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A Simple Model for Expected Exchange Rate E(s) of Currency – It is About the Present Not the Future!

Gary R. Waissi

The Polytechnic School, Ira A. Fulton Schools of Engineering, Arizona State University, Sutton Hall 340G, Mesa, Arizona 85212, U.S.A

Corresponding Author:** ***Gary R. Waissi, *The Polytechnic School, Ira A. Fulton Schools of Engineering, Arizona State University, Sutton Hall 340G, Mesa, Arizona 85212, U.S.A.* ***Email:*** *gary.waissi@asu.edu*

Abstract: *This paper proposes a simple empirical model, and presents a simple estimator, for expected currency exchange rates. The model attempts to find the expected value E(s) = μ_s for a currency exchange rate s for the current point in time. The model has conceptual similarity with the FEER and NATREX approaches, but also with MULTIMOD [6]. It is emphasized, that the model is not attempting to forecast future exchange rates, but rather, the model attempts to find the expected value for an exchange rate for the current point in time. The expected value for an exchange rate is obtained by adjusting the spot rate by a "cumulative factor effect". The model provides a measure for currency misalignment as the difference between the expected exchange rate and the actual exchange rate (the spot rate). It is hypothesized, that there is an equilibrium exchange rate between two currencies, when countries with respect to fundamental underlying economic-, societal-, and political factors, but also environmental factors, are in "balance" or at "equilibrium". The "balance" or "equilibrium" is not a specific known quantity, may never be achieved, and ideally may hold for an infinite number of variable value- and factor level combinations. Simple tests show that the modeling approach shows promise. The paper also provides additional support for the Meese and Rogoff (1983 [1], 1988 [2]) "random walk" model, and suggests that the continued search of exchange rate forecasting models are exercises in futility.*

JEL classification: G1; G15; G150

Keywords: *Currency exchange rate models, exchange rate forecasting*

1. Introduction

Existing exchange rate "forecasting" models work well within known data, but, as reported in a number of studies (see the literature review section), not outside of the known data. Among the classic papers, Meese and Rogoff concluded in their 1983 [1] paper ("Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?'', (1983) [1]) that earlier exchange rate models did not work. Meese and Rogoff repeated the same finding in their 1988 [2] paper. In 2009 [3] Rogoff revisited the progress made, and still confirmed support for the hypothesis of 1983.

Several other authors also report, that they have not be able to show any improvement in forecasting exchange rates when compared to the random walk models. Among those, for example, the paper [4] (Cheung, Chinn, Pascual, 2005) investigated a set of exchange rate models of the 1990s, and concludes that "models that work well in one period do not necessarily work well in another period", and that "interest rate parity-, and productivity based models" do not perform better than the random walk models. The collection of six conference papers in 2003 [5] (by Engel, Rogers, Rose) examined "empirical exchange rate models" and, in particular, summarized the development and results since the Meese and Rogoff 1983 [1] study with an overall conclusion that the papers "contribute to our comprehension of exchange rate behavior", but, while not explicitly stated, no paper shows evidence of improved forecasting capability. This same can be said today – none of the proposed models are able to forecast exchange rates.

While we agree with Meese and Rogoff (1983) [1] that the exchange rate forecasting models cannot outperform random-walk models, and we agree that this continues to be true today, we disagree on the reported reasons. The reasons do not relate simply to a mathematical modeling approach or model formulation. Among other, Meese and Rogoff suggested as reasons for model failure "simultaneous equations bias, sampling errors, stochastic movements in the underlying parameters, misspecification or nonlinearity". Similar claims have been made by other authors (see the literature review section). None of those aspects, their presence or absence, can improve the forecasting capability of a model, because none of those aspects have the ability to capture the "future" exchange rate behavior. Here, "equation bias" is structural about a model, "sampling error" relates to known data, "stochastic movements" relate to model structure and known data, and "misspecification" and "non-linearity" are structural characteristics of the model.

As a simple comparison, if this, the currency exchange system, would be a production line, or a machine, with controllable variables, we could "predict" the machine's output considering the past performance of the machine, or that of a machine with identical design and performance characteristics, over an average length-of-life of the machine. The model would then be fitted to known data. When using the model for "prediction" or "forecasting", it would be assumed that the new machine would behave approximately as the previous machine of same design over the estimated length of life of the machine --- simple enough, similar data pattern! And, similarly, we can consider weather forecasting. In weather "forecasting" we have something to base those "forecasts" on. We have, for example, seasonality and weather patterns. We observe satellite images of, say, a storm or weather front movement, and we can estimate from those images the movement direction, speed, expansion/contraction, of the storm, and can extrapolate from there, when the storm is likely to hit a specific geographic region. But, is this actually "forecasting", or just knowing with better data, and established patterns, when the "train" is likely to arrive. Again, we have known data and previously observed patterns. At one geographic location the storm is already "history", while at another location it is "present", and at a third location to be "expected in the future". Even in weather forecasting, this approach only works for short term time horizons, like one to two weeks, maybe one to two months, but not next year, or the year after. If it would, farmers and the agriculture sector would be much better off with their planning. This is the type of forecasting the models can do, nothing more than that.

With respect to currency exchange rates, even as there are models that can capture the present, there is no model, and there will be no model to be able to "forecast the future" currency exchange rates. Still, futile efforts continue to attempt to find this magic forecasting model. Why will it not work ---- we are dealing with a complex, stochastic, action- and reaction based interconnected system of economies, societies, political systems ---- including their interaction, economic- and political decisions and -reactions, private sector- and business decisions and -reactions, rules and regulations, labor movements, unionization, education, entrepreneurship ---- but also, impact of weather, natural disasters, riots, war, etc., of many independent and co-dependent "actors" within and outside of a country (or society) in an integrated network of countries and economies. While some factors may show "predictable" patterns over time (like weather), others (like political actions and reactions, election outcomes, riots, war, natural disasters) defy predictability, but affect economies, and thereby affect exchange rates. We have over 30 years of evidence of failure after failure of exchange rate model forecasting. We, therefore, offer a proposition, because of the above factors and other unknown factors, that there will never be a forecasting model, regardless of how elegant mathematically, that would actually be able to "forecast future" currency exchange rates. There is no evidence, and there does not appear to be any sensible reason to claim otherwise.

Ideally, all macro- and microeconomic (internal and external) factors and variables, all economic fundamentals, all societal- and political factors and variables, all environmental (climate-, weather-, natural disasters) factors and variables should be included. These factors and variables form the fabric of a country, economy and society. It is hypothesized, that there is an equilibrium exchange rate between two currencies, when countries with respect to such fundamental underlying economic-, societal-, political, and environmental variables and factors are in "balance" or at "equilibrium". When conditions change, those changes put pressure on the economy, and thereby impact the currency exchange rate. In a free floating system currency exchange rates always follow (represent the effect), never lead (never represent the cause).

The "balance" or "equilibrium" is not a specific known quantity, it may never be achieved, and ideally may hold for an infinite number of variable value- and factor level combinations (like continuously tuning the volume, balance and intensity of sound of a radio to different listening audiences, conditions and surroundings). The balance, or equilibrium, within this context is similar to the concept of "mean" (or expected value, or the "first moment of a random variable about its origin") as known in probability. And similarly, the equilibrium exchange rate can be compared to the concept of the "center of gravity" as it is known in physics. When the shape, size and density of an object change, the center of gravity changes.

