

The Relationship between Exchange Rates and Stock Prices: Studied in a Multivariate Model

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In the period November 2003 to February 2004, there was an unambiguous upward trend in the U.S. stock market. Over the same period, the U.S. dollar kept depreciating against all major currencies. Analysts kept trying to predict when this downward trend would come to an end based on the U.S. trade deficit. Was not the exchange rate affected by the stock market instead?

In this paper, I study if there is a link between the stock market and exchange rates that might explain fluctuations in either market. I make the case that, in the short run, an upward trend in the stock market may cause currency depreciation, whereas weak currency may cause decline in the stock market. To test these assertions, I will use a multivariate, open-economy, short-run model that allows for simultaneous equilibrium in the goods, money, foreign exchange and stock markets in two-countries. Specifically, I focus on the United States and the United Kingdom over the period January 1990 through August 2004.

Establishing the relationship between stock prices and exchange rates is important for a few reasons. First, it may affect decisions about monetary and fiscal policy. Gavin (1989) shows that a booming stock market has a positive effect on aggregate demand. If this is large enough, expansionary monetary or contractionary fiscal policies that target the interest rate and the real exchange rate will be neutralized. Sometimes policy-makers advocate less expensive currency in order to boost the export sector. They should be aware whether such a policy might depress the stock market. Second, the link between the two markets may be used to predict the path of the exchange rate. This will benefit multinational corporations in managing their exposure to foreign contracts and exchange rate risk stabilizing their earnings. Third, currency is more often being included as an asset in investment funds' portfolios. Knowledge about the link between currency rates and other assets in a portfolio is vital for the performance of the fund. The Mean-Variance approach to portfolio analysis suggests that the expected return is implied by the variance of the portfolio. Therefore, an accurate estimate of the variability of a given portfolio is needed. This requires an estimate of the correlation between stock prices and exchange rates. Is the magnitude of this correlation different when the stock prices are the trigger variable or when the exchange rates are the trigger variable? Last, the understanding of the stock price-exchange rate relationship may prove helpful to foresee a crisis. Khalid and Kawai (2003) as well as Ito and Yuko (2004) among others, claim that the link between the stock and currency markets helped propagate the Asian Financial Crisis in 1997. It is believed that the sharp depreciation of the Thai baht triggered depreciation of other currencies in the region, which led to the collapse of the stock markets as well. Awareness about such a relationship between the two markets would trigger preventive action before the spread of a crisis.

Next I review literature related to the hypothesis and modeling approach of this paper. In Section II, I outline the theoretical background which yields the model presented in Section III. The data and results are analyzed in section IV.

I. Literature Review

Most studies that try to explain the fluctuations of stock prices and exchange rates are interested in finding a high-frequency, statistical relationship between the two variables. The papers analyzed below pertain to my research in the following way. Ajayi and Mougoue (1996) examine the short run relationship between stock and currency markets in the U.S. and U.K.,

which are the countries of interest in my paper. Their results support my hypotheses about the expected signs of the two-way relationship. Granger, Huang and Yang's (2000) work further illustrates that the two markets can jointly affect each other. Hsing (2004) and Zietz and Pemberton (1990) develop models with monthly data and simultaneously determined macroeconomic variables. Thus, their approach is particularly relevant to the one undertaken in my study.

Ajayi and Mougoue (1996) investigate the short-and long- run relationship between stock prices and exchange rates in eight advanced economies. Of interest to me are the results on short-run effects in the U.S. and U.K. markets. They find that an increase in stock prices causes the currency to depreciate for both the U.S. and the U.K., supporting the hypothesis of my paper. Ajayi and Mougoue explain this as follows: a rising stock market is an indicator of an expanding economy, which goes together with higher inflation expectations. Foreign investors perceive higher inflation negatively. Their demand for the currency drops and it depreciates.

As to the currency effect on the stock market, the authors find that currency depreciation leads to a decline in stock prices in the short run, also consistent with my hypothesis. The authors explain this negative relationship as follows: exchange rate depreciation suggests higher inflation in the future, which makes investors skeptical about the future performance of companies. As a result, the stock prices drop. This hypothesis is supported by data from the U.K. markets.

Granger, Huang and Yang (2000) research whether currency depreciation led to lower stock prices or whether declining stock prices led to depreciating currencies during the Asian Crisis of 1997. The data on some of the Asian countries support the case of bivariate causality.

Stock prices are expected to react ambiguously to exchange rates. The authors explain this with the effect of currency changes on the balance sheets of multinational companies. Depreciation could either raise or lower the value of a company, depending on whether the company mainly imports or mainly exports. When the stock market index is considered, the net effect cannot be predicted.

The other hypothesis is that the currency will depreciate if the stock market declines (contrary to my expectation--that currency depreciates if the stock market is booming). This is explained as follows: in markets with high capital mobility, it is the capital flows, and not the trade flows that determine the daily demand for currency. A decline in stock prices makes foreign investors sell the financial assets they hold in the respective currency. This leads to currency depreciation. In my study, it is reasonable to assume that in a period of one to three months, trade flows (current account) also play a role in determining the demand for currency. Therefore, the result observed here is contrary to what I expect because of the different time frame assumptions.

Seven of the countries examined by Granger, Huang and Yang (2000) showed a strong relationship between the two markets—causality was unidirectional in some cases and bi-directional in others. Whenever the relationship was unidirectional, it was found to be negative, regardless of which the lead variable was. For four of the countries the authors found evidence of joint causality. The direction (positive or negative) of the dual causality could not be determined, nor could it be specified which the trigger variable was.

The reason for the disparity of results between the different countries might be the different degree of the capital mobility, trade volume and economic links among them. Another reason could be an omitted variable bias—for example interest rates may have an influence on stock and currency markets.

Granger, Huang and Yang's (2000) results imply that I should use a time period longer than daily time span if I want to capture trade flows as a determinant of the exchange rate.

The findings of Ajayi and Mougoue (1996) and Granger, Huang and Yang (2000) support my hypothesis that stock prices and exchange rates are jointly determined. Therefore, they can be included as simultaneously determined variables in the same model. Both papers use a two-variable VAR model with daily data. I believe this approach does not capture a sound theoretical relationship. In that sense, my study differs fundamentally as it views the same relationship in the context of other variables and uses monthly data. The following papers I review address that issue.

Hsing (2004) studies how fluctuations of macroeconomic indicators affect the output in Brazil in order to prescribe monetary and fiscal policy. The article is especially pertinent to my study in its consideration of stock prices in a Mundell-Fleming model. It also uses monthly data, which still provides a short-run insight, but captures more macroeconomic relationships than daily data.

The author builds upon the open economy Mundell-Fleming framework where net exports depend on the real exchange rate. The model is slightly extended by including variables which research claims as relevant—oil prices, domestic and external debt. Stock prices are also included and they are expected to affect output through wealth and investment.

Hsing (2004) adopts a structural VAR model originally proposed by Sims (1986), using this method allows for the simultaneous determination of several endogenous variables. Among the seven endogenous variables are output (Y), real interest rate (RR), exchange rate (EX) and the stock market index (ST), which are also the four endogenous variables in my model. The model consists of seven equations where each endogenous variable is expressed as a function of its own lag, the lags of the other six endogenous variables, the two exogenous variables (which are the same for all seven equations), and a white noise term.

Hsing (2004) uses the simultaneously estimated model to examine the following relationship:

$$(1.1) \quad Y = f(\text{REAL INTEREST RATE, BUDGET DEFICIT, EXTERNAL DEBT, DOMESTIC DEBT, REAL EXCHANGE RATE, STOCK MARKET, FOREIGN INTEREST RATE, OIL PRICES})$$

Because all the presented results relate to the author's interest in output, the conclusions about the relationship between stock prices and exchange rates are drawn quite indirectly. To determine the sign of the relationship, Hsing (2004) introduces an artificial shock to each variable. The response of output to a shock in exchange rates and stock prices is given in Figure 1. The author finds a negative relationship between stock prices and output in the initial three to four months (Figure 1 below), which turns into an unambiguous positive relationship after the fourth month. Hence, the short-run effect is not consistent with any expectations.

