The Real Euro-Dollar Exchange Rate and Equity Market

Abstract

This study estimates the Behavioural Equilibrium Exchange Rate (BEER) for the real euro-dollar exchange rate. It relates the euro-zone and US equity market to the real euro-dollar exchange rate. The simple equity market parity model outperformed many of the traditional BEER models for the euro-dollar exchange rate. Notably, the misalignment of the euro in the early years of the EMU (1999-2001) seemed to be associated with the performance of the US and euro-zone equity markets. The results suggested that the equity market could play an important role in understanding the equilibrium value of real exchange rates.

Keywords: the real euro-dollar exchange rate, equity market, BEER.
JEL Classification: F31, G15, G11.

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Introduction

Since the launch of the euro in 1999, the behaviour of the real euro-dollar exchange rate has not been fully understood. In effect, various models for the equilibrium exchange rate such as the PPP, BEER (Behavioural Equilibrium Exchange Rate), FEER (Fundamental Equilibrium Exchange Rate), PEER (Permanent Equilibrium Exchange Rate) and NATREX models have all unanimously predicted undervaluation of the euro; see e.g. Björksten and Kim (2000), Chinn (2000), Maeso-Fernandez et al. (2001), Koen et al. (2001), Clostermann and Schnatz (2000), Hansen and Roeger (2000), Detken at al. (2002). In effect Detken et al. (2002) suggest that undervaluation of the euro increases with the structure imposed on the model and with the horizon regarding the underlying long-run equilibrium. This leaves the equilibrium real euro-dollar exchange rate a puzzle and calls into question the ability of the current models to explain the real euro-dollar dynamics. Detken et al. (2002) also call for alternative explanatory variables to explain euro-dollar dynamics. This study offers one such alternative and examines the relationship between the equity market for the real euro-dollar exchange in the BEER-type medium-run real exchange rate model.

The PPP, Balassa-Samuelson, NATREX, FEER models are all seen as producing a long-run equilibrium real exchange rate. The macroeconomic balance approach, such as FEER, calculates an equilibrium exchange rate that is consistent with the economy operating at capacity output and in a sustainable current account position. In case of a new currency such as the euro, it seems more appropriate to consider a medium-term assessment, such as the medium term equilibrium exchange rate produced by the BEER type of model. The current values of the determinants of the long-run equilibrium exchange rate may, in the BEER, depart from the sustainable level of fundamentals in the FEER. The BEER provides a measure of current misalignment, which is the difference between the actual value of the exchange rate and the estimated level of exchange rate given by the current value of all economic fundamentals employed in the model. The BEER is also very useful because of its empirical flexibility.[1]

Our modelling strategy is to incorporate and test the importance of a new factor, the stock market, in the BEER type of model for the euro-dollar exchange rate. The importance of the

[1] The PEER could be derived, e.g., by utilizing Johansen's cointegrating vector and Gonzalo-Granger (1995) decomposition. The main difference between the PEER and the BEER is due to the way the latter measure incorporates transitory elements. To the extent the BEER is a permanent series, the BEER and PEER would produce rather similar equilibrium exchange rates, as indicated by the evidence in Maeso-Fernandez et al. (2001) for the real effective exchange rate of the euro and Clark and MacDonald (2004) for the equilibrium Canadian and the US dollar exchange rate.

equity market variable is also examined with respect to factors proven to be of importance in previous studies for the euro-dollar exchange rate; see Maeso-Fernandez et al. (2001), Detken et al. (2002), Clostermann and Schnatz (2000), Alquist and Chinn (2000).[2] We test the importance of the Balassa-Samuelson hypothesis, demand side variables, such as government and private consumption (relative fiscal position), and the real price of oil in determining the medium-run dynamics of the euro-dollar exchange rate. Our research strategy is then to test the significance of the proposed new factor, the equity market, in these more traditional versions of the BEER for the euro-dollar rate. The stock market variable could have an impact of its own or it could capture the impacts of some other factors, such as productivity or demographic factors indirectly.

The structure of the remaining part of the study is as follows. The next section discusses the possible relation between the equity market and the real exchange rate. Section three presents the factors behind the euro-dollar dynamics. Section four introduces the real equity market parity. Section five provides several BEER estimates for the euro-dollar exchange rate and section six concludes.

2 Equilibrium Exchange Rate and Equity Market

Purchasing Power Parity is a traditional approach to the concept of an equilibrium exchange rate. However, a large body of empirical research calls into question the existence of PPP; for a survey see e.g. MacDonald (1995), Froot and Rogoff (1995), Rogoff (1996), Sarno and Taylor (2002). Detken et al. (2002) provide evidence that PPP may not hold between the euro and the dollar either.

In many cases incorporation of the bond market into PPP has provided more evidence on the long-run equilibrium exchange rate; see MacDonald (2004), Juselius (1991), (1995), Johansen and Juselius (1992a) MacDonald and March (1997), Juselius and MacDonald (2000), (2004). However, studies on the equilibrium exchange rate have all neglected the potential impact of the equity market, although the size of the market has dramatically increased during recent years. Moreover, since equity portfolio flows, unlike debt flows, are not usually hedged, their influence on exchange rate dynamics could be even stronger than that of the bond markets. Accordingly, due to

[2] Other explanations have also been offered. Among others e.g. Cohen and Loisel (2001) suggest that the surge of the euro is due to an overly restrictive fiscal policy. Sinn and Westerman (2001) propose that the weak euro was due to shifts in substitute currency balances from the DEM into the US dollar among the transition countries. Gómez et al. (2007) provide evidence that the euro was weak because market participants were first learning the low inflation policy of the ECB.

the omission of the equity market previous studies may have provided erroneous equilibrium exchange rates and potential bias in the speed of adjustment towards the long-run equilibrium.

The equity market might capture the impacts of many different factors. First, the equity market may reflect the impact of productivity on the equilibrium real exchange rate. This is consistent with the Balassa-Samuelson hypothesis, which points out that any appreciation of the real exchange rate should go in tandem with the appropriate productivity gains. Alquist and Chinn (2002) offer evidence that appreciation of the dollar against to the euro would be mainly because of the higher level of US productivity. Chinn (2000) relates the impact of stock markets to expected productivity growth. Higher productivity generates higher incomes in the US and, further, a disproportionate increase in spending on domestic goods, which causes appreciation of the dollar. Among others, Maeso-Fernandez et al. (2001) indicate that the real euro exchange rate would be mainly affected by developments in productivity, real interest rate differentials, and external shocks due to the oil dependence of the euro area. However, we lack evidence as to whether the changes in productivity reflected in the equity markets are already captured, e.g. through the Balassa-Samuelson effect, or whether the equity market could have an impact of its own. Neither Chinn (2000) nor Alquist and Chinn (2002) explicitly incorporate the equity market into the analysis. Moreover, the evidence on the impact of productivity on the euro exchange rate is not unanimous either. Detken et al. (2002) and Schnatz et al. (2003) propose that other factors rather than differences in the growth of productivity underlie the recent dynamics of the euro-dollar exchange rate.

The NATREX model proposes also that the real exchange rate is related to productivity; see Stein (1995). A positive productivity shock produces a real exchange rate appreciation in the medium run, which implies a larger current account deficit and an increase in foreign debt. An increase in productivity may result appreciation of the long-run real exchange rate, since in addition to foreign debt, the capital stock also rises in the medium term. This causes productivity to grow even faster, leading to higher GDP and higher savings. In this situation, foreign debt decreases and the real exchange rate appreciates in the long run to counterbalance the improved current account. Higher imports may offset part of the appreciation of the real exchange rate. Imports may be boosted if the wealth effect of equity prices and returns on consumption are strong. The latter effect, in turn, relates to the share of domestic equities owned by domestic residents. Moreover, the increase in productivity may be reflected in equity prices directly, which generates an additional link between the real exchange rate and the equity market.