The expected value of an exchange rate changes continuously when internal (domestic, in-country) and external (trading partners, in country, and in-between countries) conditions change. The term "country" in this paper, generally includes both individual legal territorial entities (like Canada, Japan, the United States), or groups of legal territorial entities (like the Eurozone (euro area) countries of the European Union), and their respective floating currencies.

At the macroeconomic level the MULTIMOD (see Laxton D, Isard P, Faruqee H, Prasad E, and Turtelboom B) (1998) [6] models attempt to capture many of the previously mentioned characteristics of economies and societies. And, the MULTIMOD is not a forecasting model. The proposed model considers the macroeconomic (internal and external) balance, the economic fundamentals, but also other societal- and political factors somewhat similarly as the MULTIMOD. The proposed model has also similarity with the fundamental expected exchange rate (FEER) model, see e.g. Williamson (1983) [7] (1991) [8], and Britton [9] (1992).

In this paper we will develop the expected exchange rate model, and show how the expected value for an exchange rate is obtained by adjusting the spot rate by a "cumulative factor effect". Simple tests show that the modeling approach shows promise.

The paper also provides additional support for the Meese and Rogoff (1983 [1], 1988 [2]) random walk model. Therefore, we propose that the focus of exchange rate modeling should be shifted toward learning to understand the present (like in MULTIMOD, 1998 [6]), and by developing integrated- and interactive models with capability for real-time micro-trend response rather than forecasting.

2. A Longitudinal Review and Critical Analysis of Literature – Why Exchange Rate Forecasting Models Have Not Worked

Among other, the paper (2004) [10], by Driver and Westaway, provides a thorough discussion and analysis of many exchange rate models. The paper discusses, among other, the models proposed or extended by Williamson [7] (1983), Frankel and Goldstein (1986), Williamson and Miller (1987), Huizinga (1987), Barrell and Wren-Lewis (1989), Currie and Wren-Lewis (1989), Cumby and Huizinga (1990), Wren-Lewis (1992) [11], MacDonald and Taylor (1992), Frankel (1993), Williamson (1993 and 1994 [72]), Bayoumi et al (1994), Stein [14] (1994), Artis and Taylor (1995), Frankel (1996); Taylor (1995), Stein and Allen (1995), Clark and MacDonald (1997 and 1999), Stein and Paladino (1998), Wadhwan (1999), Groen (2000), MacDonald (2000), Rapach and Wohar (2002). The models discussed by Driver and Westaway (2004) [10] include the FEER - fundamental equilibrium exchange rate model by Williamson (1983 [7], 1991 [8]), and its derivatives and extensions, like the CHEER - capital enhanced (EER) (MacDonald (2000), the ITMEER - intermediate-term model-based EER (Wadhwan (1999)); the BEER - behavioral EER (Clark and MacDonald (1997 and 1999)); DEER - the desired EER (Bayoumi et al (1994) and Artis and Taylor (1995)); APEER - atheoretical permanent EER (Huizinga (1987) and Cumby and Huizinga (1990), MacDonald (2000)); and NATREX - natural real exchange rate (Stein [14] (1994), Stein and Allen (1995), Stein and Paladino (1998)).

The above mentioned models are discussed in a number of papers with each study adding another view or dimension. We will next briefly go through some of the interesting studies shedding light to the complexity and non-tractability surrounding exchange rate modeling with our comments added. The review is by no means comprehensive, but we believe that some of the interesting contributions and controversies are included:

2.1. The FEERs, BEERs, and Other Similar Models and Extensions – Promising Approaches?

In a book chapter [15] (1999) by Clark and MacDonald discusses economic fundamentals of exchange rates, and compare the FEERs and BEERs. Among their conclusions they state that "An assessment of a country's exchange rate can be made by comparing its current level with the calculated FEER".

In the study [16] (2012) Lòpez-Villavicencio, Mazier, and Saadaoui, investigate the relationship between the FEER and BEER and postulate that the concepts are similar and closely related with some significant differences. The FEER, according to the paper is a “medium run concept”, while BEER is a “long run concept”. The study appears to suggest that future currency exchange rates, outside of known data, could be forecasted.

The fundamental equilibrium exchange rate, FEER, is discussed, among other, by Barrell, Gurney and in't Veld [17] (1992) and by Barrell and in't Veld [18] (1991), Britton [9] (1992), and recently (2015) by Saadaoui [20]. It is argued, Barrell and in't Veld [18] (1991), that the relative prices of two countries "will come into line with FEER sooner or later", and that the time period is likely to be extended for the "real misalignment to disappear". Saadaoui [20] (2015) agrees that the “FEER is related to real exchange rates” over the long term.

In (2006) [21] Barisone, Driver and Wren-Lewis examine the power of the FEERs. Their study concludes that “the FEER approach represents an improvement over PPP in explaining medium- to long-term trends in the real exchange rates of the major industrialized countries.”

In the study [22] (2013) the “effect of macroeconomic fundamentals on real effective exchange rates (REER)” are examined by Holtemöller and Mallick. The paper proposes that “currency misalignment could be used as a leading indicator of potential crisis”. Our findings and our model support this hypothesis, and provide a model to measure the level of currency misalignment.

The 2004 study [23] by Hallett and Richter, takes a more comprehensive approach to exchange rate forecasting than other studies we reviewed. The study provides an excellent discussion of currency exchange rate change symptoms, but not causes. The approach combines the macroeconomic multi-country model, MULTIMOD [6], with FEER. The authors state, that with this approach the MULTIMOD “imposes a steady state solution to define its terminal conditions”, and “likely outcomes for the following five years”. These likely outcome values then, when interpolated for the intermediate years, provide the input, and define the values, for the “FEER equilibrium exchange rates for the near future”. The approach proposed in this study agrees with our approach, that we need to consider a broader set of variables along the lines of at least, what is considered in MULTIMOD [6]. However, while the model inputs are improved when compared to exchange rate forecasting models reviewed in this paper, the model inputs are still projections of macroeconomic outcomes, essentially guesses, by country experts for the following five years, and therefore, at the end, the model forecasts fail.

2.2. No Improvements in Model Outcomes When Compared to Random Walk

Several authors report, that they have not be able to show any improvement in forecasting exchange rates when compared to the random walk models. Here is brief summary.

The paper [4] (2005) (Cheung, Chinn, Pascual) investigated a set of exchange rate models of the 1990s, and concludes that “models that work well in one period do not necessarily work well in another period”, and that “interest rate parity-, and productivity based models” do not perform better than the random walk models.

The 2010 study [24] by Bacchetta, van Wincoop, Beutler, reports that “.. even if we could solve the small-sample problem (by having infinitely long samples), in most cases we would not do much better than the random walk”. Chinn in (2010) [25], as a response (to Bacchetta, van Wincoop, Beutler, (2010) [24]), is critical about their findings, and suggests that “there are other types of parameter variation that could explain the Meese-Rogoff results. Indeed, like nonlinearities, there are a myriad of different types of parameter variation”. And further, Chinn states, that “we do find lots of evidence, in sample, of cointegration between exchange rates and posited fundamentals”. Interestingly, we are in agreement with both Bacchetta et al (2010) [24], that there is no model that can forecast future exchange rates (i.e. not do better than random walk), and we agree with Chinn (2010) that fundamentals matter. However, Chinn’s comment in the above referenced paper [25] (2010) relates to the relationship between exchange rates and fundamentals at the current point in time and considering known data, and focuses on structural characteristics of a model (e.g. “parameter variation”). Chinn’s (2010) [25] comments do not consider, that the fundamentals can explain only part of the puzzle, but not all (see the introduction of this paper - all macro- and microeconomic factors and variables, all societal- and political factors and variables, all environmental (climate-, weather-, natural disasters) factors and variables, and other factors and variables (wars, riots)). It is a complex system, within which some factors and variables follow predictable patterns while others do not. Therefore, we offer, using an analogous but opposite statement to Chinn, that the "book is closed" on this matter.