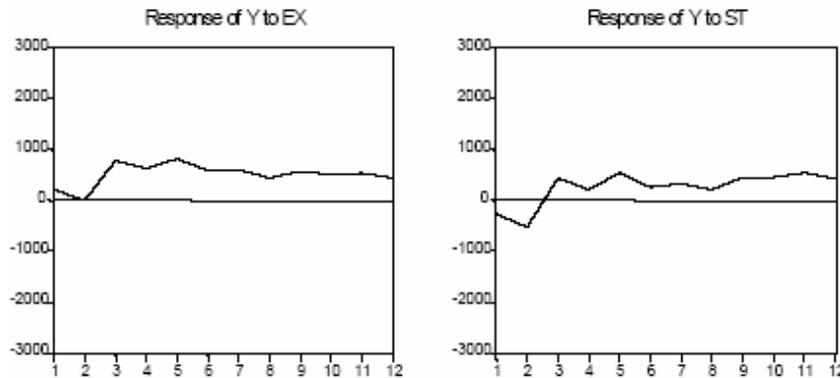


Figure 1: Impulse response results for stock prices and exchange rates

The exchange rate increase (depreciation) does cause a slight drop in output over the first two months but overall, the relationship is positive and strengthens with time. This is consistent with a long-run relationship between the exchange rate and the current account (a positive one). The author points out that this result is contradictory to other studies. The observed effect varies with a specific country's reliance on imports, the time period, and model specifications. In a country like the U.S., which relies on imports and runs a negative trade balance, depreciation will have a negative effect on the current account and output.

The obtained short-run results are: a positive relationship between exchange rates and GDP and a negative relationship between stock prices and GDP. Therefore, I can indirectly deduce that the short-run relationship between stock prices and exchange rates is positive. For output to remain constant, an increase in stock prices must be accompanied by an increase in the exchange rate.

The study that I found closest to my research is the one by Zietz and Pemberton (1990). The authors use a two-stage least squares method to estimate a modified open economy Mundell-Fleming model with flexible prices. In addition to the three endogenous variables in the standard model (output, interest rates and exchange rates), they add a fourth variable to be determined within the system, prices. Thus, the general structure of their simultaneous system of equations is based on a similar theoretical framework as my study.

The major difference from Zietz and Pemberton's model is my assumption of fixed prices implied by my short-run focus. Zietz and Pemberton (1990) study long-run relationships and allow prices to vary by including them as one of the endogenously determined variables. In the case of fixed prices, it is the exchange rate that acts as the adjustment variable to any fluctuation in net exports. Therefore, my study does not include a price variable.

Because my study focuses on the relationship between exchange rates and stock prices, I incorporate a stock price variable, which Zietz and Pemberton's model lacks. Stock prices are both an explanatory variable that affects output and an endogenous variable that is determined together with output, interest rates and exchange rates.

Zietz and Pemberton (1990) omit two variables that I have found important to include—*CC* (marginal propensity to consume) and *OP* (oil prices). There is abundant theoretical support that the marginal propensity to consume as well as oil prices are factors that affect domestic output (income). A variable the authors include and I find pertinent to my model is government deficit. This variable captures the difference between taxes and government spending.

Regarding the exchange rate variable, I keep the nominal exchange rate in the model, even though the authors use the real exchange rate. My assumption of fixed prices permits this, because under fixed prices changes in real and nominal exchange rates are identical¹.

The authors include a current account variable, which is a quarterly measure of the cumulated real balance on goods and services. The change in current account over one period is fully determined by the change in net exports. Therefore, I use the change in net exports between the U.S. and the U.K. as a proxy for the change in the U.S. current account that is due to the change in U.S.-U.K. trade flows. Furthermore, monthly data is available for net exports and not for the current account.

The existence of joint determination between stock prices and exchange rates is, in general, supported by the literature. However, there is no ubiquitous support for a particular sign of the relationship. The predominant estimation technique appears to be the vector autoregression (VAR) model. Because of its atheoretical nature and high sensitivity to variable choice and ordering, my study will follow Zietz and Pemberton (1990) in building a multivariate model, estimated using the two-stage least squares approach.

II. Theoretical Background

In this section, I theoretically justify a positive link from stock prices to exchange rates². I argue that an increase in stock prices causes an increase in output through an increase in wealth and investment. Then, I make use of a Mundell-Fleming model with J-curve effect to trail out the impact of higher output on the exchange rate. Finally, I outline theoretical support for the negative impact of exchange rates on stock prices.

A. The effect of the stock market on exchange rates

The effect of a stock price increase on expenditure is explained by Mishkin (2001) as follows. First, it leads to increased investment by firms. The value of a firm's equity increases as its stock price rises while the prices of new equipment remain unchanged in the short run. As a result, investment is now relatively cheaper and companies will tend to invest more. Hence, investment is a function of stock prices:

$$(2.1) \quad I = f(R, SP)$$

- +

where I is investment, SP is stock prices, and R is the borrowing/ lending interest rate, which has a negative impact on investment because it makes investment funding more costly.

Second, an increase in stock prices will affect positively the value of financial assets held by households, leading to an increase in household wealth and therefore consumption. As people associate higher wealth with lower probability of financial distress, they are likely to hold more illiquid assets. This means expenditure on durables and housing will rise as well. Thus,

$$(2.2) \quad C = f[MPC(Y-T), W(SP)]$$

+ +

where C is consumption, Y is income, T is taxes, W is wealth, and MPC is the marginal propensity to consume, which along with disposable income (Y-T) affects consumption positively.

The aggregate expenditure of the economy (E) equals income (Y) in equilibrium and is defined by the identity:

$$(2.3) \quad Y = E = C + I + G + NX = C(MPC(Y - T), W(SP)) + I(R, SP) + G + NX$$

+ + + - + + +

where G is government spending and NX is net exports.

I have incorporated the stock price effect into the consumption and investment patterns and thus obtained an investment-savings (IS) relationship that depends on stock prices. This is the first modification I introduce into the classical open economy Mundell-Fleming model.

The second way in which I diverge from the standard model is by assuming a short run negative relationship between the nominal exchange rate and the current account. This assumption is based on the inverse relationship between the exchange rate and the current account. This is typical of the short-run and is known as the J-curve effect.

The J-curve effect (Figure 2) states that the immediate effect of exchange rate depreciation is to generate a current account deficit, before it translates into a surplus³. This lag is estimated to last around six quarters⁴. Therefore, I can assume within a time frame of fixed prices, there is an inverse relationship between the exchange rate and the current account.

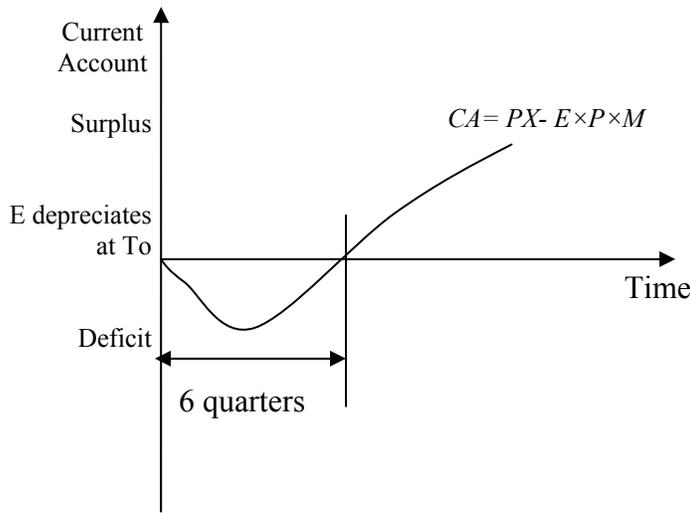


Figure 2: J-curve effect

Therefore, the current account term in the balance of payments schedule has the following characteristics:

$$(2.4) \quad CA = f(Y, E, Y^*)$$

- - +

where Y is domestic income, Y^* is foreign income, and E is the nominal exchange rate defined as domestic per foreign currency

After introducing these modifications to the model, it becomes⁵:

$$(2.5) \quad BP = CA(Y, E, Y^*) + K(R - R^*) = 0$$

- - + +

$$(2.6) \quad IS: Y = C(Y, T, W(SP)) + I(R, SP) + G + CA(Y, E, Y^*)$$

+ - + + - + - + -

$$(2.7) \quad LM: MB/P = L(Y, R)$$

+ -

where CA is the current account defined as

$$(2.8) \quad CA = NX = X \times P - M \times P \times E.$$

X is the amount of exports, M is the amount of imports, P is the price level in home currency, which is fixed in our short-run model, MB/P is real money balances, K is the capital account, R is the domestic borrowing / lending rate, and NX is net exports. All variables marked with a star (*) pertain to the foreign country.

