MACROVARIABLES IN DETERMINING THE EXCHANGE OF THE U.S. DOLLAR AND MAJOR CURRENCIES

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ABSTRACT

Purchasing Power Parity and Interest Rate Parity are well established theories of exchange rate determination. Purchasing Power Parity is basically the law of one price, a basket of goods and services are priced in one country, and the same basket of goods and services are priced in another country and the exchange rate is determined based on the price of the commodity basket in each country. Interest Rate Parity is another theory which states that the Interest Rate Parity determines exchange rate. This paper finds that although Purchasing Power Parity and Interest Rate Parity are well established theories of exchange rate determination, there are other variables which are unique for each country for determining exchange rate for those individual countries. In the case of the U.S. dollar it was found that there are some macrovariables which determine the exchange rate of the dollar against its major trading partners. Therefore we cannot say that exchange rate of every country in determined by Purchasing Power Parity or Interest Rate Parity alone. This paper finds that there are some macrovariables that determine the exchange rate of the dollar against some major currencies.

INTRODUCTION

The most well established theories of exchange rate determination are Purchasing Power Parity and Interest Rate Parity. If the absolute Purchasing Power Parity holds, this means that exchange rate is determined by relative prices in two countries and there would be no opportunity for arbitrage profit by speculating in the foreign exchange market. It has been found that although Purchasing Power Parity holds in the long run between the United States and other industrialized countries, Purchasing Power Parity does not hold between the United States and other developing countries. Therefore, there is reason to believe that exchange rate is determined not only by Purchasing Power Parity but there are other variables which are unique to each country for determining exchange rate. The absolute form of Purchasing Power Parity implies that if exchange rate changes deviates from PPP it affects

the competitiveness of a country in international trade (Haque, 2003). Empirical studies failed to prove PPP holds, nevertheless, it remains a valid theory for Academicians and practitioners. If you are planning to take a job in Bangladesh, converting your U.S. salary into Bangladesh taka, it will not give you the true purchasing power, because cost of living in Bangladesh may be significantly lower. Most of the empirical study on Purchasing Power Parity has given negative results; therefore, this study tries to find what variables are important in determining exchange rate for each individual country. The results clearly indicate that even within the OECD and European Union countries there is significant difference in cost of living in different countries (Vachris & Thomas, 1999).

The theory of Interest Rate Parity holds that one cannot make arbitrage profit by speculating in foreign exchange market due to different interest rate in different countries. Let us say for example that interest rate is 8 percent in the U.S. and 6 percent in U.K. Investors in U.K. will want to transfer funds to the U.S. to invest at the higher prevailing interest rate. Suppose they have a 3 month investment horizon, at the end of 3 months the pound will appreciate against the dollar. Because of the depreciation of the dollar, the U.K. investor will receive fewer pounds which will wipe out any gain made from the higher interest rate in the U.S. Therefore, the British investor will not be any better off by investing in the U.S. to take advantage of the higher interest rates. In order for the British investor to make any gain, the investor buys dollar in the spot market and sells dollar in the forward market. The opportunity to make this arbitrage profit will induce all British investors to buy dollar in the spot market and sell dollar in the forward market. This will cause an appreciation of the dollar in the spot market and depreciation of the dollar in the forward market until equilibrium is reached and arbitrage profit is wiped out. In a study it was found that although Interest Rate Parity holds for the most part between the U.S.A. and other industrialized countries, it does not hold between the U.S.A. and developing countries, therefore it is possible to make arbitrage profit in foreign exchange speculation through covered interest arbitrage (Haque, 2003). Uncovered Interest Rate Parity suggests that existence of different interest rates in different countries can be explained by expected changes in exchange rates, although, empirically this theory does not hold (Micheal & Christensen, 1999). Therefore, one could reasonable argue that there are other factors besides interest rates that influence exchange rate determination.

Since it is found thus far that neither Purchasing Power Parity or Interest Rate Parity alone or combined determines exchange rates, there are other variables that are unique in determining exchange rates for different countries.

This study was undertaken to determine whether the exchange rate of the dollar is dependent upon some macrovariables, especially against its major trading partners Canada, Europe, Japan and also the SDR. The study found that in all of these cases the exchange rate of the dollar against these currencies depends on some U.S. macrovariables. Similar studies were undertaken to determine the exchange rate of the British pound against its major trading partners.

METHODOLOGY

Data were collected and compiled on the following macrovariables for the United States economy: Gross Domestic Products, exports, imports, national income, personal consumption, personal income, farm income, corporate profits and unemployment for the years 1997 to 2006.