The paper [27] in (2014) by Moosa and Burns confirmed the "Meese-Rogoff puzzle", that exchange rate models cannot outperform random walk models in out-of-sample forecasting. However, in the same paper, the authors suggest that when measuring the forecasting accuracy differently, the same models would outperform the original random walk model. The reported results of this study are rather gimmicky, and add no new light to improving forecasting. The results offer no proof of generalizable out-of-sample improvement in forecasting capability of exchange rate models. It is always possible to manipulate a model, or technique, using past data, even if the model input is time-sequential, and create a desired outcome. Such outcomes may occur when a modeler subconsciously incorporates characteristic into a model or analysis that has the appearance of improved performance in the known data set.

In (2014) [28] Beckmann and Czudaj report that "Markov switching models, which depend upon a stochastic switching process, have turned out to be a useful tool for modeling exchange rates". The study shows another dimension and view into exchange rate modeling, but, like others, fails in improving forecasting outcomes outside of known data. Therefore, the study essentially supports the Meese-Rogoff (1983) random walk model. In addition, the study shows empirical evidence for relationship between fundamentals and exchange rates. This latter (fundamentals) agrees with findings reported by Beckmann, Belke, Kühl (2011) [29], as well as our hypothesis.

The paper [30] by Beckmann and Schüssler (2016) claims to introduce a "forecasting method that closely matches the econometric properties required by exchange theory". The paper revisits the history of exchange rate modeling by referencing, among other, the Meese and Rogoff (1983) [1] paper, and the Engel et al. (2007) [31] "exchange rate disconnect" puzzle. The paper recites the many findings of exchange rate model forecasting capabilities and failures (e.g. Molodtsova and Papell, (2009), Sarno and Valente (2009)), with an almost desperate attempt to try to solve this puzzle. At the end, the paper appears to fall into the same trap as many others, trying to improve "forecasting" of exchanges rates with some manipulation of regression models.

In (1994) [32], Engel studies Markov switching models, but fails to show that those models can improve exchange rate forecasting.

The study [33] by Mangee (2016) reports that "fundamentals matter" when considering "stock price fluctuations". This finding agrees with our hypotheses and modeling approach relating to "fundamentals". However, the paper also reports that the "predictive ability of a present value model" is "significantly better at medium to longer-run horizons" than the random walk benchmark. We believe, that while exchange rate fluctuations and stock price fluctuations relate, the fundamentals are different, and therefore an extension of the Meese-Rogoff puzzle and concept to stock prices is not meaningful. It is like comparing apples and oranges. The fundamentals (say A) underlying currency exchange rates are vastly broader than those fundamentals (say B) underlying fluctuation of stock prices. And, here B is a proper subset of A, but B will never be equal to A. See the introduction section of our paper for our argument.

The paper [34] by Faust, Rogers and Wright (2003) reports on "forecasting performance" of exchange rate models using different "vintages of data". Findings are not conclusive, but rather confusing, and speculative, for example, it is stated in the paper that "approximately one-third of the improved forecasting performance over a random walk is eventually undone by data revisions". And further, it is stated, that "the models consistently perform better using original release data than fully-revised data, and sometimes forecast better using real-time forecasts of future fundamentals instead of actual future fundamentals." What can be more inconclusive and confusing than that. The paper also references several papers (MacDonald and Taylor (1993, 1994 [12]), Chinn and Meese (1995), Mark (1995), MacDonald and Marsh, (1997)), which claim improvements in out-of-sample forecasting over random walk, and papers (Kilian (1999; Berkowitz and Giorgianni (2001), Berben and van Dijk (1998)) calling those claims into question. All in all, it appears clear, that still the Meese and Rogoff (1983) [1] claim stands.

In (1994) [12] MacDonald and Taylor state among other that "once proper account has been taken of the short-run data dynamics, that an unrestricted monetary model outperforms the random walk and other models in an out-of-sample forecasting contest". This statement and the results clearly do not hold, as here again, like in many of the referenced papers some mathematical manipulation of a model is supposed to improve out-of-sample forecasting of exchange rates. See the introduction section of this paper.

The study [35] by Burns and Moosa (2015) examines whether introduction non-linearity would improve the "forecasting power" of exchange rate models. We agree with the findings that the "Meese- Rogoff puzzle" cannot be explained by introducing non-linearity, or by introducing any other gimmick into a model. We disagree with the reported finding, that exchange rate models "can be enhanced by introducing dynamics through a linear error correction". Exchange rate models are fitted into known data, "error correction" also relates to known data. An error is between something estimated or measured and something known. It cannot be assumed, or extrapolated, that future exchange rates would behave the same way as known data.

In 1991 Chinn [26] argues that "in-sample and out-of-sample nonlinear forecasts yield substantial improvements over a random walk". And further states that "The superiority of the random walk in forecasting exercises such as Meese and Rogoff (1988) may not be so much an indictment of structural models, as much as one of linear structural models". This is another study [25] (see also (2010), in which Chinn attempts to make the case for model structure and model characteristics. We have to note again, that if we do not know the input data to the model, then the features and characteristics of the model (structure, linearity, non-linearity, dynamics, stochasticity, etc.) do not matter.

In the paper [36] Rusek in 2012 reports on the "Eurozone" exchange rates. We agree with the broad statements relating to "perceived causes" and exchange rate misalignments. However, we hypothesize that the relationships are reciprocal not unidirectional. In other words, "loss of a competitiveness, growth slowdowns and currency crises in cases of overvaluation, overheating and inflation in cases of undervaluation, sectoral misallocations of resources and global economic imbalances" can be both causes for currency misalignment, but can also be caused by deliberate monetary and other policies and policy changes.

In Engel, Mark and West in 2007 [31] examine the status of exchange rate models in a working paper titled "Exchange Rate Models Are Not as Bad as You Think". The lengthy discussion covers most of the issues presented in this literature review, but fail to provide any new insights, and any new results for out-of-sample forecasting. The paper also makes a rather interesting and flawed comment that "out-of-sample forecasting power relative to random walk is an unreliable gauge for measuring models". In our opinion, forecasting is supposed to be out-of-sample, the power of a model should be measured out-of-sample, otherwise it is not forecasting. This is also confirmed by K. Rogoff's rebuttal in the same reference source.

- The paper [37] by Asici (2011) investigates "currency crisis models", and identifies that "*exchange rate regime choice*" depends on the "*structural, political and financial features of countries*". The findings relating to factors affecting exchange rates are in alignment with our hypothesized model structure. We, however, propose that there are many more variables affecting exchange rates.
- The study [38] by Patton (2006) reports on interesting findings relating to the strength of currency pair correlation (DMark/USD, JPY/USD) when the currencies (DMark and JPY) are appreciating or depreciating against US dollar. The results indirectly support the reciprocal relationships adopted by our paper.
- The paper [39] by Zahid Ali and Anwar (2011) reports on "*supply-side and demand-side effects of exchange rate variations*". The results indirectly support our paper's the adopted reciprocal relationships, and identify a number of the same economic variables.
- The paper [40] by Morutan (2015) reports on economic variables and economic patterns supporting non-forecastability of exchange rates. This aligns with our paper's hypothesis, because of the inherent complexity and interaction of economic-, political-, business-, environmental- and other variables and conditions.