Figure 3 below gives a graphical representation of the model.

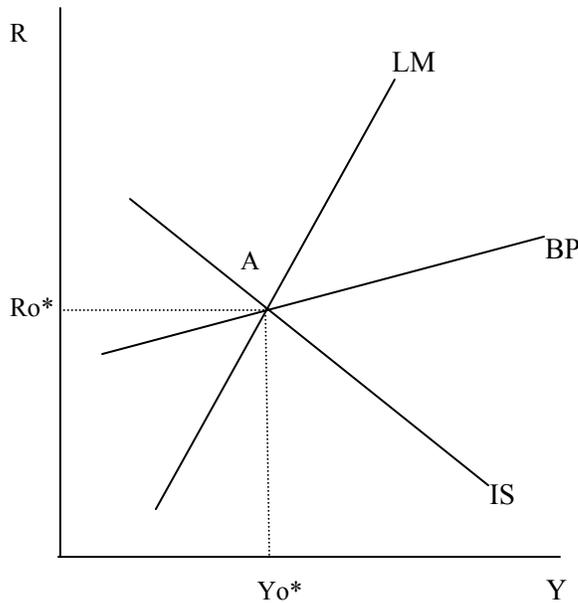


Figure 3: Open Economy Mundell-Fleming model

The BP schedule represents the accounting identity of the balance of payments account. It is the mechanism that equilibrates the international capital and goods markets. If a country has a negative trade balance (current account), it has essentially borrowed money from abroad, which would be consistent with a positive capital account. Since I assume high but imperfect capital mobility, the BP schedule is slightly upward sloping. The LM locus represents possible equilibrium levels of income (Y) and interest rates (R) in the domestic money market. It reflects the idea that higher income increases the demand for money balances. For a fixed money supply by the central bank, money market equilibrium is consistent with a higher interest rate. Therefore, the LM curve is upward sloping. The IS locus represents the equilibrium between savings and investment in the economy. At lower interest rates, borrowing is cheaper, companies will invest more, and hence expenditure (which equals output in equilibrium) will be higher. The IS locus is upward sloping. The three markets determine the equilibrium in the economy (point A).

Below I trail out the effect on the exchange rate after an increase in stock prices (Figure 4).

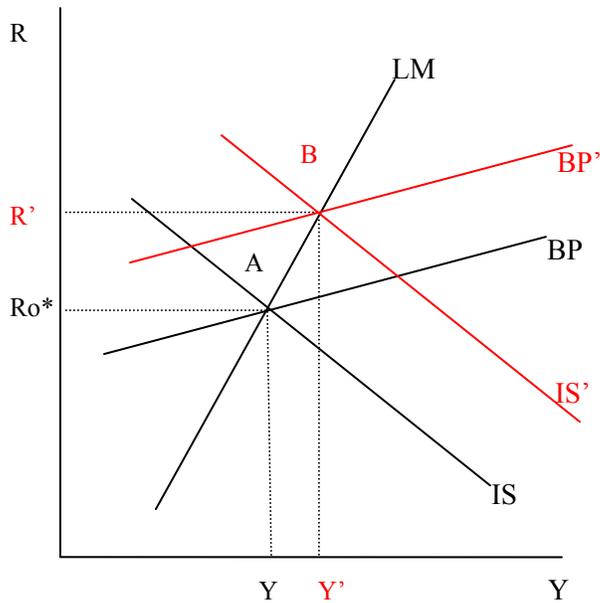


Figure 4: Reaction to a stock market shock

An increase in stock prices will increase the level of expenditure for a given interest rate (right shift of the IS schedule to IS'). The LM schedule is not affected by a change in stock prices. Thus, as a result of a positive shock to stock prices, the new domestic equilibrium is at point B, higher output and higher interest rates. This new equilibrium point is above the BP curve which indicates that for a given output level (Y), the interest rate at B is higher than the one consistent with a balanced account. A higher interest rate attracts foreign capital flows ($R > R^*$ leads to higher K in equation 2.5). As a result the balance of payments account is in surplus ($BP > 0$). The adjustment in the capital account takes place relatively quickly in markets with high capital mobility.

The new domestic equilibrium (B) also has a higher income level (Y). This is consistent with higher expenditure both domestically and abroad, which means imports increase and the current account deteriorates (as can be seen through equation 2.8). However, in the short run imports do not adjust as quickly as the capital markets. Therefore, the effect of a capital account surplus dominates the effect of a current account deficit and, overall, the balance of payments account is in surplus. That is why point B is above the BP curve.

In order to reach international market equilibrium, adjustment in the balance of payments account takes place via the exchange rate when prices are fixed. The exchange rate rises (currency depreciates), the current account deteriorates and the balance of payments is restored back to zero. An increase in the exchange rate is consistent with an upward shift of the BP schedule (in Figure 4— BP to BP').

A final equilibrium in all markets is reached at point B (R' , Y') in Figure 4. This new equilibrium is consistent with a higher expenditure level, higher interest rates, higher domestic exchange rate and higher stock prices. The most important result of this analysis is that an increase in stock prices is followed by currency depreciation in the same country.

B. The effect of the exchange rate on the stock market

There are several ways in which the exchange rate can affect the stock market.

First, a depreciating currency causes a decline in stock prices because of expectations of inflation (Ajayi and Mougoue, 1996).

$$(2.9) \quad RER = \frac{E \times P^*}{P}$$

where RER is the real exchange rate

Higher nominal exchange rate in the short run is consistent with a decrease in the price ratio P^*/P towards a long run equilibrium level, where the real exchange rate equals unity. A lower P^*/P ratio implies relatively higher domestic prices. Therefore, a depreciation of the nominal exchange rate creates expectations of inflation for the future. Inflation is seen as negative news by the stock market, because it tends to curb consumer spending and therefore company earnings.

Second, foreign investors will be unwilling to hold assets in currency that depreciates as that would erode the return on their investment. In a case of USD depreciation, investors will refrain from holding assets in the US, including stocks. If foreign investors sell their holdings of US stocks, share prices ought to drop.

Third, the effect of exchange rate depreciation will be different for each company depending on whether it imports or exports more, whether it owns foreign units, and whether it hedges against exchange rate fluctuation. Heavy importers will suffer from higher costs due to weaker domestic currency and will have lower earnings, thus lower share prices. Multinational corporations based in the US will have higher income when the US currency depreciates. The income realized by the foreign subsidiary is converted into dollars at the higher exchange rate. Companies that have hedged adequately will have their earnings and stock price unaffected by a fluctuating currency. The stock market, which is a collection of a variety of companies, will tend to react ambiguously to currency depreciation.

Last, on a macroeconomic level, a depreciated dollar will boost the export industry and depress the import industry. The impact on domestic output will be positive. Increasing output is seen as an indicator of a booming economy by investors and tends to boost share prices.

Overall, the effect of exchange rates on stock prices is quite inconclusive as there is some support for both a positive and a negative relationship. Based on Ajayi and Mougoue's (1996) work, I assume that the negative link will be predominant. In the short run, it will be the expectations of investors that affect the stock market, rather than the fundamentals of the economy.

Based on the discussion above, I can specify the factors that influence stock prices as follows:

$$(2.10) \quad SP = f(\underset{+}{Y}, \underset{-}{INF}, \underset{-}{E})$$

where Y is output, INF is inflation, and E is the exchange rate.

Based on the theoretical background outlined in this section, I next derive an empirical model by making reference to the study by Zietz and Pemberton (1990).

