6.805	5.674	9.142	0.141	

RE-NORMALIZATION OF THE EIGENVECTORS:

THE EIGENVECTOR(s) (transposed)

	DSPOT	LAGIUS	LAGIUK	CONSTANT
Beta(1)	-43.686	128.308	-104.105	0.070

PI

	DSPOT	LAGIUS	LAGIUK	CONSTANT
DDSPOT	-0.922	2.708	-2.197	0.001
	(-9.978)	(9.978)	(-9.978)	(9.978)
DLAGIU	0.000	-0.000	0.000	-0.000
	(0.230)	(-0.230)	(0.230)	(-0.230)
DLAGIU	0.001	-0.003	0.003	-0.000
	(0.948)	(-0.948)	(0.948)	(-0.948)

Log-Likelihood = 4172.078

0.225

8      -0.000    0.078    -0.000  
 Root6 -0.065    -0.000    0.065    -3.142  
 TEST OF RESTRICTED MODEL:      CHISQR(1) = 0.152 [0.696]  
 BARTLETT CORRECTION:            CHISQR(1) = 0.132 [0.716]  
 (Correction Factor: 1.154)

RE-NORMALIZATION OF THE EIGENVECTORS:

THE EIGENVECTOR(s) (transposed)  
           DSPOT    LAGIUS    LAGIUK    CONSTANT  
 Beta(1) 43.688 -105.793 105.793    -0.210

THE MATRICES BASED ON 1 COINTEGRATING VECTOR:

BETA (transposed)  
           DSPOT    LAGIUS    LAGIUK    CONSTANT  
 Beta(1) 1.000 -2.422    2.422    -0.005  
           (.NA) (-1.964) (1.964) (-1.420)

The alpha values show the degree to which the variable is error correcting, provided a significant t-value. If the Beta and Alpha have opposite signs then the variable is adjusting for the disequilibrium.

ALPHA

          Alpha(1)  
 DDSPOT -0.922  
           (-9.982)  
 DLAGIU  0.000  
           (0.144)  
 DLAGIU  0.001  
           (0.996)

PI

          DSPOT    LAGIUS    LAGIUK    CONSTANT  
 DDSPOT -0.922    2.234    -2.234    0.004  
           (-9.982) (9.982) (-9.982) (9.982)  
 DLAGIU  0.000    -0.000    0.000    -0.000  
           (0.144) (-0.144) (0.144) (-0.144)  
 DLAGIU  0.001    -0.003    0.003    -0.000  
           (0.996) (-0.996) (0.996) (-0.996)

Log-Likelihood = 4172.001  
 TEST OF RESTRICTED MODEL: CHISQR(3) = 6.690 [0.082]  
 BARTLETT CORRECTION: CHISQR(3) = 5.923 [0.115]  
 (Correction Factor: 1.130)

The p-value is the test of the restricted model. The model is rejected if the p-value is below .05.

RE-NORMALIZATION OF THE EIGENVECTORS:

THE EIGENVECTOR(s) (transposed)  
           DSPOT  LAGIUS  LAGIUK  CONSTANT  
 Beta(1) 42.392 42.392 -42.392    0.000

THE MATRICES BASED ON 1 COINTEGRATING VECTOR:

BETA(transposed)  
           DSPOT  LAGIUS  LAGIUK  CONSTANT  
 Beta(1) 1.000  1.000 -1.000    0.000  
           (.NA)  (.NA)  (.NA)    (.NA)

ALPHA  
           Alpha(1)  
 DDSPOT  -0.862  
           (-9.449)  
 DLAGIU   0.000  
           (0.602)  
 DLAGIU   0.002  
           (1.885)

PI  
           DSPOT      LAGIUS      LAGIUK      CONSTANT  
 DDSPOT  -0.862      -0.862      0.862      0.000  
           (-9.449)  (-9.449)   (9.449)      (.NA)  
 DLAGIU   0.000      0.000      -0.000      0.000  
           (0.602)  (0.602)  (-0.602)      (.NA)  
 DLAGIU   0.002      0.002      -0.002      0.000  
           (1.885)  (1.885)  (-1.885)      (.NA)

Log-Likelihood = 4168.733

**MODEL SUMMARY: UIP *ex ante***

Sample:                          1982:12 to 2000:09 (214  
 observations)  
 Effective Sample:              1983:02 to 2000:09 (212  
 observations)

Obs. - No. of variables: 194  
 System variables: EXDSPOT IUS IUK  
 Constant/Trend: Restricted Constant  
 No. of Centered Seasonals: 12  
 Lags in VAR: 2

The unrestricted estimates:

BETA(transposed)

	EXDSPOT	IUS	IUK	CONSTANT
Beta(1)	-124.189	0.930	-102.143	1.206
Beta(2)	-16.371	-710.772	449.946	0.804
Beta(3)	24.363	-262.221	-258.352	3.235