- The study [41] by Corte, Sarno and Tsiakas (2009) evaluates "*short-horizon predictive ability of economic fundamentals and forward premiums on monthly exchange rate returns*". The paper makes a highly speculative, and non-supportable claim about the future, that "*strategies based on combined forecasts yield large economic gains over the random walk benchmark*".
- The paper [42] by Bénassy-Quéré, Lahrèche-Révil and Mignon (2011) takes an interesting approach on deriving "*equilibrium exchange rates*". The paper talks about "*real effective misalignments of currencies*", which are "*implicitly assumed to be the mirror image of those of the currencies under review*". This latter, in particular, aligns well with our hypotheses and modeling approach. We propose a measure for currency misalignment, and we propose a reciprocal interaction between variables.
- The paper [29] by Beckmann, Belke and Kühl (2011) concludes that "*fundamentals play an important role in determining the exchange rates*". This agrees with our approach on fundamentals. However, the study falls into the same trap as some others (e.g. Meese, Rogoff (1983) [1], Burns, Moosa (2015) [35], Chinn (1991 [26], 2010 [25])) in attempting to explain and suggest that technicalities ("*error correction mechanism*", "*adjustment to disequilibria*", "*adjustment speed*", "*non-linearity*") somehow have something to do with forecasting exchange rates outside of the known data.
- The popular ESTAR models (*Exponential Smooth Transition Autoregressive models*) like other regression models are theoretically elegant, easy to construct and update, and have high utility within known data (see for example Taylor, Peel, Sarno, 2001 [13]). However, ESTAR type of models, and all regression based and related models, have no predictive capability for exchange rate modeling, as we have no past repeating data patterns to fit those models into. It should be obvious, that the quality of the output of a model can be only as good as its inputs. Simple analyses of model variables, parameters and model structure are sufficient to show that ESTAR- and other regression type models have no predictive capability outside of the known data set for exchange rate modeling. The ESTAR and other regression model applications in exchange rate modeling represent a total misunderstanding of what regression models are designed for, and what they are capable of. The ESTAR and other regression based models are in our opinion the "*fool's gold*" of exchange rate modeling. Therefore, models relating to, or derived from, regression type models (line- or curve fitting to known data, historical data, or extrapolated (unknown) data) are not further discussed in this paper.
- Among exchange rate related tools available to policy makers for tracking economic interaction are various periodic currency exchange rate indices. In Frumkin (1990) [43] four such value-of-the-dollar indices are outlined. These indices include the 10 nation *Federal Reserve Board* index, the 15 nation *Morgan Guaranty Trust Company of New York* index, the 17 nation *International Monetary Fund* index, and the 131 nation *Federal Reserve Bank of Dallas* index. These indices are obtained by first determining periodic percentage changes of each nation's currency, and then using (geometric) averaging and weights to combine the currency exchange rate changes into indices. For further discussion about these indices see Artus and McGuirk [66] (1981), Cox (1986) [44], Cox (1987) [45], and Pauls [67] (1987).
- In Barrell and Whitley [19] (1992) and Whitley in [46], [47] (1992) among other, some developments prior to the introduction of Euro, with respect to the European Monetary System (EMS) and the European Monetary Union (EMU), are discussed. Several macroeconomic models are presented. Generally, these macroeconomic models are not designed for exchange rate modeling, e.g. the INTERLINK model, the NiGEM model, the QUEST model, the MULTIMOD-, and the MIMOSA model. For example, of the above models the QUEST, see Horn and Zwiener (1992) [48], the MULTIMOD, see Laxton, Isard, Faruqee, Prasad and Turtelboom (1998) [6] and Whitley [46], [47] (1992), and the MIMOSA, see Chauffour, Harasty and Le Dem [49] (1992), use a similar type of an exchange rate rule. With this rule a future exchange rate is calculated as a function of the current exchange rate adjusted by the nominal interest rate differential and a change in the ratio of the current balance to gross domestic product (GDP). Common to all these exchange rate related model implementations is an attempt to "forecast", or at least find "forward" exchange rates.

- Among the macroeconomic models the MULTIMOD (MARK III), according to Laxton, Isard, Faruqee, Prasad and Turtelboom (1998) [6], is stated to be "*forward looking*" but not to be a "*forecasting tool*". The "*forward looking*" feature comes from the baseline corresponding to the medium term "*World Economic Outlook*" projections. The MULTIMOD framework (inputs, variables, etc.) appears to be suitable to serve also as the basis for developing a model for expected exchange rate. As pointed out earlier, the MULTIMOD model is used, among other, by Hallett and Richter [23] (2004), in combination with FEER.

3. The Exchange Rate Equilibrium Model for the Current Point in Time

3.1. Model Background

Most introductory books in financial management, e.g. Block and Hirt [50] (1992), Philippatos and Sihler [51] (1987), Rao [52] (1989), Ross, Westerfield and Jordan [53] (1991), have a chapter in international financial management discussing some background, basics and history of currency exchange rate systems. These textbooks cover, among other, the absolute purchasing power parity(PPP), the relative PPP, the interest rate parity (IRP), the spot- and forward exchange rates. This paper assumes familiarity with the above topics and concepts. Because these concepts form the basis for the proposed model, a brief review based on the above reference sources is included.

The absolute PPP states that a commodity's price is unaffected by the currency and its exchange rate. The relative PPP incorporates inflation, and states that the exchange rate change depends on the inflation rate difference of the respective countries. Empirical evidence supporting PPP over the long term is reported among other by Wu [54] (1996), and Sarno and Valente [55] (2006), and Rogoff [68] (1996).

But regardless of whether the PPP holds or not, for this paper the important aspect of the below formulation is the reciprocal relationship. We assume that the reciprocal relationship holds for the current point in time. This ratio and the reciprocal relationship will be used in the proposed model. However, it has to be pointed out, that we disagree with the commonly made proposition in financial economics that the forward rate calculated using this formula would be able to "forecast the future exchange in t periods". Therefore, for the discussion of the proposed model, the reader should ignore the exponent t, and just consider the reciprocal relationship. For completeness of discussion relating to this paper we present the formula in its common form as:

$$s_t = s_0\left(\frac{1+i_f}{1+i_d}\right)^t$$

where
s_t = exchange rate in t periods (foreign currency per unit of domestic currency)
s_0 = spot exchange rate at $t = 0$ (foreign currency per unit of domestic currency)
i_f = foreign currency inflation rate
i_d = domestic inflation rate

Similarly, as above, the IRP condition states that the forward exchange rate of a currency depends on the spot-rate and relative risk-free interest rates of the respective economies. We assume that the reciprocal relationship holds for the current point in time. This ratio will be used in the proposed model. Like before, we disagree that the future exchange rate in t periods can be found, or is related to, raising the ratio into the power t. For completeness of discussion relating to this paper we present the formula in its common form as:

$$\phi_t = s_0\left(\frac{1+\rho_f}{1+\rho_d}\right)^t$$

where
ϕ_t = forward exchange rate in t periods
s_0 = spot exchange rate at $t = 0$
ρ_f = foreign country risk-free interest rate
ρ_d = domestic risk-free rate

As criticism of the PPP and IRP formulas, as well as the above referenced, and other, attempts to forecast "(future) exchange rates", it has to be noted that the none of the models, formulas, or ratios have predictive capability for future exchange rate values. In fact, no forecasting model has been shown to work with any degree of reliability or accuracy. However, there is empirical evidence (e.g. Wu [54] (1996), Sarno and Valente [55] (2006)), that the ratios (reciprocal relationships of PPP and IRP) considering the current point in time appear to have validity. Therefore, such ratios and reciprocal relationship will be used in the proposed model.