III. Empirical Model

The operationalized model is specified next. The signs in front of the variables reflect the expected relationships discussed earlier. Table 3.1 summarizes what data is used to measure the variables, the units of measurement, and the concept they capture.

$$(3.1) R = \alpha_1 + \alpha_2 Q - \alpha_3 MB_{-1} + \alpha_4 NX + \alpha_5 DF_{-1} + \varepsilon_1$$

$$(3.2) E = \beta_1 + \beta_2 (R - R^*) + \beta_3 Q - \beta_4 NX + \beta_5 E_{-1} + \varepsilon_2$$

$$Y \left\{ \begin{array}{l} (3.3) Q = \gamma_1 + \gamma_2 \sum_{-1}^{-3} Q_i - \gamma_3 \sum_0^{-3} R_i + \gamma_4 \sum_{-1}^{-3} MB_i + \gamma_5 \sum_{-1}^{-3} DF_i + \\ \quad + \gamma_6 \sum_0^{-3} SP_i - \gamma_7 \sum_{-1}^{-3} OP_i + \gamma_8 \sum_{-1}^{-3} CC_i + \varepsilon_3 \\ (3.4) X = \delta_1 + \delta_2 \sum_0^{-3} YF_i + \delta_3 \sum_0^{-3} E_i + \delta_4 X_{-1} + \varepsilon_4 \\ (3.5) M = \phi_1 + \phi_2 \sum_0^{-3} Q_i - \phi_3 \sum_0^{-3} E_i + \phi_4 M_{-1} + \varepsilon_5 \end{array} \right.$$

$$(3.6) SP = \theta_1 + \theta_2 Y + \theta_3 MB_{-1} - \theta_4 CPI_{-1} - \theta_5 \sum_0^{-3} E_i + \varepsilon_6$$

Identities:

$$(3.7) NX = X - M$$

$$(3.8) Y = Q - X + M$$

where $\varepsilon_1 \dots \varepsilon_6$ are random error terms, i is the time period with $i=0$ indicating the present period; $\alpha_i \beta_i \gamma_i \phi_i \theta_i$ are the coefficients to be estimated. The sign before each of these coefficients indicates the sign of the expected relationship.

Consistent with the theoretical model, equation 3.1 stems directly from the LM locus, equation 3.2—from the BP locus, equations 3.3, 3.4 and 3.5 represent the output of an open economy (see identity 3.8) and thus represent the IS schedule presented earlier. The addition of a stock market is represented by equation 3.6, which includes explanatory variables for the fourth endogenous variable—stock prices. The theory discussed earlier and results presented in the reviewed literature support the inclusion of the stock price (SP) variable as an endogenous one. Hence, it is determined simultaneously with the other endogenous variables—interest rates (R), income (Y) and exchange rates (E). The simultaneous effect comes from the presence of the stock price variable as an explanatory one in equation 3.3 and from the fact that it is affected by factors like output, interest rates and exchange rates.

Table 3.1: Definitions and variable measures

Variable	Concept	Measured with:	Units
<i>CC</i>	Marginal Propensity to Consume	The University of Michigan's Consumer Sentiment Index	Index 1966 = 100
<i>CPI</i>	Inflation Expectations	Consumer Price Index (CPI)	Index 1982-84=100
<i>DF</i>	Government indebtedness	Federal budget deficit/surplus	Millions of dollars
<i>E</i>	Exchange rate	U.S. / U.K Exchange Rate	USD / 1 GBP
<i>M</i>	Imports	US imports from UK	Millions of dollars
<i>MB</i>	Money	M2 monetary base	Billions of Dollars
<i>NX</i>	Net exports	$x-m$	Millions of dollars
<i>OP</i>	Oil prices	Crude Oil WTI Spot Price FOB	Dollars/ bbl
<i>Q</i>	Domestic expenditure	$(y-nx)$	Millions of dollars
<i>R</i>	Domestic interest rate	Effective Federal Funds Rate	Percent
<i>RF</i>	Foreign interest rate	Bank of England base rate	Percent
<i>SP</i>	Stock prices	Standard and Poor's 500 Index	Index 1941-43 = 10
<i>X</i>	Exports	US exports to UK	Millions of dollars
<i>Y</i>	Domestic output	US Industrial Production Index	Index 1997 =100
<i>YF</i>	Foreign output	UK Index of Production	Index 2001 =100

Equation 3.1 regresses interest rates (R) against the variables implied by the LM schedule: domestic output (Q) and net exports (NX) comprise the total output of the economy (Y). The government deficit (DF) is included because Hsing(2004) argues that higher deficit and debt levels will lead for higher borrowing cost for the government. Equation 3.2 includes only the variables from the balance of payments schedule, as it was specified in the previous section. Since prices are fixed, it is the exchange rate that acts as the adjustment variable to net exports fluctuations. In line with the J-curve effect, I expect a negative relationship between net exports (NX) and the exchange rate.

I introduce a few additional variables into equation 3.3— CC (marginal propensity to consume) and OP (oil prices). Their inclusion has the following theoretical support. The marginal propensity to consume affects domestic absorption via private consumption—the higher the marginal propensity to consume, the higher the output. Oil prices have an inverse relationship with output. Rising oil prices lead to higher costs, lower consumer spending and lower production by firms, hence lower output. Zietz and Pemberton (1990) also include the government deficit (DF) in their equation. This variable captures government spending and taxes. Thus, in equation 3.3 the government deficit (DF) along with income (Y) account for the effect of disposable income on consumption. There is no need to include a disposable income

variable, since its effect is already captured. Including a disposable income will create perfect collinearity.

Net exports (NX) is an endogenous variable in the system (determined by equations 3.4 and 3.5). Its dependence on the exchange rate is justified as follows: With dollar depreciation (E increases), US goods appear cheaper to foreigners and they are prone to consume more and US exports increase. Hence, the positive sign in equation 3.4. Similarly I can argue that the US imports differential on the nominal exchange rate is negative.

For the inclusion of the particular variables in equation 3.6, I reference Ibrahim(1999), but exclude his foreign reserves variable, which is applicable to regimes of pegged exchange rates. I do keep his inflation variable, even though I have assumed fixed prices. Theoretically, expectations of inflation affect the stock prices because investors take it as bad news. So, I use the percentage change in the CPI index as a leading indicator of inflation expectations, assuming that next period's inflation expectations adjust to the observed inflation for this period: $[EXPECTED\ INFLATION_{t+1} = INFLATION_t]$. Thus I expect that higher inflation in the previous month will have a negative impact on the stock market in the current month.

The most problematic specification of this model is the lag length. There is no consensus in the literature on this issue. It is determined either arbitrarily or through lengthy empirical tests. Hsing (2004) in a study of the Brazilian economy includes lag length of three months "based on several criteria", which he unfortunately does not discuss. Another study by Ibrahim(1999) on the relationship between macroeconomic variables and stock prices in Malaysia uses a final prediction error criterion. This is an econometric estimation tool which determines the lag length. The largest lag length is three months and is used for the stock price variable.

For the US- UK case, I can argue that market efficiency is higher than in Brazil and Malaysia. Efficient markets help shocks travel faster through the economy, meaning that for US and UK the lag period is likely to be under three months. From an econometric perspective, it is better to include more variables than exclude relevant ones. Thus, based on the studies cited above and being overly cautious, I use a lag of three months. The sample size of 176 months allows this without creating a severe degrees of freedom problem.

The model ensures that equilibrium is achieved at the same time in the goods, money, foreign exchange and stock markets. Endogenous variables appear both as explanatory and dependant, which makes the error terms correlated with certain independent variables. For example, the error term of equation 3.3 affects the dependent variable Q . Naturally, total output (Y) is affected as well because of identity 3.8. The output variable (Y) then appears as explanatory in equation 3.6 and affects stock prices (SP). Ultimately, the error term in equation 3.3 is correlated with the stock price variable, which also appears in equation 3.3 as explanatory. The problem created is known as simultaneous equation bias. A basic assumption of the OLS estimation is violated and the estimation of the model requires the use of a simultaneous-equation econometric model. The two-stage least squares (2SLS) method is appropriate here.

The two stage least square technique consists of two stages of OLS regressions. First, each endogenous variable is expressed in terms of only exogenous variables in the model. Then the first stage of the OLS regression is run and thus estimates of all endogenous variables are obtained. In the original model, wherever an endogenous variable appears as explanatory on the right hand side, it is substituted with the obtained estimate. The second stage can then be run. It entails an OLS regression on each of the equations in the original model. However, the use of estimates in place of explanatory endogenous variables ensures that the simultaneous equation

bias is eliminated. The product of the second stage is coefficient estimates for the variables of the initial model.