ALPHA

	Alpha(1)	Alpha(2)	Alpha(3)
DEXDSP	0.003 (6.048)	0.000 (0.488)	-0.001 (-1.363)
DIUS	0.000 (3.879)	-0.000 (-0.113)	0.000 (2.071)
DIUK	0.000 (1.307)	-0.000 (-3.351)	0.000 (0.153)

PI

	EXDSPOT	IUS	IUK	CONSTANT
DEXDSP	-0.409 (-6.208)	0.008 (0.022)	-0.024 (-0.087)	0.002 (0.924)
DIUS	-0.007 (-3.366)	-0.007 (-0.606)	-0.015 (-1.857)	0.000 (3.184)
DIUK	-0.003 (-0.813)	0.058 (3.092)	-0.041 (-3.178)	-0.000 (-0.176)

Log-Likelihood = 4503.278

RESIDUAL ANALYSIS

Residual S.E. and Cross-Correlations

	DEXDSPOT	DIUS	DIUK
	0.0075152	0.0002248	0.0003587
DEXDSPOT	1.000		
DIUS	-0.055	1.000	
DIUK	-0.032	0.179	1.000

LOG(|Sigma|) = -42.484  
 Information Criteria: SC = -41.119

H-Q = -41.629  
Trace Correlation = 0.251

Tests for Autocorrelation

Ljung-Box(53): ChiSqr(459) = 526.128 [0.016]  
LM(1): ChiSqr(9) = 8.719 [0.464]  
LM(2): ChiSqr(9) = 3.985 [0.912]

Test for Normality: ChiSqr(6) = 63.417 [0.000]

Test for ARCH:

LM(1): ChiSqr(36) = 119.929 [0.000]  
LM(2): ChiSqr(72) = 194.824 [0.000]

Univariate Statistics

	Mean	Std.Dev	Skewness	Kurtosis	Maximum	Minimum
DEXDSPOT	0.000	0.008	0.113	3.993	0.029	-0.023
DIUS	0.000	0.000	-0.106	4.436	0.001	-0.001
DIUK	0.000	0.000	0.492	5.836	0.001	-0.001

	ARCH(2)	Normality	R-Squared
DEXDSPOT	6.013 [0.049]	9.709 [0.008]	0.327
DIUS	20.920 [0.000]	17.099 [0.000]	0.236
DIUK	14.296 [0.001]	37.576 [0.000]	0.191

RE-NORMALIZATION OF THE EIGENVECTORS:

THE EIGENVECTOR(s) (transposed)

	EXDSPOT	IUS	IUK	CONSTANT
Beta(1)	-124.189	0.930	-102.143	1.206

PI

	EXDSPOT	IUS	IUK	CONSTANT
DEXDSP	-0.388 (-6.018)	0.003 (6.018)	-0.319 (-6.018)	0.004 (6.018)
DIUS	-0.007 (-3.841)	0.000 (3.841)	-0.006 (-3.841)	0.000 (3.841)
DIUK	-0.004 (-1.273)	0.000 (1.273)	-0.003 (-1.273)	0.000 (1.273)

Log-Likelihood = 4494.699

TEST OF RESTRICTED MODEL: CHISQR(3) = 9.862 [0.020]

BARTLETT CORRECTION: CHISQR(3) = 8.451 [0.038]  
 (Correction Factor: 1.167)

RE-NORMALIZATION OF THE EIGENVECTORS:

THE EIGENVECTOR(s) (transposed)  

	EXDSPOT	IUS	IUK	CONSTANT
Beta(1)	122.103	122.103	-122.103	0.000

THE MATRICES BASED ON 1 COINTEGRATING VECTOR:

BETA(transposed)  

	EXDSPOT	IUS	IUK	CONSTANT
Beta(1)	1.000	1.000	-1.000	0.000
	(.NA)	(.NA)	(.NA)	(.NA)

ALPHA  

Alpha(1)	
DEXDSP	-0.371 (-5.826)
DIUS	-0.005 (-2.765)
DIUK	-0.001 (-0.298)

PI  

	EXDSPOT	IUS	IUK	CONSTANT
DEXDSP	-0.371 (-5.826)	-0.371 (-5.826)	0.371 (5.826)	0.000 (.NA)
DIUS	-0.005 (-2.765)	-0.005 (-2.765)	0.005 (2.765)	0.000 (.NA)
DIUK	-0.001 (-0.298)	-0.001 (-0.298)	0.001 (0.298)	0.000 (.NA)

Log-Likelihood = 4489.768

**MODEL SUMMARY: IKE Gap Model**

**The Gap Model was normalized on the expected change in s, which then also sets the interest rates to coefficients of 1 and -1**

Sample: 1982:12 to 2000:09 (214 observations)  
 Effective Sample: 1983:02 to 2000:09 (212 observations)



Obs. - No. of variables: 192  
 System variables: EXDSPOT BUS BUK GAPMAC2  
 Constant/Trend: Restricted Constant  
 No. of Centered Seasonals: 12  
 Lags in VAR: 2

I(2) analysis not available for the specified model.