3.2. The Model

The model is based on work presented by Waissi in [69] 1998a, [70] 1998b, [71] 1999.

The expected value of an exchange rate, or equilibrium exchange rate, is defined as the rate at which the cumulative effect of all "factors" of all trading partners in relation to the domestic economy are in balance. A factor within this context is a formula- or sub-model relating to, and describing, the reciprocal interaction of related variables.

It is proposed that a country should not only consider monetary policy (relating to e.g. interest rates, or money supply), but a coordinated set of policies (monetary-, labor-, incentive-, investment-, tax-, trade-, etc.) to manage exchange rate changes, and to create economic alignments and realignments within an economy to manage change toward a desired strategic objective.

Factors to be considered include, but are not limited to, economic-, societal-, political- and environmental. Factors are determined from, among other, interest rates, unemployment rate, export/import balance, tax regulations and taxes, money in circulation, government debt, private debt, government budget deficits or surpluses, government- and private investments, foreign direct investment (FDI), capacity for entrepreneurship and innovation, quality of education, physical infrastructure, communications infrastructure, health- and wellbeing of people, rule of law, political stability, level of corruption, unionization, and many others.

There is no artificial starting point, or required values for factors and variables. Ideally, all factors and variables should be included, but practically, all those factors and variables are not even known, and at least, data are not available. Therefore, initially one has to make choices in factor selection, which factors and variables are the "most important" (factor and variable "weights"), and which factors and variables to include (compare to multi-attribute modeling (MAM)).

The model is formalized in the following two conjectures, and a corollary.

3.2.1. Conjecture1

The expected value E(s) of the exchange rate s of two currencies, at the current point in time, t=0, is the mean, or equilibrium exchange rate μ_s of two currencies considering all economic-, political-, societal- and environmental factors, say F, as well as the interaction of those factors, affecting the economies of all trading partners of the domestic economy, and is obtained from the spot-rate s_0 using:

$$E(s) = \mu_s = s_0(1 + \sum_{\forall p} \alpha_p F_p + \sum_{\forall p,q} \alpha_{p,q} F_p F_q + \ldots + \sum_{\forall p,\ldots,m} \alpha_{p\ldots m} F_p \ldots F_m)$$

where
s_0 = spot exchange rate at $t = 0$ (as before)
α_x = relative weight of F_x where $x = p, q, \ldots, m$
F_x = factor relating to variable x where $x = p, q, \ldots, m$
$x = p, q, \ldots, m$ variables p, q through m

Assumptions

- The factors are independent and additive.
- The sum of the absolute values of the relative weights of factors is equal to one, i.e. $\sum|\alpha_x| = 1$ *for* $\forall x$.
- Initial values for relative factor weights α_s of factors are assigned by experts, or obtained by fitting the model to market data. Factor weights are improved as more information becomes available.

Conjecture 1 states that the expected value of the exchange rate s at the current time, t = 0, is the spot-rate, unless there are some factors Fx (or forces), which affect the relationship between the economies, attempting to "pressure" the exchange rate equilibrium to change. Conjecture 1 is consistent with the concept of expected value as defined in probability theory, where the expected value of a random variable is the first moment of the random variable with respect to its origin. For finding the expected value all factor- and variable information has to be available and known, and therefore the expected value can be found only for the present time and not for any future time.

The expected value E(s) formulation includes a strong assumption that the factors Fx for ∀x are independent and additive. While this assumption is not likely to hold, it simplifies the model construct significantly. The assumption has to be considered when interpreting model outcomes. It is also clear that factor interaction terms may cause unwanted model bias, and may not improve model outcomes.

Initially, like in multi-attribute modeling, factor weights α_x can be assigned by experts. Factor weight α_x values can then be improved and adjusted by, for example, by fitting the model to historical market data. The model also allows running of different scenarios to study the impact of changes in factors by changing the values of the underlying variables.

3.2.2. Conjecture 2

Each factor F_x in Conjecture 1, has an identical form describing a reciprocal interaction of each variable, say x, between economies:

$$F_x = 1 - \frac{\left(\Pi_{j=1}^{k} \lambda_j (1 + x_j)\right)^{1/k}}{1 + x_d}$$

where
λ_j = relative weight of economy j in relation to domestic economy d where $\sum \lambda_j = 1$ for $\forall j$
x_j = (relative) value of variable x for economy j
x_d = (relative) value of the variable x for the domestic economy d
$j = 1$ to k
k = total number of trading partners of the domestic economy
F_x = factor relating to variable x where $x = p, q, \ldots m$
$x = p, q, \ldots, m$ variables p, q through m

Assumptions

- The variable, say $x = p$, of economy j and the corresponding variable of the domestic economy d are inversely and reciprocally related.
- The weighted geometric average (nominator of the formula) of a specific variable x of all trading partners ($j = 1$ *to* k) and the corresponding variable x_d of the domestic economy are inversely and reciprocally related.
- The sum of the relative weights is equal to one, i.e. $\sum|\lambda_j| = 1$ *for* $\forall j$.

The factor Fx for ∀x uses the ratio formulation of PPP and IRP. The nominator is the weighted geometric average of all economies interacting (trading) with the domestic economy. The relative weight λ varies from economy to economy in relation to the domestic economy as, for example, the level of interaction between economies varies. Obviously, the relative weight of an advanced industrial economy with significant trade and interaction at multiple levels is higher than the weight of a developing economy, or a non-trading economy. Initial values for the relative weights λ of economies are assigned by experts, and measure, for example, the relative amount of activity (e.g. trade) between economy j and the domestic economy d.

Conjecture 2, providing a measure for equilibrium, or balance, between the geometric mean of variables of the trading partners and the corresponding domestic variable, and inferred from the PPP and IRP, is also consistent with the concept of the expected value.

In addition, the empirical findings by Dropsy [56] (1996) support the reciprocal interaction of monetary policy related variables, and the economic growth related variables as proposed by the above model.

Also, the findings by Moosa and Bhatti [57] (1996) support such a reciprocal interaction in their tests of the covered interest parity (CIP). The findings by Ibrahim and Kumah [58] (1996) support the co-movement of macroeconomic variables (budget deficits, money, interest rates, current account balance, ...) between economies. The empirical findings by Parikh and Bhattacharya [59] (1996) also appear to support the proposed model (see e.g. page 463 of the reference).

Within the context of Conjectures 1 and 2 the term "factor" is equated to a "force" attempting to cause a change in the expected value E(s) of the exchange rate s. If the economic relationships between countries are in perfect balance, or at equilibrium, then there is no pressure for the exchange rate to change, and consequently $E(s) = \mu_s = s_0$. For this statement to be true the cumulative factor effect (the sum of the sums) of Conjecture 1 has to equal to zero. Still, this clearly suggests that individual factors may not be zero, but their sum is equal to zero. For an individual factor to have no effect, the value of the geometric average $\left(\prod_{j=1}^{k} \lambda_j (1 + p_j)\right)^{1/k}$ has to equal the value of $(1 + p_d)$ with respect to a variable, say x = p.