Most recent studies, including the ones reviewed in the previous section of this paper, use newer econometric models such as vector autoregression (VAR) after Sims(1980) or structural vector autoregression(SVAR) after Sims(1986). However, there is little evidence that it is a superior estimation technique, and is extensively criticized because of its limited theoretical foundation and high sensitivity to order and omission of variables (Cooley and LeRoy, 1985 and Giannini, 1992)⁶.

All data is time-series with monthly frequency, seasonally adjusted, over the period January 1990 through August 2004. The sample size is 176 months. For the estimation, I generate variables as percentage changes of the collected data.

The exchange rate, federal funds rate, monetary base, US industrial production index and the CPI data are obtained from the St Louis Federal Reserve⁷; the UK Index of Production data--from The Office for National Statistics-UK⁸. The UK interest rate data was collected through the Bank of England⁹. The S&P500 index time series comes from Yahoo Finance¹⁰. The US budget deficit and consumer sentiment index are acquired from EconStats¹¹. Imports and exports data comes from The US Census Bureau¹² and crude oil prices—from the US Department of Energy¹³.

IV. Data Analysis and Results

This section is structured as follows: first I examine the properties of the data and determine whether any econometric problems exist; next I estimate the model using a two stage least squares procedure; finally I summarize and analyze the results.

Time-series macroeconomic data is notorious for its problematic nature as to meeting the classical assumptions of OLS estimation. Because the two-stage least squares procedure is essentially an OLS estimation performed twice, the validity of the assumptions still needs to be checked. I perform Durbin-Watson tests for autocorrelation, Dickey-Fuller tests for non-stationarity. I analyze the correlation matrix of the variables to detect signs of collinearity and evaluate VIF statistics to test whether multicollinearity is present. I plot the residuals for each of the six equations in the model in order to spot any pattern of non-constant variance of the error term (heteroskedasticity). Because I use data in percentage changes, I do not expect to have any of these problems, as they seem to be common for data in levels. Finally, I test for Granger causality to see whether there is empirical evidence for joint causality between stock prices and exchange rates.

A. Autocorrelation

A way to test for the presence of this problem is to regress $\varepsilon_t = \rho \varepsilon_{t-1} + u_t$, where ε is the error term from the regressed equation; ρ is a coefficient whose value can be between $[-1,1]$, u is a random error term. A value of zero for ρ suggests no autocorrelation.

The RSTAT command in Shazam¹⁴ gives an estimated value for ρ , and also a Durbin-Watson test statistic (d), which takes values within the interval $[0,4]$. A value of $d=0$ corresponds to $\rho=1$ and perfect positive autocorrelation; $d=4$, $\rho=-1$ suggests perfect negative correlation; $d=2$, $\rho=0$ is consistent with no serial correlation. Below I show the conclusions of a two sided Durbin-Watson test with a null hypothesis of no autocorrelation.

Ho: $\rho=0$, $d=2$

Table 4.1: Durbin-Watson test results¹⁵

Equation	n	Explanatory variables in equation	Round down to n=100 10 percent test		<i>d</i>	ρ	Conclusion
			D _L	D _U			
3.1) <i>R</i>	172	4	1.59	1.76	1.97	0.00428	Accept Ho
3.2) <i>E</i>	172	4	1.59	1.76	1.88	0.05664	Accept Ho
3.3) <i>Q</i>	172	25	≈1.53	≈1.83	1.98	0.00697	Accept Ho
3.4) <i>X</i>	172	8	≈1.53	≈1.83	2.60	-0.30104	Accept Ho
3.5) <i>IM</i>	172	9	≈1.53	≈1.83	2.21	-0.11624	Accept Ho
3.6) <i>SP</i>	172	7	1.53	1.83	1.70	0.14701	Inconclusive

In the case where the test is inconclusive for equation 3.6 and where the Durbin-Watson tables did not provide accurate critical values, the values of ρ can be considered closer to 0 than to the endpoints of the interval [-1, 1]. Also, all Durbin-Watson statistics are closer to a value of 2 than to any endpoint in the interval for d , [0, 4]. Overall, I conclude that the 2SLS model does not suffer from autocorrelation.

B. Non-stationarity

Non-stationarity is a commonly observed problem with time-series. It stems from the fact that the time series is not independent of time. When a variable is not stationary, its mean and variance are not constant over time, and an observation is correlated with its more recent lags.

A number of studies, including the ones reviewed earlier, found the data to be non-stationary of unit root one I(1), which means that the value of the variable for the current period is correlated with the value of the variable in the previous period. To check for non-stationarity, I use a Dickey-Fuller test, which has the general form:

$$\Delta x_t = \phi x_{t-1} + u_t, \text{ where } x \text{ is any of the variables represented above, } \phi = \rho - 1,$$

where ρ measures the link between x_t and x_{t-1} ($x_t = \rho x_{t-1} + u_t$)

The tested hypotheses are: Ho: unit root one (data is non-stationary in levels, but first difference is stationary) $\phi=0, \rho=1$ and H₁: $\phi<0, \rho<1$. Upon performing a t-test on ϕ , if the test statistic exceeds the critical value in absolute value, I reject null hypothesis of non-stationarity. Non-stationary data creates fallacious correlation between the variables. The result is inflated R² and t-statistics. The data I use for the regression is in percentage change form:

$$x_p = \frac{x_t - x_{t-1}}{x_{t-1}}$$

Therefore, I test whether the time series in percentage changes are stationary over time. Table 4.2 summarizes the test results for unit root one (first difference is stationary) at the 10 percent significance level.

Table 4.2: Dickey-Fuller test results

Variable	Test Stat	10 percent critical value	Conclusion
<i>E</i>	-4.91	-2.57	Stationary
<i>R</i>	-3.02	-2.57	Stationary
<i>RF</i>	-2.51	-2.57	Non-stationary
<i>MB</i>	-1.89	-2.57	Non-stationary
<i>X</i>	-3.92	-2.57	Stationary
<i>IM</i>	-3.23	-2.57	Stationary
<i>Y</i>	-3.27	-2.57	Stationary
<i>Q</i>	-3.26	-2.57	Stationary
<i>YF</i>	-3.18	-2.57	Stationary
<i>DF</i>	-3.70	-2.57	Stationary
<i>CC</i>	-3.84	-2.57	Stationary
<i>SP</i>	-3.24	-2.57	Stationary
<i>OP</i>	-3.03	-2.57	Stationary
<i>CPI</i>	-3.33	-2.57	Stationary

I was not able to reject the null hypothesis of non-stationarity only for two variables, *MB* (money base) and *RF* (foreign interest rate). The latter result is surprising and, theoretically, there is no theoretical reason why I might observe it. If the two variables are cointegrated, then the non-stationarity of the two variables cancels out and they can be left as they are. To eliminate the non-stationarity when there is no cointegration, first differences can be taken. This has the major drawback of changing the meaning of the variables and losing information about their long-run trend. Studenmund (p.427) advises that “first differences should not be used without weighing the costs and benefits”. I keep the variables as percentage changes and will take account of the possibility that the money balances (*MB*) and foreign exchange rate (*RF*) coefficients might be inflated.

C. Multicollinearity

The correlation matrix shows very low correlation between pairs of variables. The absolute value of most correlation coefficients is below 0.2. This might be related to the fact that the data is percentage changes, which does not fluctuate as much as data in levels (millions of dollars). An exception is $\text{Corr}(q,y)=0.9999$. By definition, *Q* is a linear function of *Y*. I do not expect this to cause a problem, because the two variables do not appear in the same equation, nor do they appear as exogenous variables together.

To test for multicollinearity, I regress each of the explanatory variables against all other explanatory variables. I run an OLS regression for each of the thirteen variables. Each equation has the form:

$$X_1 = \alpha_1 + \alpha_2 X_2 + \dots + \alpha_{13} X_{13} + u$$

where *u* is a stochastic error and the variables $X_1 \dots X_{13}$ are the variables listed below

The R-squared statistic and the Variance Inflation Factor (VIF) for each equation are listed in Table 4.3 below.