Similarly, data were compiled on the exchange rate of the dollar against major currencies: Japanese yen, Euro, SDR, and Canadian dollar for annual average from 1997 to 2006. The direct quote was used for the regression. The macrovariables were used as independent variables and the exchange rate between each currency and the U.S. dollar as the dependent variable. A separate regression was used for the macrovariables and each of the major foreign currencies.

In multiple regression backward elimination was used which is largely a trial and error procedure to derive the best regression estimates. This involves computing a regression equation with all the independent variables, then going back and deleting independent variables which do not contribute significantly.

LITERATURE REVIEW

In an article regarding theoretical issues in exchange rate determination, it discusses the ability of the sticky price general equilibrium model in explaining the behavior of nominal and real exchange rate. It shows that structural macroeconomic models are unsuccessful in explaining exchange rate movements. Three popular structural models of exchange rate are flexible price monetary models, sticky price monetary models and portfolio balance models. These models show that an unanticipated money supply increase will increase welfare in the short run because money supply shocks lead to increased consumption leading to higher output levels. The main feature of these models is the fact that there is no deviation from Purchasing Power Parity even in the short run (Crosby & Voss, 1999).

Empirical evidence has shown that the speed at which prices and interest rates transmits is not fast enough to keep parity in the short run with the foreign exchange market. Current exchange rate models ignore future exchange rate behaviors. It is believed that gold price movements have great explanatory power with respect to exchange rate movement. Gold price data is used because it is considered a highly homogenous commodity and is continuously traded in all markets. It is empirically shown that the exchange rate between Europe and U.S./Japan have a significant effect on U.S. gold prices. However, the article proposes a relationship between stock return and exchange rate. It was found that a weak positive relationship existed between real stock return differentials and changes in the real exchange rate over the 1979 to 1983 period. Therefore, they conclude return in share market and return in foreign exchange market move together. Because share prices adjust quickly to new information, therefore, it should be used in models for exchange rate determination.

Because a depreciation of a currency leads to higher exports and therefore to higher corporate profits, it can be said that there is a relationship with share market and exchange rate. Since depreciation of a currency leads to higher share market return, therefore, it is concluded that there is a relationship between stock market return and exchange rate (Ong & Izan, 1999). In a study about exchange rate hysteresis the author develops a theory of exchange rate that hysteresis generates through hysteresis in the current account. It is found that trade account hysteresis leads to hysteresis in exchange rate and vice versa. Trade account is an important variable in determining exchange rate (McCausland 2000). Papadopoulas and Zis in discussing the flexible monetary model states that the model is based on the assumption of Purchasing Power Parity hold constantly and demand for money functions of the domestic and foreign economies are stable. They wanted to find whether there is a long run equilibrium exchange rate between Drachma and the ECU. In testing the order of integration, they employed Augmented Dickey Fuller (ADF) and Phillips-Perrons (PP) tests. They identify a quadratic trend. For analyzing the determination of the Drachma/ECU exchange rate, a four equation parsimonious VAR was used. They determined a well defined exchange rate equation which was not satisfactory in the short run. The results were consistent with monetary approach of exchange rate determination. Although the findings are satisfactory, the usefulness of the model is limited because the sample period is short and extends only to 1991. However, the findings do establish the monetary approach to exchange rate determination (Papadopoulas & Zis, 2000).

Coakley and Fuertes in discussing the application of linearity test in estimating nonlinear models, the findings show that in the presence of transactions costs, real exchange rate adjusts towards equilibrium in a nonlinear way. Their study suggests that nonlinearities because of transaction cost is consistent with PPP. In doing the nonparamatric cointegration analysis the real exchange rate has been defined as the nominal exchange rate deflated by relative price indices. They use Phillips-Perron (PP) test where the data were nonstationary and Bienens and Guo test where the data were stationary. They used the limit root tests on the nominal exchange rate. Then, they used the mean reversion to see if real exchange rates and relative prices are cointegrated with vector. They did this analysis on 18 OECD countries and found cointegration in eight of those countries. Bienens test showed evidence of cointegration for15 out of 18 countries based on CPI. However, cointegration is rejected for five of those countries. The article shows that nonlinear real exchange rate adjustment is valid (Coakley & Fuertes, 2001).