If, on the other hand, the economic relationships between countries are not in balance, then there is pressure for the exchange rate to change, and consequently $E(s)= \mu_s \neq s_0$. For this statement to be true the cumulative factor effect (the sum of the sums) of Conjecture 1 is not equal to zero. For this statement to be true the value of the geometric average $\left(\prod_{j=1}^{k} \lambda_j (1 + g_j)\right)^{1/k}$ will not be equal the value of (1+gd) with respect to at least one variable, say g, considering all k trading partners. Hence, $E(s)= \mu_s \neq s_0$ for at least one g.

Corollary: *The exchange rate equilibrium condition is satisfied when the sum of all factors, say F_{cum} is equal to zero. In other words, if*

$$F_{cum} = \sum_{\forall p} \alpha_p F_p + \sum_{\forall p,q} \alpha_{p,q} F_p F_q + \ldots + \sum_{\forall p,\ldots,n} \alpha_{p,\ldots,n} F_p \ldots F_n) = 0$$

In the case presented by the Corollary there is no external pressure for the exchange rate to change. Then the expected value of the exchange rate is equal to the spot rate, and the domestic economy is in balance with respect to the cumulative effect of all considered economies, and thereby the exchange rate is at equilibrium. However, in practice, for example, policy makers may be interested in creating an economic realignment within an economy, and may adjust not only an economic variable (e.g. interest rates, or money supply), but a coordinated set of policies (monetary-, labor-, incentive-, investment, tax-, trade-, etc.) to cause $F_{cum} \neq 0$.

Suppose, we present F_{cum} vs. time t in a Cartesian coordinate system for t=0,1,2,...,n historical time periods, then the horizontal axis forms an "exchange rate market line". It should be noted again, that the last time period (n) can only be up to the current time period, as this model is no attempting to forecast exchange rates. If $F_{cum} > 0$ then $E(s) > s_t$, and F_{cum} falls above the market line, and there is pressure for the domestic currency to appreciate. Conversely, if $F_{cum} < 0$ then $E(s) < s_t$, F_{cum} falls below the market line, and there is pressure for the domestic currency to depreciate. The market line, with respect to the current value of the exchange rate, provides information relating to the current spot rate being below-, at- or above the expected rate. The proposed exchange rate market line concept is similar to the security market line concept of the Capital Asset Pricing Model (CAPM) Sharpe [60] (1964) (see also Doherty [61] (1985), Haley and Schall [62] (1979), Jarrow [63] (1988)).

4. A Simplified Estimator for the Exchange Rate Equilibrium – Empirical Support

In this section we will develop a simplified estimator, as a proof-of-concept and empirical support, for the exchange rate equilibrium model presented in the previous section to demonstrate how the model works. It has to be pointed out again, that this estimator attempts to estimate the expected exchange rate at the current point in time, and it should not be confused with any forward- or future exchange rate estimators. The simplified estimator $\widehat{E}(s)$ includes components for the first set of factors $\sum \alpha_p F_p$ for $\forall p$ only, and excludes all interaction components. The estimator is further simplified by eliminating the geometric averaging, and considering only selected variables for the pair of economies for which the expected exchange rate is being sought. Clearly, from the point of view probability, the resulting estimator becomes a biased estimator, i.e. $E\left(\widehat{E}(s)\right) \neq E(s)$.

The proposed simplified estimator $\hat{E}(s)$ is of the form:

$$\hat{E}(s) = s_0(1 + \sum_{\forall p \in A} \hat{\alpha}_p \hat{F}_p)$$

where
s_0 = spot exchange rate at $t = 0$ (as before)
$\hat{\alpha}_p$ = estimated relative weight of $\hat{F}_p$ such that $\sum |\hat{\alpha}_p| = 1$ for $\forall p$
$\hat{F}_p$ = estimator of factor F_p in a set A of selected variables p

with

$$\hat{F}_p = 1 - \frac{1 + p_j}{1 + p_d}$$

p_j = value of a selected variable p for economy j
p_d = value of the corresponding variable p for the domestic economy d

Among economic variables affecting exchange rates are for example the following: interest rates, inflation, balance of payments (balance of trade), government spending (budget deficit or surplus), government debt, money supply, labor stability, rate of unemployment, etc. Clearly, some of the variables are dependent making the resulting factors dependent, e.g. money supply is known to affect inflation, and also, interest rates and inflation interact.

It should also be noted, that in the presented estimator $\hat{E}(s)$ the ratio $\hat{F}_p$ is of the same format as the ratios of the relative PPP and the IRP. In fact, $\hat{E}(s)$, when using $\hat{F}_p$, reduces to st for t=1, if we assume that $\hat{\alpha}_p$ = -1, and substitute the respective inflation rates for pj and pd. Similarly, $\hat{E}(s)$ can be shown to reduce to Φ_t for t=1.

Example

This example outlines some intuitive cases for the components of $\hat{E}(s)$ for interest rates (discount rate), money supply, inflation, balance of payments (balance of trade), and government spending (budget deficit or surplus). Other similar relationships may be developed along these same lines.

4.1. Estimator of the Factor of Discount Rate

$$\hat{F}_\rho = 1 - \frac{1 + \rho_f}{1 + \rho_d}$$

where
ρ_f = foreign country discount rate
ρ_d = domestic discount rate

The IRP uses also the above ratio for calculation of forward exchange rates. Here, instead of "risk free rates", the discount rate is used. Now, as an example, if the foreign country discount rate is greater than the domestic discount rate, then the ratio is greater than one, and $\hat{F}_\rho$ becomes negative. Consequently, as borrowing is more favorable in the lower rate domestic economy, then, among other, direction of flow of money should be toward the domestic economy, therefore, there should be pressure for the domestic currency to appreciate or strengthen in value against the foreign currency suggesting that $\hat{\alpha}_\rho < 0$.

4.1.1. Estimator of the Factor of Relative Money Supply Change

$$\hat{F}_\eta = 1 - \frac{1 + \eta_f}{1 + \eta_d}$$

where
η_f = foreign country relative money supply change; increase (+), decrease (-)
η_d = domestic relative money supply change; increase (+), decrease (-)

This relationship also follows Conjecture 2. For example, if, for the foreign country, the periodic money supply change (increase) is greater than the domestic periodic money supply change (increase), then the ratio in the equation is greater than one, and there is pressure for the domestic currency to appreciate or strengthen against the foreign currency. In such a case $\hat{F}_{\eta}$ becomes negative suggesting that $\hat{\alpha}_{\eta} < 0$. See also Dropsy [56] (1996) and Parikh and Bhattacharya [59] (1996).

4.1.2. Estimator of the Factor of Inflation

$$\hat{F}_i = 1 - \frac{1 + i_f}{1 + i_d}$$

where
i_f = foreign country inflation rate
i_d = domestic inflation rate

The relative PPP uses also the ratio for calculation of exchange rates. For example, if the foreign country inflation rate is greater than the domestic inflation rate, then the ratio is greater than one, and there is pressure for the domestic currency to appreciate or strengthen against the foreign currency. In such a case $\hat{F}_i$ becomes negative suggesting that $\hat{\alpha}_i < 0$. See also Moosa [64] (1996), and MacDonald [65] (1996), and Wu [54] (1996).