The equity market may also capture changes in demographic factors, which have an impact on the real exchange rate. A rise in stock prices is frequently attributed to a growing demand for financial assets as baby boomers began to save for their retirement; see e.g. Jamal and Quayes (2004), Able (2001), Campbell and Cochrane (1999) and Poterba (2001). Equity prices would then be expected to decrease as this generation reaches retirement age; Jamal and Quayes (2004) and Abel (2001). Accordingly, the demographic structure could be related to stock market behaviour since the age structure is related to the amount of savings. In addition, Higgins (1998) and Feroli (2006) provide evidence that changes in demographics have had a significant impact on current account balances. The long-run effects of aging on the real exchange rate can be described as follows. First, a country accumulates foreign assets, e.g. to pay for the retirement of its aging population, experiences a regular real appreciation of its currency and a current account surplus. Ultimately, aging causes a lower savings rate, which causes higher interest rates and a current account deficit. This is associated with capital inflow and appreciation of the domestic currency to the point where expectations for future depreciation are consistent with the current interest rate differential. Future devaluations are expected by the capital markets, since they expect a decline in demand as the economy is running down its assets. Finally, the long-run external balance requires more exports/less imports, which leads us to expect that the real exchange rate will depreciate. Accordingly, if the changes in the equity markets were due to aging, then its impacts would be opposite of those of an increase in productivity. Tille et al. (2001) found no evidence for the impact of the age structure in case of the USA vs. the euro-zone although such evidence was much clear in Japan vs. the USA. They interpreted that it is the productivity rather than the age structure which drives the long-run dollar real exchange rate.

It has also been proposed that exchange rates could be driven in part by the flow of funds to the stock market; see e.g. Bailley and Millard (2000), Meredith (2001) and Brooks et al. (2001). The flow of fund increases equity prices which in turn boost both consumption and investment, explaining the shock on the demand side. Higher investment in turn could also raise the capital stock and thus labour productivity. This increases potential output on the supply side.

Equity market and equity flows could have some short-run effects on the real exchange rate. This channel goes through the order flow on the foreign exchange market. The simultaneous appreciation of the nominal dollar exchange rate with the rise in the US stock market during the early days of the euro suggested that the stock market and the nominal euro exchange rate could be related. Meredith (2001) relates the dollar appreciation in the dollar, among other things, first, to the surge in global equity values that has occurred since the mid-1990s, which has disproportionately affected the US economy and, second, to the portfolio shifts which occurred as a result of a surge in the issuance of euro debt by borrowers, and a corresponding shift towards non-euro assets by lenders.

The sign of the short-run impact of the equity market on the exchange rate is not clear-cut, however. Hau and Rey (2002), (2006) indicate that the short-run relationship between equity returns and the nominal exchange rate is negative rather than positive. Hau and Rey (2006) propose that appreciation of the foreign equity market relative to the home equity market induces a portfolio rebalancing process in which the home investor reduces his foreign equity holdings in order to reduce his exchange rate exposure. This results in foreign equity outflows and nominal appreciation of the domestic currency. Similarly, net equity flows into the foreign market are positively correlated with the appreciation of a foreign currency. Cappiello and DeSantis (2005) also provide evidence, based on the arbitrage condition, that higher equity returns in one country are related to the expected nominal depreciation of its currency. This result is not inevitable, however. If the supply of equities is elastic due to new issues of stocks, there would be no correlation between equity returns and the exchange rate; see Sinn and Westerman (2001). Pavlova and Rigobon (2003) propose that dynamics in the equity market and nominal exchange rate are largely driven by the same factors and that the sign of the relationship is determined by the type of shock. In an in IAPM setting Pavlova and Rigobon (2003) indicate that, ceteris paribus, a positive shock to a country's output leads to deterioration in the terms of trade and the country enjoys nominal exchange rate depreciation. At the same time the national equity market sees a positive return. The demand shock, in turn, leads to appreciation of the nominal exchange rate. The evidence for the supply shock as a long-run and the demand shock as a short-run impact, provided in Pavlova and Rigobon (2002) is consistent with the propositions of the traditional equilibrium exchange rate models on the impact of productivity on the real exchange rate.

Finally, there is also some evidence that the equity market is in related to the prevailing macroeconomic conditions; for evidence see e.g. Cheung and Ng (1998), Fama (1981), (1990), Chen et al. (1986), Ferson and Harvey (1991), Schwert (1990) and Flannery and Protopapadakis (2002). Accordingly, the equity market could then reflect the overall shocks of the business cycle, which play a significant role in the real exchange rate dynamics; see e.g. Clarida and Gali (1994), Chadha and Prasad (1997).

2.1 Equity Market Parity

We incorporate the *real equity market parity* to measure the dynamics of the real exchange rate and deviations from PPP. The arbitrage condition states that prices of similar equities (*SP*) should be the same irrespective of the country or currency. In terms of the IAPM (International Asset Pricing Model; see Solnik, 1974) or IAPT (International Arbitrage Pricing Theory; see Solnik, 1983) it is assumed that markets are perfect, risks are equal, and that all agents have the same consumption opportunity set. Investors in the equity markets do not face any exchange rate risk and are thus not expected to hedge their positions. In the short run this assumption may be violated, while over a very long period the currency risk would be expected to be washed out; see Froot (1993).[3] Expected real equity prices in the two countries are assumed to be equal (1).

$$\frac{SP_t}{P_t} = \left[\frac{SP_t^{US}}{P_t^{US}}\right] \qquad (1)$$

From the above we define the real equity market parity (2).

$$eq_t = \log\left[\frac{\frac{SP_t}{P_t}}{\frac{SP_t^{US}}{P_t^{US}}}\right] \qquad (2)$$

The real equity market parity in logs (2) defines the real exchange rate (3).

$$eq_t = sp_t - sp_t^{US} \qquad (4)$$

$$q_t = eq_t \qquad (5)$$

In both countries equity prices (*SP*) are generated through the Discounted Present Value (*DPV*) model for future dividends (D_n); see Equation (6). On the aggregate level, the dividend depends on the level of output. We assume further that dividends are based on the potential (natural) level of output y_p. Accordingly, equity prices may also capture the impact of output on the real exchange rate. This is supported by the evidence in Alexius (2005), who suggests that the changes in output, which she labelled as changes in productivity, account for most of the shocks to the real exchange rate among the major currencies.

$$SP^{EMU,US} = DPV_i^{EMU,US} = \frac{D_1}{(1+r_a)} + \frac{D_2}{(1+r_2)^2} + .. + \frac{D_n}{(1+r_n)^n} = \sum \delta_n D_n^{EMU,US} \qquad (6)$$

$$where,\ \delta_n = \frac{1}{(1+r_i)^n} \qquad (6.1) \qquad \text{and } D_n^{EMU,US} = \gamma\, y_p^{EMU,US} \qquad (6.2)$$

In this study the simple real equity market parity is utilised as one competing BEER model for the real euro-dollar exchange rate. The performance of the simple equity market BEER model for the real euro-dollar exchange rate is first examined and then compared with several other more

[3] In the short run currency risks could still be significant; see e.g. Jorion (1990), Dumas and Solnik (1995), DeSantis and Gerard (1998).

traditional specifications of the BEER, which incorporate Interest Rate Parity, the Balassa-Samuelson hypothesis and terms-of-trade shocks.

2.2 Equity Market Parity and the Dynamics of the Real Euro-Dollar Exchange Rate

The real equity market parity in BEER is evaluated in terms of the real equity market spread (*eqs*), which relates the performance of the real Euro50 and S&P500 equity market indices. Real stock market indices were constructed by deflating the Euro50 by the HICP and the S&P500 by the US CPI. In the empirical analysis the log of the real equity market indices were utilized.