Table 4.3: Test for multicollinearity: auxiliary regression results

Variable	Auxiliary R ²	VIF ¹⁶
<i>E</i>	0.365	1.574
<i>R</i>	0.337	1.508
<i>RF</i>	0.214	1.272
<i>MB</i>	0.155	1.184
<i>X</i>	0.171	1.206
<i>IM</i>	0.189	1.232
<i>Q</i>	0.087	1.095
<i>YF</i>	0.057	1.061
<i>DF</i>	0.310	1.449
<i>CC</i>	0.208	1.263
<i>SP</i>	0.241	1.318
<i>OP</i>	0.222	1.285
<i>CPI</i>	0.365	1.574

Based on the very low values of the R-squared and the VIF for all the variables, I conclude that there is no multicollinearity.

D. Heteroskedasticity

Heteroskedasticity is a phenomenon usually observed in cross-sectional data, but I need to make sure that it is not present in my model. Heteroskedasticity violates the assumption that the error term has constant variance. Because the standard tests may not be valid for a 2SLS model, I plot the error terms of each equation as a way to observe whether they follow the required homoskedastic pattern. Non-constant variance of the error term will show up as a distinct fanning out pattern in the plot of the residual against time. The plotted error terms for each of the six equations in the model are included in Appendix B.

The plots of residuals seem to have an obviously stable variance around the zero mean. An exception is the error term for equation 3.4, where the variance of the residuals seems to slightly reduce over time. One possible way to adjust this would be to measure all variables in per capita terms. However, I choose not to redefine the variables and be aware that the presence of slight heteroskedasticity in equation 3.4 will underestimate the standard errors and therefore may lead to inflated t-statistics. I conclude that the rest of the residuals have homoskedastic properties.

E. Granger Causality Test

Lastly, I test whether the assumption of joint causality between the exchange rate and stock price variables holds. This assumption is derived analytically from theory, and is backed empirically by many studies, including the ones reviewed in Section I.

The Granger causality test, after Granger (1969)¹⁷, checks for causality between an explanatory variable and the dependent variable. I first let the exchange rate be a dependent variable and test whether past values of stock prices impact current values of the exchange rate. This is done by comparing the results of an Ordinary Least Squares Estimation (OLS) on equation (4.1) and its restricted form (4.1R) below.

$$(4.1) E = \alpha_0 + \alpha_1 E_{-1} + \alpha_2 E_{-2} + \alpha_3 E_{-3} + \alpha_4 SP_{-1} + \alpha_5 SP_{-2} + \alpha_6 SP_{-3} + \varepsilon_1$$

$$(4.1R) E(R) = \alpha_0 + \alpha_1 E_{-1} + \alpha_2 E_{-2} + \alpha_3 E_{-3} + \varepsilon_1$$

$$(4.2) SP = \beta_0 + \beta_1 SP_{-1} + \beta_2 SP_{-2} + \beta_3 SP_{-3} + \beta_4 E_{-4} + \beta_5 E_{-5} + \beta_6 E_{-6} + \varepsilon_2$$

$$(4.2R) SP(R) = \beta_0 + \beta_1 SP_{-1} + \beta_2 SP_{-2} + \beta_3 SP_{-3}$$

where E is the exchange rate, SP are stock prices, α and β are the coefficients to be estimated, ε is a random error term, and (R) denotes the restricted version of the specified equation.

The F-statistic is calculated as follows:

$$F(i) = \frac{\frac{(RSS(iR) - RSS(i))}{\text{number of constraints on } i}}{\frac{RSS(i)}{\text{degrees of freedom}(i)}}$$

where $F(i)$ is the test statistic for the equations with dependent variable i ; iR is the restricted form equation for variable i ; RSS is the residual sum of squares, or the amount of variance in the dependent variable that was not captured by the explanatory variables; the number of constraints in our case is 3 for either restricted equation; the degrees of freedom for the unrestricted equations are 165 (= 172 observations— 6 explanatory variables—1).

The null hypothesis is that the variables on the right hand side do not Granger-cause the variables on the left hand side. A high F statistic is the result of higher explanatory power of the unrestricted equation. If it exceeds the critical F-value for the specified significance level, the null hypothesis of no Granger causality is rejected.

The F-test results for the equations specified above are:

Null hypothesis	F statistic	Critical F at 10 percent confidence¹⁸	Conclusion
<i>SP</i> does not cause <i>E</i>	1.060	2.748	<i>SP</i> does not cause <i>E</i>
<i>E</i> does not cause <i>SP</i>	0.561	2.748	<i>E</i> does not cause <i>SP</i>

I conclude that causality from past values of stock prices to current values of exchange rates and from past values of exchange rates to current values of stock prices does not exist. This is not consistent with Ajayi and Mougoue (1996), who performed a similar test for the same two countries over a different time period. I believe the insignificance of the test is due to a poor data set and the transformation of data into percentage changes, which eliminated a substantial part of the variance in the original data. Next I proceed with the estimation of the model specified in Section III.

F. Estimation Results

The results of the two-stage procedure are highly dependent on the fit of the first stage estimation. If the fit is poor, the estimated endogenous variable will not be a true proxy of the actual variable and therefore, the fit in the second stage of the 2SLS will also have a poor fit.

In the 2SLS technique, the R^2 as well as the adjusted R^2 statistics have a lower bound of negative infinity instead of zero, and therefore have different interpretation. A negative value usually points to poor explanatory power.

Another typical property of the 2SLS estimation procedure is that it yields negatively biased coefficient estimates for small samples. The estimate of β is likely to be smaller than the true β . This will also cause the t-statistics to be lower.

As can be seen in Table 4.4, each of the equations has a low standard error, as well as very low R^2 and adjusted R^2 statistics.

Table 4.4: Estimation results

Eq.	Dependent Variable	R^2	Adjusted R^2	SE of the estimate
3.1	R	0.010	-0.014	0.190
3.2	E	0.248	0.223	0.020
3.3	Q	0.083	-0.073	0.005
3.4	X	0.086	0.041	0.130
3.5	M	0.128	0.080	0.103
3.6	SP	-0.044	-0.088	0.036

I perform a two-tail t-test on the estimated coefficients at 10 percent confidence level with a null hypothesis $H_0: \beta=0$. Since the number of degrees of freedom in each of the six equations is greater than 120, the t-distribution can be approximated to normal. So, the critical value is 1.64. When the coefficient passes the significance test, I interpret its value as the percentage change in the variable on the left hand side that is caused by 1 percent change in the variable on the right hand side that corresponds to the particular coefficient. Also, the t-test in general is said to be “not exact for the 2SLS estimators, but accurate enough in most circumstances” (Studenmund, 467).

The estimated coefficients with t-statistics in brackets are listed below. An asterisk indicates a t-statistic higher than the critical value and hence, statistically significant coefficient. The underlined coefficients are the ones whose estimated sign is different from the theoretically expected one. The obtained t-statistics are low in general. This may be consistent with a small sample bias or bad fit of the reduced-form equations in the first stage of the two-stage process, which further worsens the fit in the second stage. This would lead to high standard errors and lower t-statistics. I do not observe high standard errors, thus the low t-values seem to be due to low coefficients. A reason for the low coefficients might be the fact that a lot of the variation in the data was eliminated by taking percentage changes.

$$(3.1) \quad R = -0.081 + 27.506 Q - 6.538 MB_{-1} - 0.163 NX - 0.001 DF_{-1}$$

$$(-2.85)^* \quad (5.96)^* \quad (-1.45) \quad (-0.89) \quad (-0.39)$$

$$(3.2) \quad E = 0.001 - 0.034 (R - R^*) + 0.336 Q - 0.044 NX + 0.180 E_{-1}$$

$$(0.30) \quad (-4.17)^* \quad (0.70) \quad (-2.31)^* \quad (2.47)^*$$

$$\begin{aligned}
(3.3) \quad Q = & 0.002 - 0.091Q_{-1} + 0.045Q_{-2} + 0.115Q_{-3} + 0.01R + 0.006R_{-1} - 0.003R_{-2} - 0.002R_{-3} + \\
& (1.36) \quad (-0.51) \quad (0.40) \quad (0.97) \quad (0.64) \quad (1.14) \quad (-0.91) \quad (-0.53) \\
& 0.13MB + 0.06MB_{-1} + 0.016MB_{-2} - 0.155MB_{-3} + 0.00DF - 0.00DF_{-1} + 0.00DF_{-2} + \\
& (0.66) \quad (0.33) \quad (-0.41) \quad (-0.86) \quad (0.57) \quad (-0.04) \quad (0.40) \\
& + 0.00DF_{-3} + 0.085SP + 0.005SP_{-1} + 0.006SP_{-2} + 0.026SP_{-3} + 0.012OP_{-1} - 0.003OP_{-2} + \\
& (1.33) \quad (1.79)^* \quad (0.29) \quad (0.37) \quad (1.60) \quad (1.55) \quad (-0.48) \\
& - 0.006OP_{-3} + 0.005CC_{-1} + 0.011CC_{-2} + 0.006CC_{-3} \\
& (-0.95) \quad (0.41) \quad (1.00) \quad (0.61)
\end{aligned}$$