The unrestricted estimates:

BETA(transposed)

	EXDSPOT	BUS	BUK	GAPMAC2	CONSTANT
Beta(1)	-135.888	-231.676	123.213	347.143	1.049
Beta(2)	-3.238	-1128.054	884.430	833.244	0.880
Beta(3)	-3.984	127.830	-496.343	601.507	2.369
Beta(4)	1.917	-614.985	65.075	-27.700	3.269

ALPHA

	Alpha(1)	Alpha(2)	Alpha(3)	Alpha(4)
DEXDSP	0.003 (6.458)	-0.000 (-0.291)	-0.000 (-0.184)	-0.000 (-0.728)
DBUS	0.000 (2.780)	-0.000 (-0.226)	0.000 (0.690)	0.000 (1.652)
DBUK	0.000 (0.663)	-0.000 (-1.401)	0.000 (1.996)	-0.000 (-0.025)
DGAPMA	0.000 (0.256)	-0.000 (-4.014)	-0.000 (-0.507)	0.000 (0.344)

PI

	EXDSPOT	BUS	BUK	GAPMAC2	CONSTANT
DEXDSP	-0.448 (-6.451)	-0.379 (-0.567)	0.297 (0.569)	0.974 (1.759)	0.002 (0.868)
DBUS	-0.006 (-2.770)	-0.021 (-1.004)	-0.001 (-0.090)	0.018 (1.056)	0.000 (2.288)
DBUK	-0.002 (-0.688)	0.028 (1.293)	-0.036 (-2.100)	0.004 (0.244)	0.000 (0.964)
DGAPMA	-0.000 (-0.140)	0.087 (3.196)	-0.067 (-3.169)	-0.074 (-3.291)	-0.000 (-0.784)

Log-Likelihood = 6311.144

I(1)-ANALYSIS

p-r	r	Eig.Value	Trace	Trace*	Frac95	P-Value	P-Value*
4	0	0.189	69.545	67.352	53.945	0.001	0.002
3	1	0.077	25.166	24.405	35.070	0.395	0.442
2	2	0.021	8.160	7.699	20.164	0.809	0.844
1	3	0.017	3.681	3.165	9.142	0.473	0.560

## RE-NORMALIZATION OF THE EIGENVECTORS:

## THE EIGENVECTOR(s) (transposed)

	EXDSPOT	BUS	BUK	GAPMAC2	CONSTANT
Beta (1)	-135.888	-231.676	123.213	347.143	1.049

## THE MATRICES BASED ON 1 COINTEGRATING VECTOR:

## BETA(transposed)

	EXDSPOT	BUS	BUK	GAPMAC2	CONSTANT
Beta (1)	1.000	1.705	-0.907	-2.555	-0.008
	(.NA)	(1.263)	(-0.814)	(-2.331)	(-1.372)

## ALPHA

	Alpha (1)
DEXDSP	-0.448
	(-6.448)
DBUS	-0.006
	(-2.759)
DBUK	-0.002
	(-0.654)
DGAPMA	-0.001
	(-0.246)

## PI

	EXDSPOT	BUS	BUK	GAPMAC2	CONSTANT
DEXDSP	-0.448	-0.763	0.406	1.144	0.003
	(-6.448)	(-6.448)	(6.448)	(6.448)	(6.448)
DBUS	-0.006	-0.010	0.006	0.016	0.000
	(-2.759)	(-2.759)	(2.759)	(2.759)	(2.759)
DBUK	-0.002	-0.003	0.001	0.004	0.000
	(-0.654)	(-0.654)	(0.654)	(0.654)	(0.654)
DGAPMA	-0.001	-0.001	0.001	0.002	0.000
	(-0.246)	(-0.246)	(0.246)	(0.246)	(0.246)

Log-Likelihood = 6298.561

TEST OF RESTRICTED MODEL: CHISQR(2) = 0.810 [0.667]  
 BARTLETT CORRECTION: CHISQR(2) = 0.638 [0.727]  
 (Correction Factor: 1.270)

## RE-NORMALIZATION OF THE EIGENVECTORS:

THE EIGENVECTOR(s) (transposed)

	EXDSPOT	BUS	BUK	GAPMAC2	CONSTANT
Beta(1)	133.930	133.930	-133.930	-253.371	-0.330

PI

	EXDSPOT	BUS	BUK	GAPMAC2	CONSTANT
DEXDSP	-0.443	-0.443	0.443	0.839	0.001
	(-6.485)	(-6.485)	(6.485)	(6.485)	(6.485)
DBUS	-0.006	-0.006	0.006	0.010	0.000
	(-2.539)	(-2.539)	(2.539)	(2.539)	(2.539)
DBUK	-0.001	-0.001	0.001	0.002	0.000
	(-0.566)	(-0.566)	(0.566)	(0.566)	(0.566)
DGAPMA	-0.001	-0.001	0.001	0.002	0.000
	(-0.406)	(-0.406)	(0.406)	(0.406)	(0.406)

Log-Likelihood = 6298.156

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