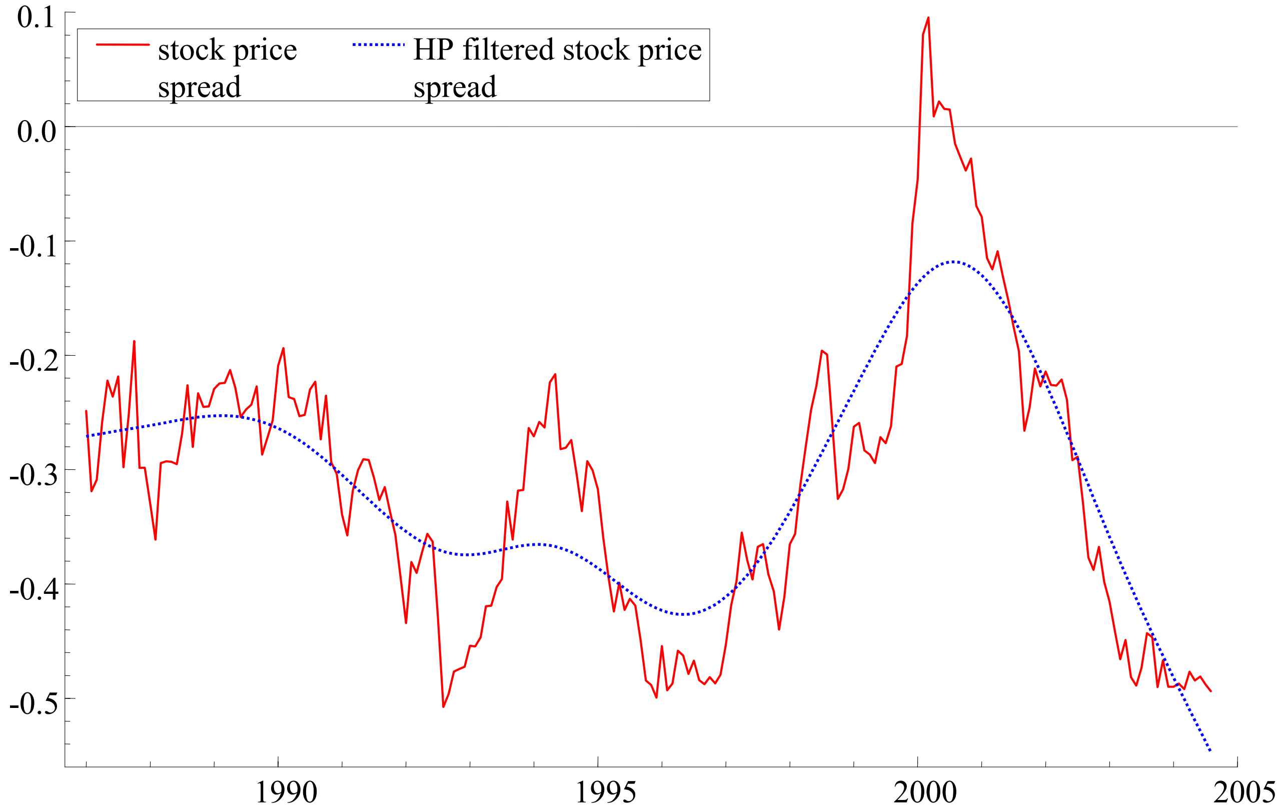
$$eqs = \log\left[\frac{Euro50 / HICP^{EMU}}{SP500 / CPI^{US}} \right] \quad (7)$$

The equity market indices are a highly volatile series. The high volatility may stem from several factors, such as overreaction of the asset market to changes in information, non-rationality, behaviour of chartists and other non-informed investors.

In order to separate the fundamental trend from the highly volatile equity price data, we applied the Hodrick-Prescot (1997) filter to the real equity market spread (*eqs*). The HP filter has a particular attraction for our purposes. First, it provides a unique decomposition of the univariate time series into permanent and transitory components in contrast to the other widely used decomposition methods, such as the Beweridge-Nelson (1981) decomposition. Second, the HP filter is widely used to smooth out the potential (permanent) level of output. Figure 1 displays the HP-filtered real stock price spread (eq_t) and the actual real stock price spread (*eqs*).

The difference between the actual values and filtered series reflects the temporary deviations in real equity prices from the prices implied by the DPV model. Apart from the impact of the DPV of dividends, the HP filter may also capture the impacts of other factors having a long-run impact on the real exchange rate, such as changes in the accumulation of portfolio wealth, changes in demographics or changes in productivity.

Figure 1 Stock price spread and permanent stock price spread.



Notes; the log of the real stock price stock price spread and Hodric-Prescot filtered log of the real stock price spread.

Figure 2 HP-filtered stock market spread and the real euro-dollar exchange rate.

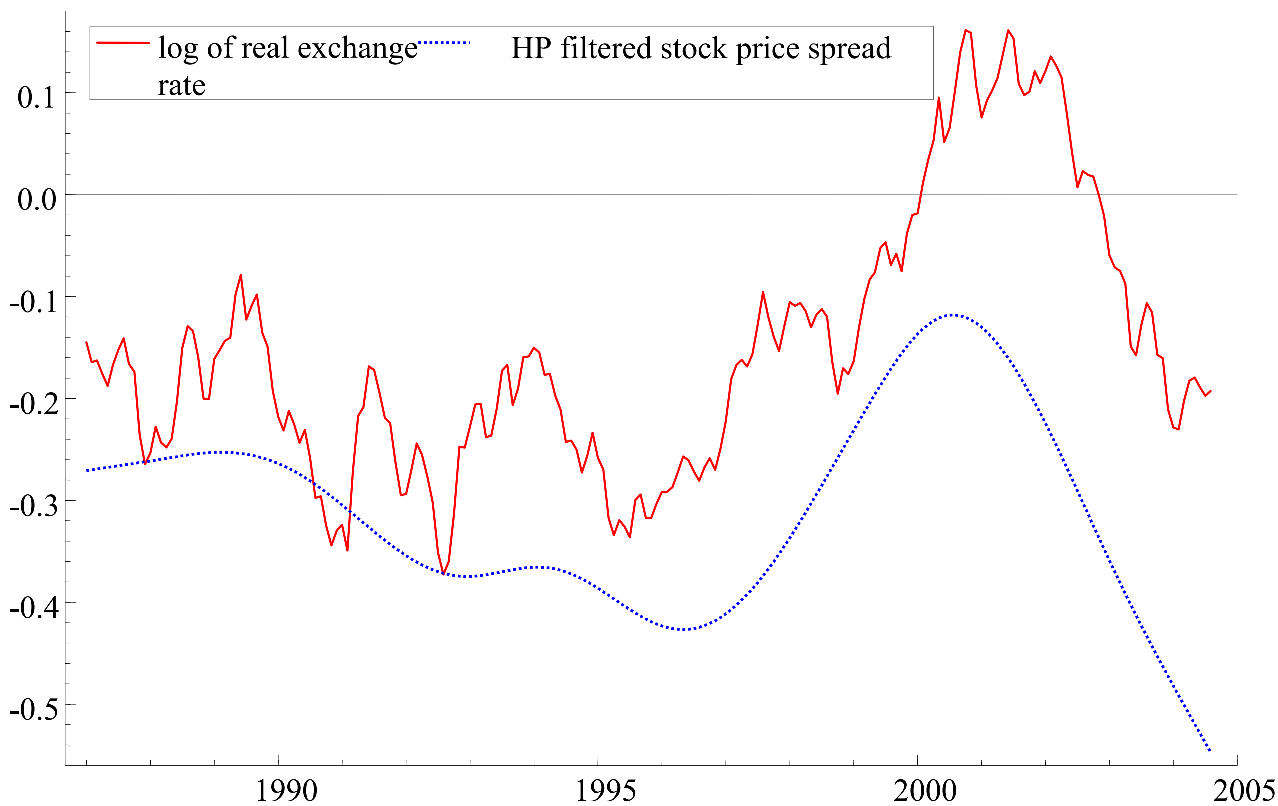


Figure 2 displays the HP filtered permanent stock price spread (eq_t) and the log of the euro-dollar exchange rate in the same figure. The real exchange rate is defined as $q=ep^{US}/p^{EMU}$ and the nominal exchange rate e as the price of one US dollar in euros. Depreciation of the nominal exchange rate of the euro against the US dollar in the early days of the euro is clearly recorded in the figure. Since 2002 nominal euro exchange rate has regained its value, which can be detected as a fall in the real euro-dollar exchange rate. The dynamics of the real euro-dollar exchange rate is associated with the relative performance of the US and euro-zone equity markets. Short-run deviations between equity market parity and the real exchange rate seem to exist. However, the trends could be related. This suggests that equity market parity could provide some valuable information regarding the equilibrium value of the real euro-dollar exchange rate.

Our research strategy is as follows. Next we examine the simple equity market parity model in terms of the BEER model for the real euro-dollar exchange rate. Second, we extend the analysis to several multivariate rival BEERs for the real euro-dollar rate. The BEERs are first estimated without the equity market variable and then augmented by equity market parity. By so doing we expect to be able to compare the performance of the alternative models with respect to the performance of the simple equity market parity BEER. This also enables us to evaluate whether equity market parity only reflects the impact of some of the fundamentals already included in the multivariate BEER model utilized in previous studies. Finally, the projected equilibrium real exchange rates are compared to the actual euro-dollar real rate.