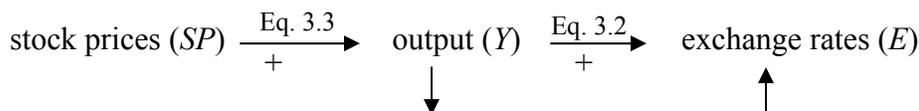
$$\begin{aligned}
(3.4) \quad X = & 0.017 + 0.378YF + 0.452YF_{-1} - 1.722YF_{-2} + 1.698YF_{-3} - 0.703E - 0.386E_{-1} \\
& (1.07) \quad (0.29) \quad (0.32) \quad (-1.22) \quad (1.25) \quad (-0.75) \quad (-0.627) \\
& + 0.845E_{-2} - 0.317E_{-3} \\
& (1.56) \quad (-0.67)
\end{aligned}$$

$$\begin{aligned}
(3.5) \quad M = & 0.001 + 2.573Q + 2.12Q_{-1} + 1.972Q_{-2} - 1.145Q_{-3} - 0.357E + 0.097E_{-1} + 0.17E_{-2} \\
& (0.07) \quad (0.84) \quad (1.24) \quad (1.03) \quad (-0.63) \quad (-0.48) \quad (0.21) \quad (0.42) \\
& + 0.55E_{-3} - 0.368M_{-1} \\
& (1.47) \quad (-4.92)^*
\end{aligned}$$

$$\begin{aligned}
(3.6) \quad SP = & 0.018 + 0.60Y - 1.9MB - 1.805CPI_{-1} - 0.611E + 0.22E_{-1} - 0.254E_{-2} + 0.163E_{-3} \\
& (2.61) * \quad (0.69) \quad (-2.19) * \quad (-1.14) \quad (-2.57) * \quad (1.38) \quad (-1.77) * \quad (1.25)
\end{aligned}$$

Very few results are statistically significant. Some of the few significant coefficients are the ones for the exchange rate variables in the stock price equation (3.6). The exchange rate in the current period and two periods back has a significant, and as expected, negative effect on stock prices. This means that a 1 percent increase in the exchange rate (depreciation) now causes a 0.611 percent decline in current stock prices. The effect seems to fade away with time, because a 1 percent increase in the exchange rate would cause the stock price to decline by 0.254 percent two months later. The coefficients for the other periods appear to be positive, but they are not statistically significant, hence I cannot say they are different from zero.

Regarding the effect of stock prices on exchange rates, most of the coefficients are insignificant. Hence, the best that can be done is to try to determine the sign of the relationship. The sign of the relationship is followed through the following link:



$$+ \text{ Eq. 3.5} \quad \xrightarrow{-} \quad - \text{ Eq. 3.2}$$

$$\text{imports (M)} \quad \xrightarrow{-} \quad \text{net exports (NX)}$$

Figure 5: Following the effect of stock prices on exchange rates

The coefficient of the stock price variable in equation 3.3 is one of the few significant ones. Also the coefficients for all periods are positive as expected. I can say that 1 percent increase in stock prices is expected to lead to 0.085 percent increase in domestic expenditure in the same period. Thus, there is evidence that stock prices affect domestic expenditure positively. In equation 3.2 domestic income appears to have a positive effect on the exchange rate. Therefore, I can deduce that stock prices have the hypothesized positive effect on exchange rates.

Following the lower part of Figure 5: domestic output (Q) in equation 3.5 affects imports with a positive sign in the current period and two periods back. Because $nx = x - m$, higher imports are consistent with lower net exports. The NX coefficient in equation 3.2 is negative, as expected, and statistically significant—which means that lower imports lead to a higher exchange rate (depreciation). This gives support for the assumption of a J-curve effect in the short run (negative correlation between the current account and the exchange rate). Overall, the hypothesis that increasing stock prices lead to depreciating exchange rates finds some weak support in the data for the period Jan 1990—Aug 2004. However, the insignificant estimates do not allow determining its magnitude.

V. Conclusion

This study developed the hypothesis that there is a link between the foreign exchange and stock markets. I asserted this link is positive when stock prices are the lead variable and likely negative when exchange rates are the lead variable. I found some support for these propositions in past literature. I developed a multivariate simultaneous equation model that allowed to study the relationship in the context of a theoretically sound, structural macroeconomic framework.

The empirical results were somewhat weak. I find support for the hypothesis that a depreciation of the currency may depress the stock market—the stock market will react with a less than one percent decline to a one percent depreciation of the exchange rate. This also implies that an appreciating exchange rate boosts the stock market.

As to my other assertion, that a booming stock market would lead to currency depreciation, I do not find support in the data for the US/ UK over 1990—2004. The results were insignificant. The signs of the variables were as expected, which somewhat substantiates a positive relationship when stock prices are the lead variable.

The implications of this research would have been much stronger, had there been stronger support for the hypotheses. Some of the following propositions can be made. Firstly, it had been debated whether the US should pursue a policy of strengthening the USD. The negative relationship that I found suggests that such a policy would also be beneficial for the stock market. However, if the country targets exchange rate appreciation in a time of rising stock prices, the policy could remain ineffective. Secondly, multinational companies interested in exchange rate forecasting may consider the stock market as a forecasting indicator—when it rises, the currency is expected to depreciate. There is an interesting implication for portfolio managers, namely that currency and equity have ambiguous correlation. It is positive when equity prices are the first to fluctuate and negative when currency prices are shocked first. Finally, the relationship I find proves to be extremely beneficial in a case of financial crisis. If

the exchange rate collapses sharply, it will trigger a milder fall of the stock market. Because of the joint causality, a collapse in the stock market will trigger exchange rate appreciation. Similarly, if there is a stock market collapse, the exchange rate will appreciate and cause a rebound in the stock market. Thus, the joint relationship between the two markets aids self-recovery during a financial crisis.

There are several ways to improve this study. Firstly, one could extend the research to determine the appropriate lag length. This will prevent the inclusion of irrelevant variables and will make the estimation process more efficient. Secondly, the validity of the assumption of fixed prices and hence the identity between real and nominal exchange rate fluctuations should be questioned and tested. In line with that, the model could be extended to allow for price flexibility and thus be applied to the long-run as well. Thirdly, the use of a more sophisticated estimation technique may provide better support for the otherwise theoretically sound hypothesis. Lastly, further research may identify particular time periods when the hypothesized relationship was rather strong and other periods when it was essentially non-existent.

VI. APPENDIX

A. The J-curve effect

The intuitive approach to the current account tells us that if there is a current account deficit, in order to restore equilibrium in the current account, I need to either an increase in exports or a decrease in imports. That will be achieved with a depreciation of the dollar in real terms because it will make US goods cheaper while foreign goods more expensive. Then the value of imports will fall, the value of exports will rise, and will improve the current account. Thus, there is a direct (positive) relationship between the exchange rate and the current account.