Tawadros in his study tests the predictive power of the monetary model exchange rate determination using cointegration based error correction model and finds that the model performs better than random walk model. Literature is cited which tested the validity of the monetary model using regression based methodology. It is suggested to use the Johansen technique, because of its proven success for the monetary model. It has proven successful in studying the back market exchange rate data for Pakistan, India and Sri Lanka. Johansen have developed a multi-variate technique which provides maximum likelihood estimates on all the cointegrating vectors which might be in existence between all variables. Johansen

method estimates the vectors directly which is otherwise not possible using conventional methods. It allows direct hypothesis testing of all the coefficients which enters the cointegrating vectors. However, its drawback includes the ambiguity of how to interpret when more than one cointegrating vector is found. Another weakness is the lack of separating the variable into endogenous and exogenous categories. In the study Dickey-Fuller and Phillips-Perron tests were used for testing the nonstationarity. The study found a single long run relationship between exchange rate, money supplies, industries output and short-term interest rate (Tawadros, 2001).

Stemp examines the impact of monetary and fiscal policy on exchange rate. He discusses the two well established theories of exchange rate determination, Purchasing Power Parity and asset market approach which is also known as interest rate parity. Fiscal policy and exchange rate is discussed in the context of IS/LM and balance of payments context. Expansionary fiscal policy leads to increased government expenditure or reduction of taxes. This leads to an increase in the aggregate level of demand for output at specific interest rate. This causes a rightward shift of the IS curve. This will induce foreign capital inflows which will lead to an appreciation of the domestic currency. This will reduce exports. Appreciation of the domestic currency and the reduction of exports will continue until the IS curve shifts back to its original long-run equilibrium. Therefore, the impact of an expansionary fiscal policy is neutralized by an appreciation of the domestic currency. The opposite will be true of a contractionary fiscal policy which will lead to a depreciation of the domestic currency. Expansionary monetary policy takes effect either by increasing monetary aggregate as reduction in interest. From the context of IS/LM and balance of payments, a reduction in domestic interest will lead to asset flows causing a depreciation of the domestic currency and increase in exports. This will continue until IS/LM equilibrium is restored at a higher level of output. In other words, if the Federal Reserve reduces interest rates, the Bank of England will also have to reduce interest rates to avoid an appreciation of the British pound against the U.S. dollar (Stemp, 2001).

In discussing the effect of news on exchange rates, Newley in his study allows for risk averse investors, makes adjustment for nonstationary data, which is determined using vector autoregressive approach and news is used in a more general way. News variables include money supply, real income and interest rate. Two different methods were used to compensate for the risk premium panel data and GARCH. Results from both techniques indicate that there is no relationship between news and exchange rates (Newley, 2002).

Camarero in a study of the IMP fiscal impulses and the determination of the real exchange rate of the Spanish peseta applied the Keynesian asset model for determining real exchange rate. The findings show that IMP fiscal impulses are not useful in determining real exchange rate with the exception of pound sterling and two vectors (Camarero, 2002).

Petrovic and Miladenovic in their study find that monetary model of exchange rate does not work in time of hyperinflation. They present the case of Yugoslavia during its period of hyperinflation. Usually it is assumed that domestic money supply and demand sets prices and Purchasing Power Parity sets the exchange rate. However, in times of

hyperinflation, the public bases its decision on exchange rate rather than prices. All prices and incomes are expressed in foreign currency rather than domestic currency. Public uses foreign currency in determining domestic money holdings. Their results show that exchange rate is determined by the expected future growth of money supply and it is set in the money market. The findings suggest a modified monetary model of exchange rate determination in periods of hyperinflation (Petrovic & Milad). Most of the literature review centers around Purchasing Power Parity and Interest Rate Parity. One important consideration should be cash flow in and out of the country. The model presented here takes into account this important factor of cash flow.

The exchange rate is usually defined as the relative price of two assets: domestic money and foreign money. A number of theories explore determinates of exchange rates.

Flexible Price Monetary Model

The flexible price monetary model assumes continuous absolute purchasing power parity, uncovered interest rate parity, perfect asset substitution, equilibrium in the goods, labor, and foreign exchange markets. Taylor (1995) notes that there are six aggregate markets in open economy macroeconomics: money, goods, labor, foreign exchange, domestic non-money assets, and foreign non-money assets. With equilibrium being assumed in the other major markets, the supply and demand for money becomes the primary focus of the monetary model.

Purchasing Power Parity (PPP) is based on the theory that in *efficient markets* goods have the same prices wherever they are purchased. The exchange rate that brings about this purchasing power parity is referred to as the real exchange rate and is equal to the ratio of the national price levels of the two countries. Empirical studies find some support for long-run purchasing power parity (Taylor 1995).

Efficient Markets are a necessary assumption of PPP. There are various forms of market efficiency, but all require market participants to have rational expectations. Weak form efficiency implies that information from past exchange rates are incorporated into the current spot exchange rate thereby eliminating the possibility of profitable trading strategies based on past exchange rate movements. A stronger form of efficiency would indicate that all available information is reflected in the current spot exchange rate.