3 Empirical Analysis

As in a number of well-documented previous studies on real exchange rates the unit root tests proposed non-stationary of the relevant time series. Therefore the empirical analysis was carried out by the well-known Johansen cointegration analysis; see Johansen (1988), Johansen and Juselius (1990). The cointegration analysis was applied in estimating the BEERs for euro-dollar exchange rate. The cointegrating β-vectors without the short term impacts are assumed to produce the BEERs for the real euro-dollar exchange rate.

The VAR models were estimated with constant unrestricted and the time trend restricted to the cointegration space, thereby allowing for possible trends in levels of the data. The trend in the cointegrating space restricts the system at most to a linear deterministic trend in levels, and possibly in cointegrating relations. An explicit trend in the cointegrating relation enables long-run linear growth to enter into the model which our data would not otherwise be able to account for. According to Doornik et al. (1998) and Hubrich et al. (2001), omitting the trend could lead to severe size distortions if the trend were present in a correct model. On the other hand, wrongly including the trend in the cointegration relation would at most only weaken the power of the cointegration test. To avoid erroneous treatment of the trend, the significance of the trend was explicitly tested by applying the LR test. The VAR also included seasonals with means restricted to zero. The minimum number of lags were specified in the VAR to guarantee residual non-autocorrelation. It turned out that 13 lags were required. Some evidence of non-normality in some specifications was recorded, reflecting the degree of excess kurtosis in the data. However, Cheung and Lai (1993) and Gonzalo (1994) have demonstrated that the Johansen procedure is robust for non-normality as long as residuals are not autocorrelated. Therefore we made no further modelling provisions with respect to non-normality. These shortcomings should be kept in mind when evaluating the robustness of our results.

3.1 Real Exchange Rate and Equity Market

We start the empirical analysis by testing whether the equilibrium relationship between the equity market and the real euro-dollar exchange rate can be detected. The equity market parity specification incorporated only the permanent component of the Hodrick-Prescot decomposition of the log of the real equity market spread (eq_t) and the log of the real euro-dollar real exchange rate (q_t). The estimation period is 1987:1-2004:8. The Johansen cointegration test results are presented in Table 1.

Table1 Test for cointegration; equity market parity and real exchange rate.

	Trace test	Critical value	Small-sample corrected test statistics
$r \leq 0$	34.654 [0.002]	25.32	28.86
$r \leq 1$	12.944 [0.041]	12.25	13.96

Notes; sample size 1989(2)-2004(8), critical values refer to Reinsel-Ahn (1991) critical values, small-sample corrected test statistics refers to Cheung-Lai (1993) test statistics at 0.05 level of risk . In VAR (p=13), Vector Portmanteau(12) 0 81.3694, Vector AR 1-7 F(112,364) = 0.99751 [0.4957], $\chi^2(8)$ = 20.399 [0.0089], vector hetero test F(10060, 93) = 0.15850 [1.0000].

Due to the relatively short sample period, the main emphasis is placed on small-sample corrected critical values, as proposed by Cheung and Lai (1993). Based on Johansen's *Trace test*, the hypothesis of non-cointegration ($r \leq 0$) is rejected and the existence of a cointegrating relation is supported. The cointegrating β-vector was normalized with respect to the real exchange rate, yielding the following long term relation between the euro-dollar real exchange rate and equity market parity:

$$\underset{}{q_t} = \underset{(0.0002)}{0.00127\, trend} + \underset{(0.2575)}{1.3609 eq_t} \quad (8)$$

Standard errors are presented in parenthesis. The equity markets (*eq*) were found to be weakly exogenous[4] while the real euro-dollar exchange rate adjusted towards the long-term equilibrium with the adjustment coefficient $\alpha_q = -0.1586$ [0.0402]. This implies very rapid adjustment as the half life of real exchange deviations from the equilibrium would be only four months.[5] The rapid adjustment towards the equilibrium is in accordance with foreign exchange traders' beliefs that changes in the exchange rate over a six-month or shorter horizon accurately reflect changes of an observable nature in economic fundamentals; see Cheung et al. (2004). Thus the equity market may be able to measure and draw on the information conveyed by a large number of different fundamentals.

The equilibrium relation between the equity markets and the real euro-dollar exchange rate contains a positive linear trend.[6] This suggests that during the estimation period the euro-dollar real exchange rate increased steadily, implying rising price competitiveness of the eurozone. In effect the time trend seems to capture some of long-run factors affecting the real exchange rate which are not reflected in the equity market.

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[4] H_0: $\alpha_{eq} = 0$, $\chi^2(1) = 1.2057$[p-value = 0.2722].

[5] For example the consensus estimates for the half-lives of the deviations from the PPP equilibrium have normally been from three to five years.

[6] The coefficient of trend turned out to be significant in the cointegrating space: the LR test yielded $\chi^2(1) = 4.6786$ 0.0305].

Figure 3 Equity market BEER and the real euro-dollar exchange rate.

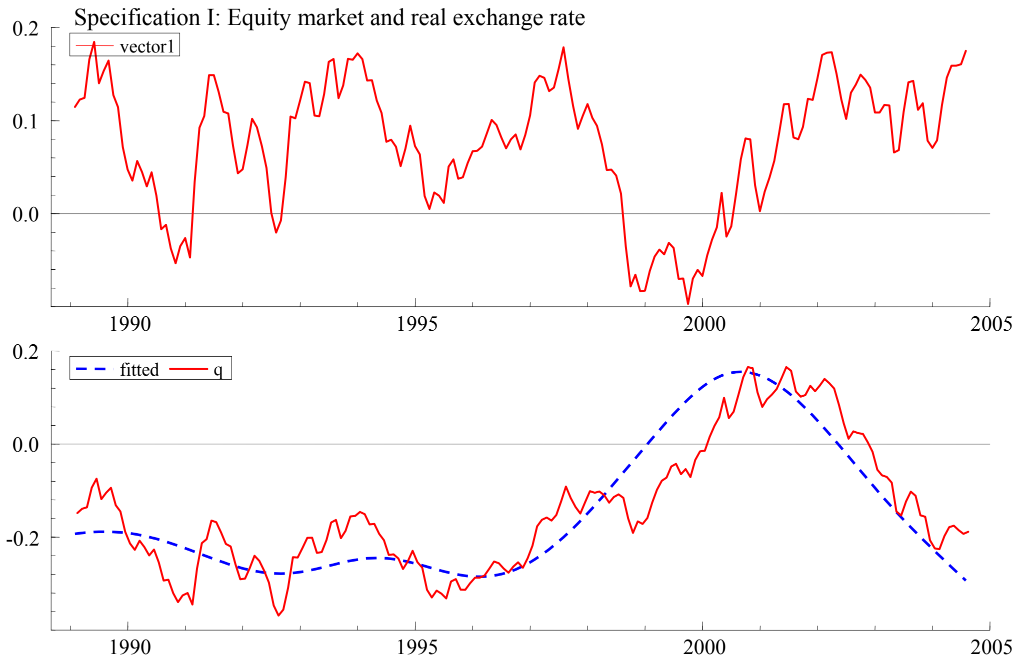


Figure 3 presents the simple equity market BEER and the real euro-dollar real exchange rate. The upper graph displays the estimated cointegrating vector while the lower graph displays the estimated BEER (fitted) and the true values of the log of the real euro-dollar exchange rate $(q)_t$. The graph for the cointegration vector appears to indicate stationarity and hence supports the inference drawn from the *Trace tests* for cointegration. The vector is not corrected for short-run deviations, and presents only the fitted values based on $\beta \hat{x}$. The graphs for the actual and fitted values (BEER) are plotted as deviations from mean; see Doornik and Henrdy (2001).[7] Surprisingly, the estimated BEER suggests that in the early days of the euro even stronger weakening of euro would have been required in order to reach the equilibrium real exchange rate. This conflicts with the evidence provided in all other studies, which unanimously proposed undervaluation of the euro-dollar exchange rate; see e.g. cf. e.g. Detken (2002), Koen et al. (2001), Alquist and Chinn (2002), Closterman and Schnatz (2000), Maeso-Fernandez et al. (2001). Figure 3 also indicated that from 2000 onwards, the real-euro dollar exchange rate tracked its equilibrium value rather closely.