4.1.3. Estimator of the Factor of Relative Balance of Payments (balance of trade)

$$\hat{F}_\tau = 1 - \frac{1 + \tau_f}{1 + \tau_d}$$

where
τ_f = foreign country export relative to its total trade
τ_d = domestic export relative to total trade

It is assumed in this model that the economic relationships between trading partners work in a reciprocal way, and tend to follow the form of the IRP condition (Conjecture 2). For example, if, for the foreign country, the fraction of exports of its total trade is greater than the domestic fraction of exports of total trade respectively, then the ratio in the above equation is greater than one, and there is pressure for the domestic currency to depreciate or weaken in value against the foreign currency. In such a case $\hat{F}_{\tau}$ becomes negative suggesting that $\hat{\alpha}_{\tau} > 0$. See also Ibrahim and Kumah [58] (1996), and Parikh and Bhattacharya [59] (1996).

4.1.4. Estimator of the Factor of Relative Government Spending (Deficit/Surplus)

$$\hat{F}_\gamma = 1 - \frac{1 + \gamma_f}{1 + \gamma_d}$$

where
γ_f = foreign country relative budget deficit (-) or surplus (+)
γ_d = domestic relative budget deficit (-) or surplus (+)

This relationship follows also Conjecture 2. For example, if, for the foreign country, the relative budget deficit (surplus) of its total budget is smaller (greater) than the domestic relative budget deficit (surplus) of total the total budget respectively, then the ratio in the equation is greater than one, and there is pressure for the domestic currency to depreciate or weaken in value against the foreign currency. In such a case $\hat{F}_{\gamma}$ becomes negative suggesting that $\hat{\alpha}_{\gamma} > 0$. See also Ibrahim and Kumah [58] (1996).

On the other hand, if, for the foreign country, the relative budget deficit (surplus) of its total budget is greater (smaller) than the domestic relative budget deficit (surplus) of total the total budget respectively, then the ratio in the equation is less than one, and there is pressure for the domestic currency to appreciate or strengthen in value against the foreign currency. In such a case $\hat{F}_{\gamma}$ becomes positive suggesting that $\hat{\alpha}_{\gamma} > 0$.

4.1.5. The Estimator $\hat{E}(s)$

The estimator $\widehat{\mathrm{E}}(\mathrm{s})$ for the exchange rate then, when combining the above estimators (p = ρ discount rate; p = η relative money supply change, increase (+), decrease (-); p = i inflation rate; p = τ export relative to total trade; p = γ relative budget deficit (-) or surplus (+)) using the simplified formula, and omitting factor interactions, becomes

$$\hat{E}(s) = s_0(1 + \sum_{\forall p \in A} \hat{\alpha}_p \hat{F}_p)$$

and, therefore

$$\hat{E}(s) = s_0(1 + \hat{\alpha}_\rho \hat{F}_\rho + \hat{\alpha}_\eta \hat{F}_\eta + \hat{\alpha}_i \hat{F}_i + \hat{\alpha}_\tau \hat{F}_\tau + \hat{\alpha}_\gamma \hat{F}_\gamma)$$

where
$p = \rho$ discount rate
$p = \eta$ relative money supply change; increase (+), decrease (-)
$p = i$ inflation rate
$p = \tau$ export relative to total trade
$p = \gamma$ relative budget deficit (-) or surplus (+)

4.2. With Some Data

This section shows a simplified example of estimating the cumulative factor effect and determining the difference between the spot rate (s0) and the expected exchange rate (E(s)). The data for these examples were downloaded from the following sites: [D.1] International Monetary Fund (IMF), [D.2] Bank of Japan (BOJ), [D.3] Wall Street Journal (WSJ), and from [D.4] the tradingeconomics.com sites. [see links in the list of references].

Figure 1 shows the inflation rates of Japan and the United States over a period from 1980 to 2015. Figure 2, correspondingly, shows the interest rates of Japan and the United States for the same period from 1980 to 2015.

Figure1. *Inflation rates: United States and Japan for the period 1980 – 2015; [See D.1, D.2, D.3, D.4]*

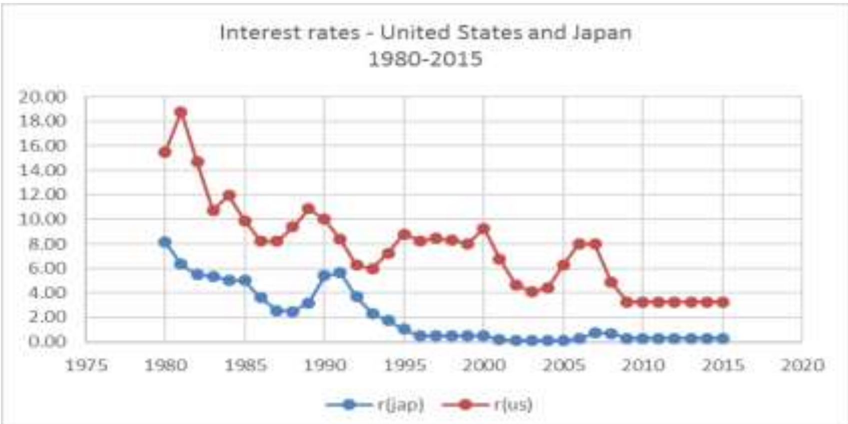

Figure2. *Interest rates: United States and Japan for the period 1980 – 2015; [See D.1, D.2, D.3, D.4]*

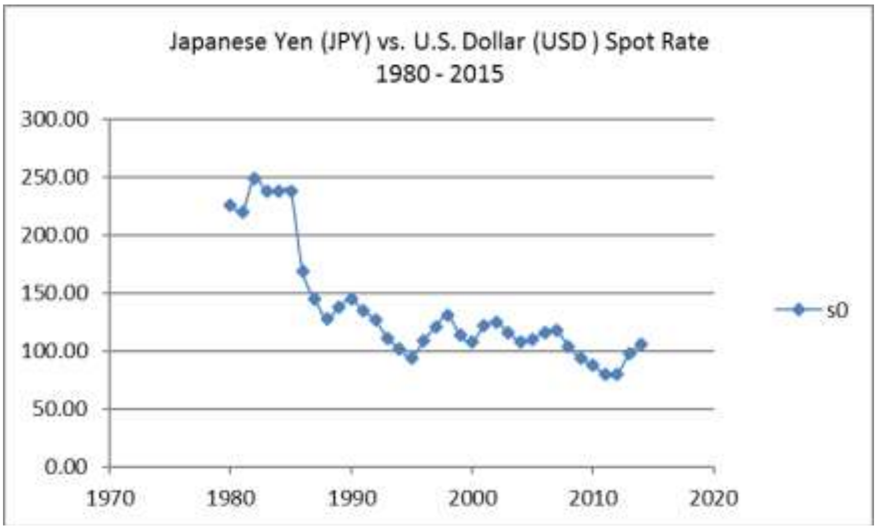

Figure3. *Spot rate: JPY vs USD for the period 1980 – 2015; [See D.1, D.2, D.3, D.4]*

Figure 3 show the spot exchange rate of Japanese Yen (JPY) vs the U.S. Dollar (USD) also for the period from 1980 to 2015.

Figure 4 shows the cumulative factor effect Fcum calculated using the simplified version of the Estimator $\widehat{E}(s)$, see the previous section, using the first-order components only. In the example only the interest rate- and inflation rate- factors were calculated to obtain the $\widehat{E}(s)$ estimates ("interest rate" representing a "policy tool", and "inflation rate" representing the "market response"). The absolute values of the relative weights for the factors were assigned to $|\widehat{\alpha}_{\rho}| = 0.8$ (relative weight for the factor interest rates; $\widehat{F}_{\rho}$) and $|\widehat{\alpha}_{i}| = 0.2$ (relative weight for the factor inflation; $\widehat{F}_{i}$). The initial values for the factor weights α_x of variables x = ρ and x = i are "expert estimates". The relative values of the factor weights add up to one, and represent the perceived importance of each factor respectively. The values of the factor weights can be adjusted to test different weight (and thereby perceived importance) scenarios.