Caves and Feige (2001) perform several tests of market efficiency relative to exchange rates. They conclude find evidence that supports the weak form of market efficiency with respect to the U.S.-Canadian market. Beyond past prices alone, they also find that the relative level of US and Canadian stock of money cannot be used as a leading indicator for the exchange rate.

Interest Rate Parity is a theory that the differential in the interest rates of similar interest bearing assets of two countries is equal to the differential between the contractual forward exchange rate and the current spot exchange rate. This condition eliminates the

possibility of earning riskless profits from the interest rate differential. Uncovered Interest Rate Parity assumes risk neutral investors; therefore the risk premium is zero.

Sticky Price Monetary Model

Dornbusch (1976) originated the sticky-price monetary model. This model assumes goods prices do not change instantaneously, but are sticky. Purchasing power parity holds in the long-run, but the model allows for deviations from PPP in the short-term. The sticky goods prices impact real and nominal exchange rates as these overshoot their long-run equilibrium rates to compensate for the sticky goods prices. As goods prices move to their equilibrium, exchange rates also revert to their long-run equilibrium levels (Taylor 1995).

Equilibrium Models

The equilibrium model relaxes the assumption of perfect substitutability of foreign and domestic goods. Agents in this model have clear preferences. Whereas the focus of the monetary models is solely on the supply and demand for money, equilibrium models focus on demand for both goods and money. The degree of substitutability between foreign and domestic goods determines the size of the effect due to goods. A number of studies have shown departures from purchasing power parity. Stockman (1980) presents an equilibrium model of the determination of exchange rates in which deviations from purchasing power parity and exchange rate volatility can occur within an equilibrium framework.

Portfolio Balance Approach

The main difference between the portfolio approach and the monetary models is that the portfolio balance approach assumes imperfect substitutability of domestic and foreign assets. The exchange rate is determined by all foreign and domestic assets, monetary and non-monetary.

Goodman (1982) presents a portfolio model for a bank optimization of foreign exchange activities. The model incorporates foreign exchange behavior and other variables such as default risk and the market price of risk. Increased participation in foreign exchange market and risky assets increases default risk. Increased default risk increases the cost of borrowed funds. The model demonstrates why it is profitable for some banks to enter the foreign exchange market and not profitable for others.

Effects of Relaxing Exchange Rate Model Assumptions

Honohan (1984) looked at the effects of a sudden reduction in the rate of monetary expansion on exchange rates and interest rates using a number of different models. Assuming rational expectations and risk neutrality the nominal interest rate will fall. Speculators who

have rational expectations, but are risk adverse, will moderate the overshooting of exchange rates and the reduction of interest rates. In the final model rational speculators are allowed to make transitory errors in forecasting the long-run equilibrium. The allowance for transitory forecasting errors leads to a pattern of an initial increase in nominal interest rates and a gradual response of the exchange rate. This result is similar to the observed behavior of exchange rates.

Recent empirical work indicates long-run elasticities are generally about twice as large as short-run. Bhandari (1983) suggests these results indicate that adjustment of aggregate demand to a change in terms of trade is a dynamic rather than static process. Bhandari constructs a simple macro-dynamic model of the economy which incorporates the lags involved in complete adjustment of aggregate demand to a given change in terms of trade and interest rates. The model assumes flexible prices, continual commodity market equilibrium, a perfectly integrated capital market, a partially integrated commodity market, and endogenously determined domestic currency price of exports. The model predicts that monetary disturbances will cause more relative volatility in the spot exchange rate than real disturbances.

Most models assume there is no uncertainty in the purchasing power of the currencies. Stulz (1984) expands the literature on exchange rate determinants by investigating the effect of purchasing power risks on exchange rates. Stulz models a number of macro variables that indicate the relative uncertainty present in a particular economy. The theory postulates that when the purchasing power of the domestic currency is riskier than the purchasing power of foreign currency, the ratio of foreign money held relative to domestic will be greater. Therefore, changes in the purchasing power risks of two currencies will affect the exchange rate.

He and Subhash (1997) expand the basic monetary model to allow for currency substitution. Foreign and domestic residents can hold the currency of the other country. The demand function for money includes money supply, price level, industrial production, and the domestic interest rate. The authors conclude that the model is a valid long-run exchange rate determination model for some of the currencies tested and currency substitution is an important factor.