The Johansen procedure also provides information on the relative importance of the effects of different shocks on the system. We estimated the Moving Average representation for VECM in order to be able to interpret on the relative importance of various shocks affecting the real

[7] These figures can be reproduced by adding the mean of the spread between the actual (x_t) and estimated ($\hat{x}_t$) values to the normalized cointegrating vector.

exchange rate. The moving average long-run impact matrix also indicates that the equity market had a strong cumulative impact on the system; see Table 2.

Table 2 Moving average long-run impact matrix, **C** matrix.

Variable	$\sum \varepsilon_q$	$\sum \varepsilon_{eq}$
q_t	0.5226	4853.0
eq_t	0.3449	6502.4

Notes; matrix estimated without any restrictions in the system.

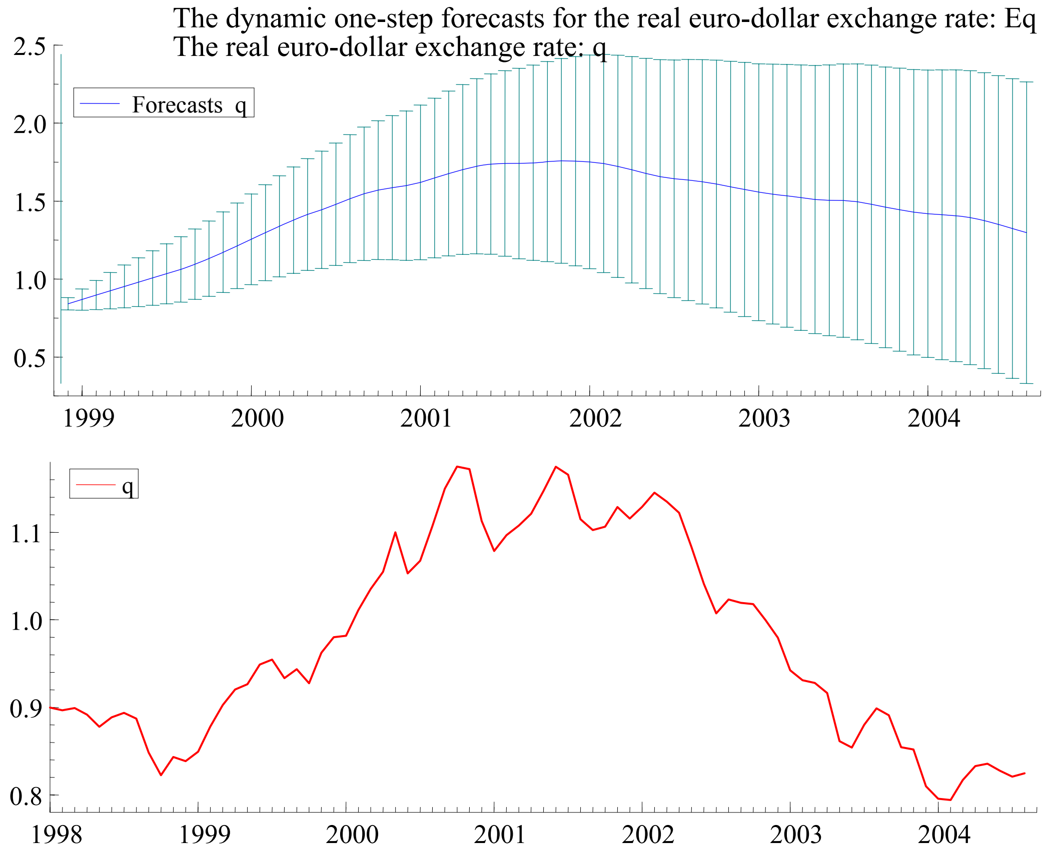
Since the equity market variable turned out to be weakly exogenous, we estimated the model as a single error correction mechanism (ECM). The model passes all the diagnostic tests. The result from the ECM (27) supports the results from the Johansen VECM. The Error Correction Term (ECT) is significant and negative, indicating cointegration between the real exchange rate and equity market parity and thus adjustment in the real exchange rate towards the long run equilibrium. However, the ECT indicates a slightly lower adjustment than estimated in the VECM.

$$\underset{}{\Delta q_t} = \underset{(3.83)}{0.0122} + \underset{(5.60)}{0.3503}\, \Delta q_{t-1} - \underset{(4.39)}{0.0915}\, [q_t - 0.00013\, trend - 1.3609 eq_t]_{t-1} + \varepsilon_t \quad (9)$$

Diagnostics
R^2 = 0.189354, σ = 0.0222773, RSS = 0.10272970, AR 1-7 F(7, 200) = 0.93261 [0.4823], ARCH 1-7 F(7,193) = 0.24360 [0.9737], Normality $\chi^2(2)$ = 1.7756 [0.4116], hetero test F(4.202) = 1.0117 [0.4024], RESET test F(1,206) = 0.25181. 1-step forecast, 69 observations 1988(12)-2004(12): Forecast $\chi^2(29)$ = 62.849 [0.6854], Chow F(69, 138) = 0.87844 [0.7231].

We also used the model for forecasting purposes. The model was estimated with 69 observations left out for forecasting purposes. Figure 4 provides the one-step-ahead forecasts for these 69 observations (months) and the $2 * S.E.$ for the forecasts. The lower graph presents the actual values of the euro-dollar exchange rate. The difference between the forecasted and actual values indicates that our simple equity parity model tends to overestimate the real exchange rate. The model shows even stronger real depreciation of the euro. In turn, the estimated long-term swing is well in line with the actual values of the real euro-dollar exchange rate. The real euro-dollar exchange rate seemed to peak somewhere in mid 2001.

Figure 4 Forecasted real euro-dollar exchange rate, 2 $*$ S.E. and the true euro-dollar real exchange rate; 69 forecasted values.



3.2 Rival Models for the Real Euro-Dollar Exchange Rates

We estimated the cointegration relations for each of our rival models. First, we examined cointegration in a by-variable case between the single fundamental and the real exchange rate. The results of the by-variable Johansen's *Trace tests* for cointegration are presented in Appendix Table A1. Based on the trace test, the test statistics showed the following decreasing order: 1) $[\, q_t, eq_t \,]$ 2) $[\, q_t, gov_t \,]$ 3) $[\, q_t, q_t^{BS} \,]$ 4) $[\, q_t, nfa(emu)_t \,]$ 5) $[\, q_t, i_t - i_t^{US} \,]$ 6) $[\, q_t, oil_t \,]$. It is noteworthy that the results suggest that a significant long-run relation can only be detected between equity market parity and long-run real euro-dollar exchange rate $[\, q_t, eq_t \,]$.

Next, we estimated several competing multifactor BEER models for the real euro-dollar rate. The models were specified on the basis of previous empirical studies, although only those which proved to be cointegrated were closely examined.[8] First, cointegration in each specification was tested. The inference on cointegration was made based on Cheung-Lai (1993) small-sample corrected test statistics at 0.05 level of risk. If more than one cointegrating vector was detected, we focused only on the first vector, which was then normalized as a *β*-vector for the real exchange rate. This is common practice in studies on the real exchange rate. Second, the first cointegrating vector with *β* and *α*-coefficients was estimated. Third, the vector was estimated in restricted form. The cointegrating *β*-vectors without the short term impacts are assumed to produce the BEERs for the real euro-dollar exchange rate. To avoid erroneous treatment of the trend, the significance of the trend was explicitly tested by applying the LR test.

The number of cointegrating vectors and restricted vectors for the real euro-dollar exchange rate are presented in Table A2 and A3. Specification I, incorporates the following vector of variables: $[\ q_t, i_t - i_t^{US}, q_t^{BS}, oil_t, gov_t\ ]$. This specification resembles that of Closterman & Schnatz (2000), Model V in Maeso-Fernandez et al. (2001) and some specifications in Schnatz et al. (2003). The biggest difference between the last-mentioned is in the treatment of productivity. Whereas Schnatz et al. (2003) utilize several explicit measures for productivity, we assume that the impacts of productivity are captured a) via the Balassa-Samuleson effect or b) through the equity market in the equity market augmented specification. Moreover, the Balassa-Samuelson effect is expected to reflect both the impact of the relative price level and the impact of productivity on the real exchange rate. For $[\ q_t, i_t - i_t^{US}, q_t^{BS}, oil_t, gov_t\ ]$ one cointegrating relation was detected. Augmenting Specification I with the equity market increased the number of cointegrating vectors from 1 to 3. Inclusion of the equity market changed the signs of many of the *β*'s. Now $i_t - i_t^{US}, q_t^{BS}, gov_t, eq_t$ had a negative impact on the real euro-dollar rate in a long-run *β*-vector. Inclusion of equity market parity also considerably increased the speed of the adjustment of the real exchange rate (from α_q = -0.02 up to α_q = -0.44). We also succeeded in imposing some restrictions on the parameters in the cointegrating vector (β_{oil} = 0 and $\beta_{i-i^{US}}$ = 0), and the final long run β-vector now had the form $q_t = -4.4114\, q_t^{BS} - 2.0187 gov_t + 1.8919\, eq_t$.