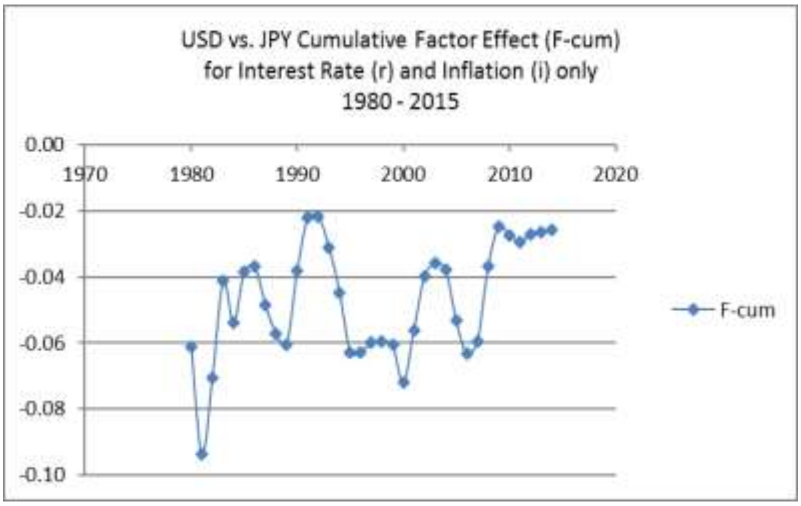

Figure4. *Cumulative Factor Effect for Currency Pair USD-JPY for 1980-2015*

Figure 5 shows the difference between the spot rate (s0) and the expected exchange rate E(s) as "Delta = s0 – E(s)". A negative Delta suggests that there is pressure for the domestic currency (USD) to depreciate. Between 1980 and 1990 the U.S. Dollar (USD) depreciated significantly against the Japanese Yen (JPY), see Figure 3. In 1980 – 1982 JPY/USD rate was approaching 250. During those years (1980-1982) the cumulative factor effect absolute value was around 0.08, see Figure 4, and the absolute value of the Delta (difference between the spot s0 rate and the expected exchange rate E(s)) was about 20, see Figure 5. The cumulative factor effect appeared to suggest a significant misalignment of the JPY/USD exchange rate. Around the end of the decade in 1990, the spot exchange rate had moved to below 150 (Figure 3). Around 1990 the absolute value of the cumulative factor effect had dropped to about 0.02 (Figure 4), and the absolute value of Delta had dropped to around 3, (Figure 5).

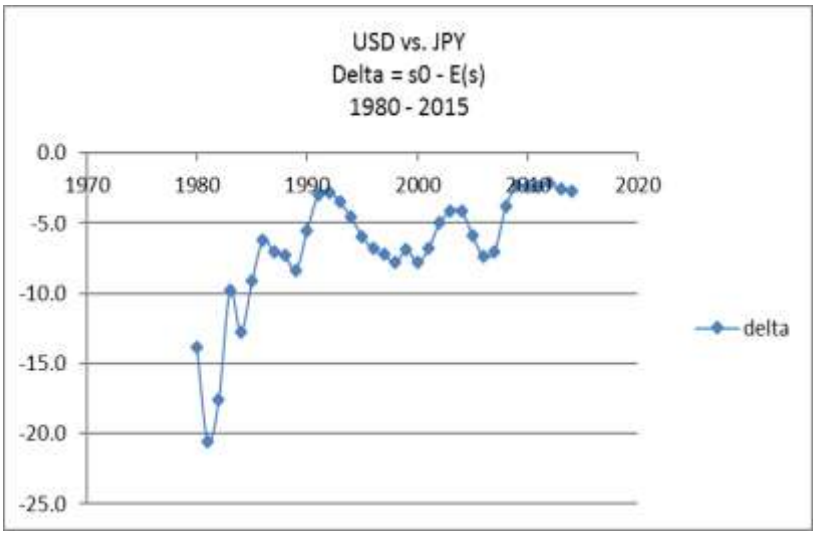

Figure5. *Difference between the Spot Rate and E(s) (= Delta) for Currency Pair USD-JPY for 1980-2015*

As a conclusion of this example, and based on this data only, we hypothesize, that the more aggressive interest rate cuts of the U.S., from about 18 percent in 1981 to about 10 percent in 1990, compared to the interest rates cuts of Japan from about 8 percent to just below 6 percent during the same time, had, partially, brought the currency exchange rate closer to equilibrium as defined in this paper.

5. Conclusion

In this paper the expected value E(s) for an exchange rate s is redefined, and a simple model for the expected exchange rate is proposed. The expected value of an exchange rate is calculated for the present time only. It is emphasized that in this paper there is no attempt to forecast future rates. It is also noted, that it appears futile and non-sensible to try to forecast future exchange rates. This is not only because of the complexity an economy, but because of other economic-, societal-, political- and environmental factors and their interaction within- and external to a country. Some of those follow seasonal patterns and predictability, but others (e.g. natural disasters, war, political decisions) defy predictability.

The model infers from the literature a reciprocal economic variable relationship, and combines those to a single model. The expected value definition is consistent with the definition of the expected value of a random variable as used in probability.

A simple estimator $\widehat{\mathrm{E}}(s)$ is also developed for E(s). The estimator can be used for quick analysis to determine e.g. cumulative economic pressures attempting to appreciate or depreciate the current exchange rate. The numerical example demonstrates, using interest rates and inflation rates only, how the model works. The modeling approach shows promise for helping to analyze and understand interaction of economies.

A simple example of the model application using the U.S. Dollar (USD) and the Japanese Yen (JPY) exchange rates for the period from 1980 to 2015 is provided. This example shows the cumulative factor effect for the JPY-USD pair, as well as the difference between the expected exchange rate and the spot rate. The example demonstrates that a need for an economic realignment within an economy may call for a coordinated set of policies (monetary-, labor-, incentive-, investment, tax-, trade-, etc.) to try to keep the expected exchange rate above or below the spot-rate for extended periods of time, i.e. show a positive or negative “cumulative factor effect” with respect to the exchange rate market-line. In other words, a country may choose to implement or continue a coordinated policy approach which attempts to keep the domestic currency misaligned for extended periods of time to, for example, “force” an economic realignment within the domestic economy. This modeling approach provides an additional tool for analysis and comparison, for policy makers to understand and to manage cycles of economic expansions and contractions.

6. Sources of Data (Downloaded Between January 1, 2015 and December 30, 2016)

[D.1] International Monetary Fund (IMF)
http://www.imf.org/external/pubs/ft/weo/2012/01/weodata/WEOApr2012all.xls

[D.2] Bank of Japan (BOJ)

http://www.stat-search.boj.or.jp/ssi/mtshtml/m_en.html

[D.3] Wall Street Journal (WSJ)
http://www.fedprimerate.com/wall_street_journal_prime_rate_history.htm#current

[D.4] Tradingeconomics

http://www.tradingeconomics.com/united-states/bank-lending-rate

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AUTHOR'S BIOGRAPHY

Dr. Gary R. Waissi, serves currently as Professor of technology entrepreneurship at the Polytechnic School, Ira A. Fulton Schools of Engineering, Arizona State University, Arizona, United States. Dr. Waissi's research interests include engineering systems, systems modeling, strategy, internal combustion engines

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