A Canada/United States exchange rate equation developed by Amano and van Norden (1993) performs well over the 1973–1990 estimation period. It continued to perform well for an additional 13 beyond the estimation period. The dependant variable is the nominal Canadian/U.S. exchange rate deflated by the gross domestic product price indices for Canada and the United States. Variables include an energy variable, a non-energy commodities variable, and the spread between U.S. and Canadian 90-day commercial interest rates. The model does not perform well after 2003. Possible explanations for the change in the performance include changes in the proportion of Canadian exports that are energy related, the growing U.S. current account deficit and currency depreciation, and different rates of growth in productivity between the U.S. and Canada. Models adding a variable for each of

these possibilities significantly improve the model's performance. However, combining all three variables with the original equation has not been successful (Bailliu 2005).

Table 1 Exchange Rate Models and Assumptions

	Basic flexible price monetary model	Basic sticky price monetary model	Equilibrium model	Portfolio balance approach	Efficient market
Assumptions:					
Risk neutral	X	X			X
Rational Expectations	X	X			X
Flexible prices	X				
Uncovered interest rate parity condition	X	X			X
Continuous purchasing power parity	X	PPP in long run only			
Perfect substitutability of foreign/domestic goods Equilibrium in Goods market	yes	yes	Differentiate between goods		
Perfect substitutability of foreign/domestic assets	yes	yes		Imperfect substitutes	
Equilibrium in labor market	yes	yes			
Equilibrium in foreign exchange market	yes	yes			
Currency substitution	Generally no	Generally no			
Results of Empirical Tests:					
Does the model outperform a random walk	Generally no	Generally no			
Results of other empirical tests	Evidence weak beyond late 1970s	Evidence weak beyond late 1970s	Weak support	Poor results	Some support for weak form

A number of studies look to the behavioral and psychological literature as a possible answer for unexplained movements in exchange rates. Harvey (2006) looks at the type of behavior expected of agents and the limitations of market participants. The cultural environment that agents operate in has significant influence on their decision making which can lead to bandwagon effects and other 'irrational' behavior.

RESULTS OF THE REGRESSION

For the exchange rate between the Japanese yen and the U.S. dollar all variables seem significant except GDP, with a R^2 of .956.

For the exchange rate between the Euro and U.S. dollar all variables were significant except GDP and unemployment rate with a R^2 of .999.

For the exchange rate between the U.S. dollar and SDR all variables except GDP and unemployment rate with a R^2 of .996.

For the exchange rate between U.S. dollar and Canadian dollar all variables except GDP were significant with a R^2 of .995.

Table 2 Summary of Regression

	R2	F	Sig.
Regression with:			
Can $	0.995	50.789	0.019
SDR	0.996	96.157	0.002
Euro	0.999	367.346	0
Yen	0.956	5.444	0.164

From the above table it is apparent that all the regression gave very good fit. Because Can $, SDR and Euro have very high F value and the significance of the F value tells us that it is almost impossible to come up with such a high F value by chance. Only in the case of the Japanese yen the model seems weak because of the low F value and the significance is pretty high.

It is clear from the table the multiple regression between the dollar and the Canadian dollar, SDR and Euro gave us a very strong model and based on the F value and its significance, these three models are fairly accurate for predicting exchange rates. In the following regression models the variables are:

X_1 = Gross Domestic Products
X_2 = Exports
X_3 = Imports

X_4 = Personal Consumption
X_5 = Personal Income
X_6 = Farm Income
X_7 = Corporate Profit
X_8 = Unemployment
X_9 = National Income

Euro = $4.260-3.198_{X2}+1.740_{X3}+12.291_{X9}-6.143_{X4}$
$-5.291_{X5+}.577_{X6}+.534_{X7}+.055_{X8}$

Yen = $.003+.651_{X2}+6.590_{X3}+7.632_{x4}-13.173_{X5+}.340_{X6}-1.571_{X7}-.177_{X8}$

SDR = $4.747-5.540_{X2}+4.875_{X3}+14.851_{X9}-9.729_{X4}-4.740_{X5}+.680_{X6}-.105_{X8}$

CAN$ = $.017+1.288_{X2}-.955_{X3}+2.443_{X4}-2.511_{X5}+.305_{X6}+.347_{X7}+.165_{X8}$

CONCLUSION

Based on the results of the regression it can be said that the exchange rate between the dollar and other major currencies is determined by some macrovariables which include unemployment rates, corporate profits, personal consumption, farm income, exports, imports, personal income and national income.

Usually it is argued that exchange rate is determined by Purchasing Power Parity and Interest Rate Parity. Although the PPP and IRP are valid theories, what the results of this research shows that macrovariables have a significant impact in determining the exchange rates between the U.S. dollar and major currencies.

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