The performance of the BEERs is also displayed in graphs. The first graph in Figure A1a displays the first cointerating vector for $[\ q_t, i_t - i_t^{US}, q_t^{BS}, oil_t, gov_t\ ]$. The second figure displays the BEER obtained from this set of variables and the real euro-dollar exchange rate. Figure A1b indicates the first cointegrating vector for $[\ q_t, i_t - i_t^{US}, q_t^{BS}, oil_t, gov_t, eq_t\ ]$ and the BEER

[8] For example, the specification of $[\ q_t, i_t - i_t^{US}, q_t^{BS}\ ]$ in Dieppe et al. (2002) offered no evidence of cointegration and therefore was left outside the further analysis.

estimated from this. It seems that the actual exchange rate followed the equity market-augmented BEER relatively closely until 1998. Since then the BEER suggests that the value of the real exchange rate should have been even higher. This could have occurred e.g. if the nominal euro had depreciated more heavily in relation to the US dollar. Correspondingly, since 2001 the appreciation of the nominal euro should have been stronger in order to attain the BEER implied by the equity market-augmented specification I. Comparing figures A1a and A1b, it seems that equity market parity is able to offer an explanation for the increase in the real exchange rate in the early days of the euro.

Inclusion of the equity market in Specification II, $[\ q_t, i_t - i_t^{US}, q_t^{BS}, nfa(emu)_t\ ]$, as e.g. Clark and MacDonald (2004), showed the following impacts. First, the number of cointegration vectors increased from 1 to 4; see Table A2. Second, it decreased the speed of adjustment in real exchange rate considerably (from -0.104 to -0.06). Third, it affected on the signs of the *β*-coefficients. Figure A2a presents the estimated BEER without the equity market: q_t = -0.0226 ($i_t - i_t^{US}$) + 8.1492 q_t^{BS} - 0.0838 *naf(emu)*$_t$. Figure A2b presents the BEER with the equity market; q_t = - 0.0716 ($i_t - i_t^{US}$) - 12.385 q_t^{BS} + 0.1569 *naf(emu)*$_t$ + 2.5303 eq_t. Specification II proposes that the BEER would track the real exchange rate more closely without the equity market. The equity-market augmented BEER provides considerably higher values for the misalignment in the real euro-dollar exchange rate. Notably, the equity market-augmented specification suggests even higher depreciation of the euro against the dollar at the end of 1990s than actually occurred.

Specification III, $[\ q_t, q_t^{BS}, gov_t, oil_t, eq_t\ ]$, roughly represents the Closterman-Schnatz (2000) model and Specification IV in Maeso-Fernandez et al. (2001). Augmenting Specification III with the equity market increased the number of cointegrating vectors from one to two; see Table A2. The inclusion of the equity market also increased the speed of adjustment of the real exchange rate towards the long-run equilibrium (from -0.0038 to -0.0568). In this specification the equity market variable eq_t turned out to be insignificant both in terms of long-run coefficients β and short-run adjustment coefficients *α*. Although the equity market was restricted to zero in the cointegration space $[\ q_t, q_t^{BS}, gov_t, oil_t, eq_t\ ]$, the estimated restricted vector was not the same as the cointegrating vector estimated from space $[\ q_t, q_t^{BS}, gov_t, oil_t\ ]$. This is possibly because the restrictions were not applied in the same cointegration space. Nonetheless, the difference between the BEERs is smaller than in other specifications; see Figures A3a and A3b. Accordingly, during the years 1998-2002 both specifications indicate the same magnitude of misalignment. Since 2002 the equity market-augmented specification, shown in Figure A3b, indicates slightly lower undervaluation than Specification III without the equity market, shown in Figure A3a.

Specification IV evaluates the importance of the equity market in the $[\ q_t, i_t - i_t^{US}, q_t^{BS}, oil_t, eq_t\ ]$ set of variables, which derives from the main results of Maeso-Fernandez et al. (2001). The Cheung and Lai (1993) small-sample corrected test statistic indicated no-cointgeration if the model was not augmented with the equity market; see Table A3. The signs of $i_t - i_t^{US}, q_t^{BS}, oil_t$ are all dependent on whether the equity market is included in the analysis. The equity market also affected the absolute size of the *β*s. Notably, oil_t remained weakly exogenous in both specifications. The inference on the impact of the equity market on the equilibrium exchange rate that can be drawn from Figures A4a and A4b is about the same as that of the previous specifications. The equity market increases the BEER during first two years of the euro. However, since 2001 the equity-market augmented BEER suggests that euro would have been too strong, while the specification without the equity market suggests the opposite.

Our results also provided some insight into the importance of the other factors than the equity market on the equilibrium real euro-dollar exchange rate. Among these, our findings regarding oil prices are largely consistent with the evidence provided in earlier studies. Closterman and Schnatz (2000) and Schnatz et al. (2003) found strong evidence for the impact of oil prices on thee euro exchange rate while the evidence found by Alquist and Chinn (2000) is to some extent weaker. Overall, the impacts of oil prices on the real euro-dollar rate appear to be sensitive to model-specification.

Finally, we specified the vector of variables for the euro-dollar BEER on purely statistical grounds by selecting those variables which yielded the largest cointegration test statistics in our by-variable tests for cointegration $[\ q_t, q_t^{BS}, gov_t, eq_t\ ]$; see Table A1. Both the finite sample critical values and the Cheung and Lai (1993) small-sample corrected critical values suggested three cointegrating vectors; see Table A3 Specification V. However, due to difficulties in finding reasonable economic interpretations, we identified only two cointegrating vectors. The first *β*-vector is regarded as the equation for equilibrium equity market parity (eq_t = 0.0023 *trend* + 1.8394 gov_t) and the second as an equilibrium real exchange, (q_t = 3.9720 eq_t -16.9240 q_t^{BS} - 4.8660 gov_t). Using these two cointegrating vectors the BEER was estimated. Figure A5 proposes that the euro-dollar exchange rate should have depreciated more strongly than it did. The estimated equilibrium equity market parity also indicated a considerable overvaluation of the euro-zone equity returns during the first two years of the euro-era. Since 2002, the euro-zone equity market would be overvalued with respect to the US equity market.

The correlations between the different BEERs and the real exchange rate provided about the same information as the graphical analysis; see Table A4a. The BEER estimated from the equity market parity model showed the highest correlation (0.87) with the real exchange rate. Specification [$q_t, q_t^{BS}, gov_t, oil_t, eq_t$] produced the second highest correlation (0.81) whereas for the remainder of the specifications the correlation varied between 0.51 [$q_t, q_t^{BS}, gov_t, eq_t$] and 0.77 [$q_t, i_t - i_t^{US}, q_t^{BS}, nfa(emu)_t$]. Further evidence of the performance of the equity market model is obtained from studying the spread between the BEERs and actual real exchange rate; see Table A4b. The simple equity market model produced in absolute terms the smallest min, max and standard deviations for the spread.

To summarize, our analysis of the equilibrium real euro-dollar exchange rate suggests that the omission of equity market performance can be regarded as one reason for the inability of the previous models to explain the euro-dollar dynamics in the early years of the euro. According to our results, the depreciation of the euro in its early years can partly be explained by equity market parity, which combines the performance of the US and the euro-zone equity markets.

3 Conclusions

The dynamics of the real exchange rate of the euro has remained largely unexplained. Independently of the specification used, almost all the previous studies have indicated that the euro was too weak in its early days. This study suggests that in part this may be related to the omission of the equity market from the analysis. The equity market could bring important information to bear regarding the equilibrium exchange rate. There are several possible channels through which the equity market may have an impact on the real exchange rate. First, the equity market may capture information on many other factors in the economy which have an impact on the equilibrium exchange rate. Second, it is possible that the equity market has an impact of its own, e.g. through the impact of equity flows on the nominal exchange rate. In other words, the equity market could be of importance for explaining real exchange rate dynamics.