Put more formally, the Marshall-Lerner condition given by:

$$|\eta_{Dm}| + |\eta_{Dx}| > 1 \quad (A1)$$

η_{Dm} —price elasticity of demand for imports

η_{Dx} —price elasticity of demand for exports

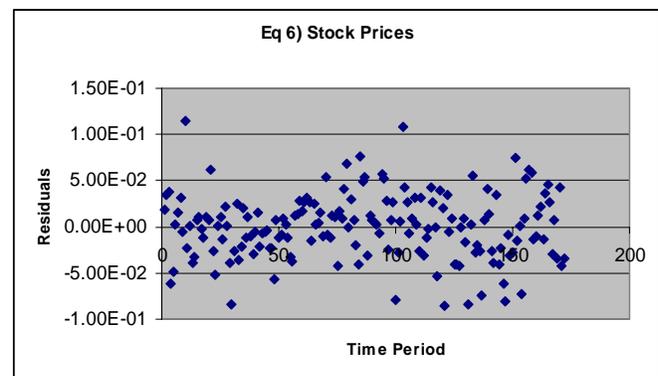
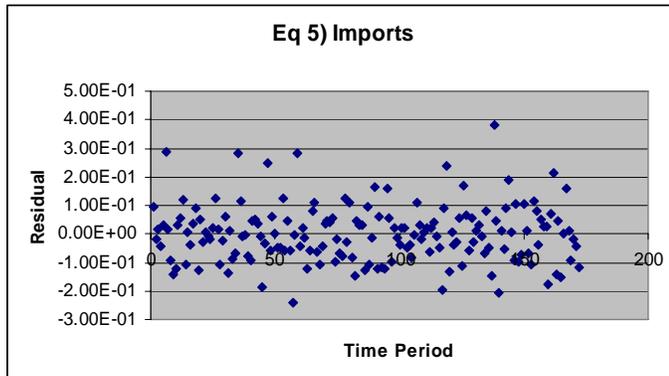
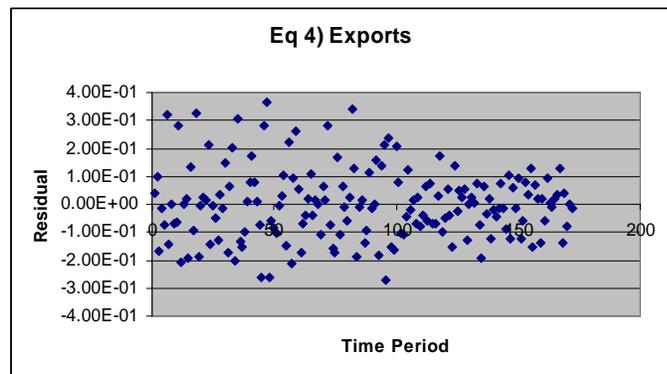
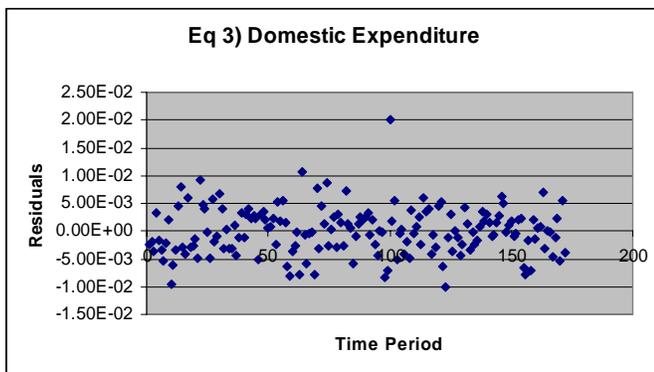
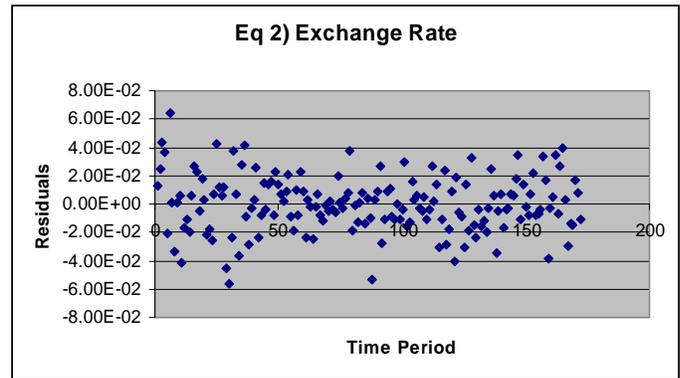
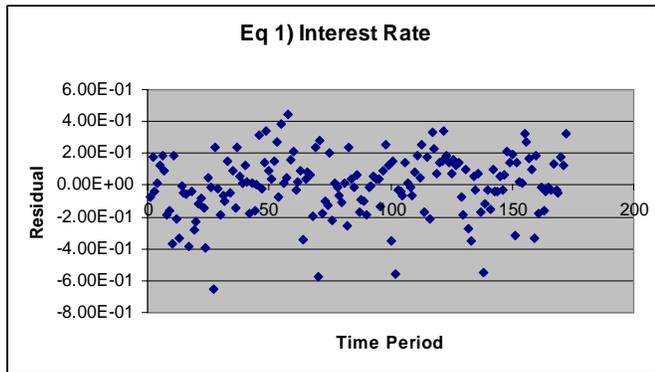
has to hold in order to have a direct (positive) relationship between the current account and the exchange rate.

Conversely, in the short run the price of no imported or exported good can react fast enough. The value of US net exports ($NX = PX - E \times P \times IM$) only depends on the exchange rate and the volume of exports or imports. If the USD depreciates (the value of e increases), the value of imports will be higher than the value of exports and the current account will deteriorate. Thus I have a negative relationship.

In other words, in the short run, demand for imports and exports is less elastic, the sum of the two elasticities falls below one and the Marshall-Lerner condition does not hold¹⁹:

$$|\eta_{Dm}| + |\eta_{Dx}| < 1 \quad (A2)$$

B. Test for Heteroskedasticity: Error term plots



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VIII. ENDNOTES

¹ The real exchange rate is defined as the nominal exchange rate multiplied by the relative price levels between the two countries. Since prices are fixed, the price ratio does not change and any changes in the real exchange rate will be consistent with changes in the nominal exchange rate.

² Throughout the entire paper, I define exchange rates as home currency per unit of foreign currency. Hence, an increase in the exchange rate is consistent with home currency depreciation.

³ More detail about the J-curve effect is included in Appendix A

⁴ A study by the Council of Economic Advisers suggests that a lag of six quarters in net export changes do follow the exchange rate changes. (Appleyard and Field, p.545)

⁵ Sources used to study the original framework of the model are Copeland (2000); Appleyard and Field (2001)

⁶ In Watson, P and Teelucksingh, S., "A practical introduction to econometric methods : classical and modern", University of West Indies Press, Kingston, Jamaica, 2002

⁷ Federal Reserve Economic Data (FRED II) at <http://research.stlouisfed.org/fred2/>

⁸ UK National Statistics at <http://www.statistics.gov.uk/STATBASE/tsdataset.asp?vlnk=708>

⁹ <http://www.bankofengland.co.uk/mfsd/>

¹⁰ <http://finance.yahoo.com/q/hp?s=GSPC>

¹¹ Deficit data provided by the US Treasury, http://www.econstats.com/rt_treas.htm; The University of Michigan Consumer Sentiment index is calculated by The University of Michigan, <http://www.econstats.com/michigan.htm>

¹² <http://www.census.gov/foreign-trade/balance/c4120.html>

¹³ Energy Information Administration at

http://www.eia.doe.gov/oil_gas/petroleum/info_glance/crudeoil.html

¹⁴ Econometrics software; the RSTAT command performs tests for autocorrelation among others

¹⁵ The statistical tables of Durbin-Watson critical values allow for 100 observations and seven explanatory variables only. Therefore, we round down the observations from 172 to 100 and use the values for seven explanatory variables whenever we have a larger number of variables. As a result, the critical values used above are rather inaccurate, but the best approximation available.

¹⁶ The VIF is a method of detecting how severe the multicollinearity is. It is calculated as

$VIF(\beta_i) = \frac{1}{(1 - R_i^2)}$ and the general rule is that $VIF > 5$ indicates severe multicollinearity.

¹⁷ In Studenmund, p.422

¹⁸ Due to the incompleteness of statistical F-tables we have used a conservative approximation of the critical F value by rounding down the denominator degrees of freedom to 120: $F(3,165) \approx F(3,120) = 2.748$

¹⁹ Long and short-run trade elasticities for G7 countries from 1950 to 1997 were estimated by the Board of Governors of the Federal Reserve System. For all seven countries, the Marshall-Lerner condition is not met in the short run. (Appleyard and Field, 539)