We introduced the equity market into the Behavioural Equilibrium Exchange Rate (BEER) analysis for the euro-dollar exchange rate. Our equity market variable measured the relative performance of the euro-zone and the US equity market indices. In order to filter out short-run speculative movements, the equity market series was decomposed into permanent and transitory components by utilising the Hordick-Prescot filter. The permanent component without the short-run volatility turned out to be of importance for the real euro-dollar exchange rate. This finding is novel. Chinn and Alquist (2000), for example, did not find any evidence for conventionally measured equity returns in the monetary fundamentals model for the long-run euro-dollar rate.

First, the relationship between the equity market and real exchange was examined in a simple by-variable system. The real euro-dollar exchange rate and equity market were found to share a common trend. The resulting simple equity market BEER model for the euro-dollar rate tracked the actual real euro-dollar rate rather closely, suggesting considerably smaller misalignment than found in the previous studies. Moreover, the impact of the equity market on the real euro-dollar exchange rate was even stronger than the impact, e.g., of the Balassa-Samuelson effect. This was interpreted as a strong evidence in favour of equity market parity in modelling the equilibrium euro-dollar exchange rate.

Second, we specified various rival models drawn from the previous literature and augmented them with equity market parity. These results were two-fold. The weakness of the euro with respect to the dollar in the early days of the EMU remained unexplained in the traditional specifications for real exchange rates. However, augmenting the traditional models with equity market parity, we were generally able to attribute some of the undervaluation to the omission of the equity market in the previous literature. Moreover, some of the equity market-augmented BEER specifications even indicated overvaluation of the euro.

To sum up, our evidence suggests that the equity market could provide valuable information regarding the real euro-dollar exchange rate. The equity market could have an impact of its own or it could just transmit information from other fundamentals which are significant for the real exchange rate. The results of this study suggest several topics for further research. Among others, the relationship between the equity market and exact measures of productivity, as used in Schnatz et al. (2003) and Alquist and Chinn (2002), call for further research. Along these lines the ability of the equity market to measure the effect of production shocks on the real exchange rate also merits scrutiny. Finally, whether the equity market and real exchange rates are related in the case of other currencies other than the euro and the dollar needs to be examined.

Appendix

Table A1 Tests of cointegration.

rank	$[\ q_t, q_t^{BS}\ ]$	$[\ q_t, i_t - i_t^{US}\ ]$	$[\ q_t, gov_t\ ]$	$[\ q_t, oil_t\ ]$	$[\ q_t, eq_t\ ]$	$[\ q_t, nfa(emu)_t\ ]$
r ≤ 0	26.457 [0.040]	25.709 [0.050]	29.533 [0.015]	14.565 [0.617]	34.645 [0.002]	25.998 [0.046]
r ≤ 1	6.5534 [0.404]	8.9389 [0.189]	6.2677 [0.438]	6.0299 [0.467]	12.944 [0.041]	10.251 [0.118]

Notes; The models were estimated including a constant in VAR and a trend in the cointegration space. Number of lags, p = 13. Johansen's *Trace test* vales are reported. Numbers in brackets denotes statistical significance on the basis of the Osterwald-Lehnum (1992) critical values. Cheung and Lai (1993) small-sample corrected *T/(T - np*) test statistic for r ≤ 0 is 28.86 and r ≤ 1 13.96 at 0.05 level of risk**.**

Table A2 Cointegrating vectors; Specifications I, II and III.

	Specification I				Specification II				Specification III			
	$[\ q_t, i_t - i_t^{US}, q_t^{BS}, oil_t, gov_t, eq_t\ ]$				$[\ q_t, i_t - i_t^{US}, q_t^{BS}, nfa(emu)_t, eq_t\ ]$				$[\ q_t, q_t^{BS}, gov_t, oil_t, eq_t\ ]$			
	Ia Excluding eq_t Rank = 1		Ib Including eq_t Rank = 3		IIa Excluding eq_t Rank = 1		IIb Including eq_t Rank = 4		IIIa Excluding eq_t Rank = 1		IIIb Including eq_t Rank = 2	
	β	α	β	α	β	α	β	α	β	α	β	α
q	1	0	1	-0.447 (0.026)	1	-0.104 (0.031)	1	-0.065 (0.041)	1	-0.004 (0.028)	1	-0.057 (0.042)
$i - i^{US}$	0.329 (0.065)	-0.412 (0.111)	0	0.632 (0.291)	0.028 (0.013)	0	0.072 (0.016)	0	-	-	-	-
q^{BS}	0	0.003 (0.001)	4.411 (0.972)	-0.034 (0.010)	-8.149 (1.796)	0.012 (0.004)	12.385 (2.842)	-0.017 (0.006)	-7.087 (1.042)	0.007 (0.004)	-3.800 (0.776)	0
oil	-	-	0	0	-	-	-	-	0.393 (0.084)	0	0.283 (0.065)	-0.042 (0.018)
gov	-0.112 (0.055)	0	2.019 (0.229)	0	-	-	-	-	-3.705 (1.042)	0.003 (0.000)	-1.542 (0.390)	-0.005 (0.001)
nfa(emu)	-	-	-	-	0.084 (0.042)	0	-0.157 (0.032)	0.006 (0.002)	-	-	-	-
trend	0.027 (0.010)	-	0	-	0	-	0	-	-0.004 (0.001)	-	-0.002 (0.000)	-
eq	-	-	-1.892 (0.199)	0	-	-	-2.530 (0.335)	1.147e-005 (3.4111e-006)	-	-	0	0
LR	4.075 [0.254]		7.989 [0.239]		7.409 [0.060]		5.759 [0.056]		0.552 [0.458]		2.400 [0.06]	

Notes; Inference on the number of cointegrating vectors are made based on Johansen's *Trace test* and Cheung and Lai (1993) small-sample corrected *T/(T - np)* test statistics. Numbers in parenthesis refers to standards errors. LR refers to the value of likelihood ratio test (χ^2) for restrictions. Numbers in brackets denote statistical significance.

Table A3 Cointegrating vectors; Specifications IV and V.

	Specification IV				Specification V			
	$[\ q_t, i_t - i_t^{US}, q_t^{BS}, oil_t, eq_t\ ]$				$[\ q_t, q_t^{BS}, gov_t, eq_t\ ]$ Rank = 3			
	IVa Excluding eq_t Rank = 1		IVb Including eq_t Rank = 3		Vector 1		Vector 2	
	β	α	β	α	β	α	β	α
q	1	-0.049 (0.019)	1	-0.068 (0.024)	1	-7.904e-006 (4.273e-0.006)	1	-0.046 (0.021)
$i - i^{US}$	-0.185 (0.034)	1.162 (0.204)	0.222 (0.038)	-0.356 (0.283)	-	-	-	-
q^{BS}	-10.594 (1.928)	0.005 (0.002)	20.470 (4.264)	-0.010 (0.003)	0	-0.009 (0.008)	16.924 (3.946)	-0.013 (0.003)
oil	0.848 (0.175)	0	-1.027 (0.195)	0	-	-	-	-
gov	-	-	-	-	-1.839 (0.390)	0.005 (0.001)	4.866 (0.908)	0
nfa(emu)	-	-	-	-	-	-	-	-
trend	-0.006 (0.001)	-	0	-	-0.002 (0.001)	-	0	-
eq	-	-	-2.754 (0.576)	5.045e-006 (1.838e-006)			-3.973 (0.885)	0
LR	1.541 [0.214]		1.403 [0.496]		1.850 [0.604]			

Notes; Inference on the number of cointegrating vectors are made based on Johansen's *Trace test* and Cheung and Lai (1993) small-sample corrected *T/(T - np)* test statistics. Numbers in parenthesis refers to standards errors. LR refers to the value of likelihood ratio test (χ^2) for restrictions. Numbers in brackets denote statistical significance.

Table A4a Descriptive statistics of the spread between the estimated BEERs and the actual real euro-dollar exchange rate; specifications without equity market spread.

	$[q_t, eq_t]$	Ia	IIa	IIIa	IIVa
Mean	0.00	0.01	0.00	0.00	0.03
Median	-0.02	0.00	0.00	0.00	0.03
Max	0.20	0.42	0.21	0.35	0.51
Min	-0.14	-0.36	-0.24	-0.29	-0.35
Std.Dev.	0.08	0.18	0.10	0.13	0.19
Obs.	188	188	188	188	188

Notes; Ia, IIa, IIIa; and IVa refer to specification without the equity market variable. Sample period 1989:1–2004:8.

Table A4b Descriptive statistics of the spreads between the estimated BEERs and the actual real Euro-dollar exchange rate; specifications augmented with equity market spread.

	$[q_t, eq_t]$	Ib	IIb	IIIb	IIVb	V
Mean	0.00	0.01	0.00	0.00	-0.01	0.00
Median	-0.02	0.01	-0.03	-0.01	-0.02	-0.02
Max	0.20	0.33	0.64	0.22	0.80	0.20
Min	-0.14	-0.24	-0.38	-0.18	-0.58	-0.14
Std.Dev.	0.08	0.13	0.22	0.08	0.27	0.01
Obs.	188	188	188	188	188	188

Notes; Ib, IIb, IIIb, IVb and V refer to specification with the equity market variable. Sample period 1989:1–2004:8.

Data Appendix

Monthly observations, sample size 1989(2)-2004(8).

q_t Log of the real euro-dollar exchange log (EP^{US}/P^{EMU}). E is nominal exchange rate between the euro and dollar; price of one dollar in euros. Monthly observation calculated on the basis of average daily observations; source: *OECD Main Economic Indicators.* P is euro area HCPI index, all items (1990:1-2004:8). Since the HCPI was not available for 1987:1-1989:12, E15CPI was used for this period; source: *OECD Main Economic Indicators.* US CPI index, all items; source: *OECD Main Economic Indicators.*

q_t^{BS} Log of the Balassa-Samuelson measure; log $[(CPI^{US}/PPI^{US})/(CPI/PPI)] = q_t^{BS}$. CPI is euro area Consumer Price Inflation all items. PPI is EU-15 producers' price index for manufactured goods. CPI^{US} is US CPI index consisting all items. PPI^{US} is US Producers' Price Index for manufactured goods; source: *OECD Main Economic Indicators*.

oilp Log of ($Oilp/PPI^{US}$). Oilp is world crude oil prices (cif), USD per barrel; Source: *OECD Main Economic Indicators*. PPI^{US} is US producers' price index for manufactured goods, quarterly data; source: *OECD Main Economic Indicators*. Quarterly data were transformed into monthly data by means of distribution procedure. The procedure computes a distribution of the series and changes the frequency to a higher one, but maintains the sum of the series to each original period (see RATS Version 5 User's Guide p.67).

eqs Log of $\left[\frac{Euro50/HICP^{EMU}}{SP500/CPI^{US}}\right]$. Euro50 is the euro area stock price Euro50, broad eurostoxx index. Monthly observations, calculated on the basis of average daily observations; source: *stoxx.com.* US stock price, Standard and Poor's 500; source: *OECD Main Economic Indicators.*

eq The Hodric-Prescot (1997) filtered equity market spread (eqs), smoothing parameter $\lambda = 14400$.

$i\text{-}i^{US}$ Real interest rate differential, long interest rates. Long interest rates are proxied by 10- year government bond yield. Inflation is calculated from CPI, data for 1994:1 – 2004:8 Euro area 10 year government bond yield. For the period 1990:1-1993:12 the euro area time series was not available, but was aggregated from national government bond yield time series for Austria, Belgium, France, Finland, Germany, Netherlands, Italy, Ireland, and Spain and Portugal. The weighting was based on the national shares of euro zone GDP. For the period 1987:1-1989:12 national time series were missing for Germany, Italy and Portugal (Finland 1987:1-1987:12). Since these countries cover almost the half of the euro area's GDP, they could not be omitted. Therefore the aggregate government bond yield data was constructed from three-month euribor interest rate data available for the whole sample period 1987:1-2004:8. The data construction was based on the following regression model estimated by OLS: $EMU10yeargbond_t = 2.60 + 0.76\ Euribor3_t$. The estimation period: 1990:1-2004:8; adjusted $R^2 = 0.85$; source for all real interest differential data: *OECD Main Economic Indicators*.

gov Log of $\left(\frac{G^{US} / Y^{US}}{G^{EURO} / Y^{EURO}} \right)$. G^{US} (G^{EURO}) = US (Euro area) government final consumption, constant USD prices (constant euro prices). Y^{US} (Y^{EURO}), US gross domestic product, constant USD prices (Euro area gross domestic product, constant euro prices). Quarterly data; source: *OECD Main Economic Indicators*. Quarterly data were transformed into monthly by means of the distribution procedure (see the variable oilp).

nfa(emu) Euro-zone net foreign assets (nfa/Y^{EURO}). Following Albertola et al.(1999) time series of net foreign assets was constructed by adding current account balances to the initial stock of net foreign assets. The initial stock of euro area net foreign assets was calculated from national figures (in US dollars); source: *OECD Economic Outlook*, *December* 1986. The figures of Portugal, Ireland and Greece were missing and omitted. The values for euro area current balances were aggregated from national figures (in constant 2000 USD dollars); source: *OECD Economic Outlook*. The figures for Luxembourg's current balances were missing and omitted. The initial stock of net foreign assets was transformed into constant 2000 USD dollars using the euro area GDP deflator; source: *OECD Main Economic Indicators*. The initial net foreign asset stock and current balances were quarterly. Quarterly data were transformed into monthly by means of the distribution procedure (see the variable oilp).

Figure Appendix

Figure A1a Specification I, BEER without equity market.

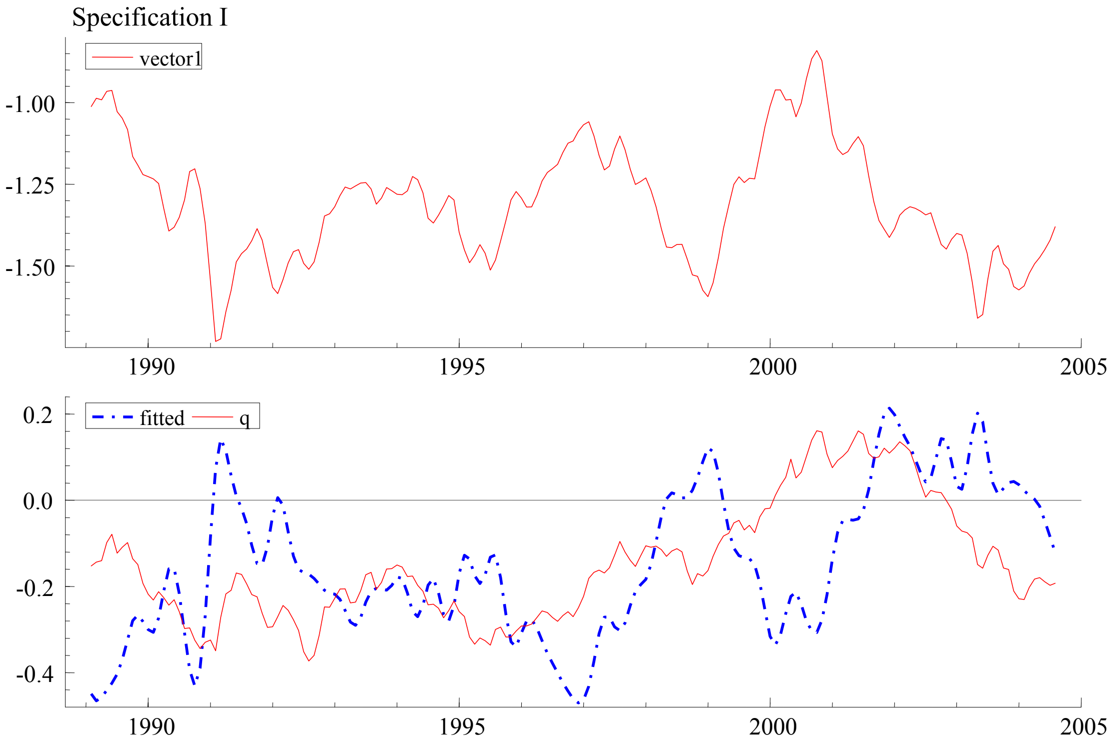


Figure A1b Specification I, restricted cointegrating vector, BEER added with equity market.

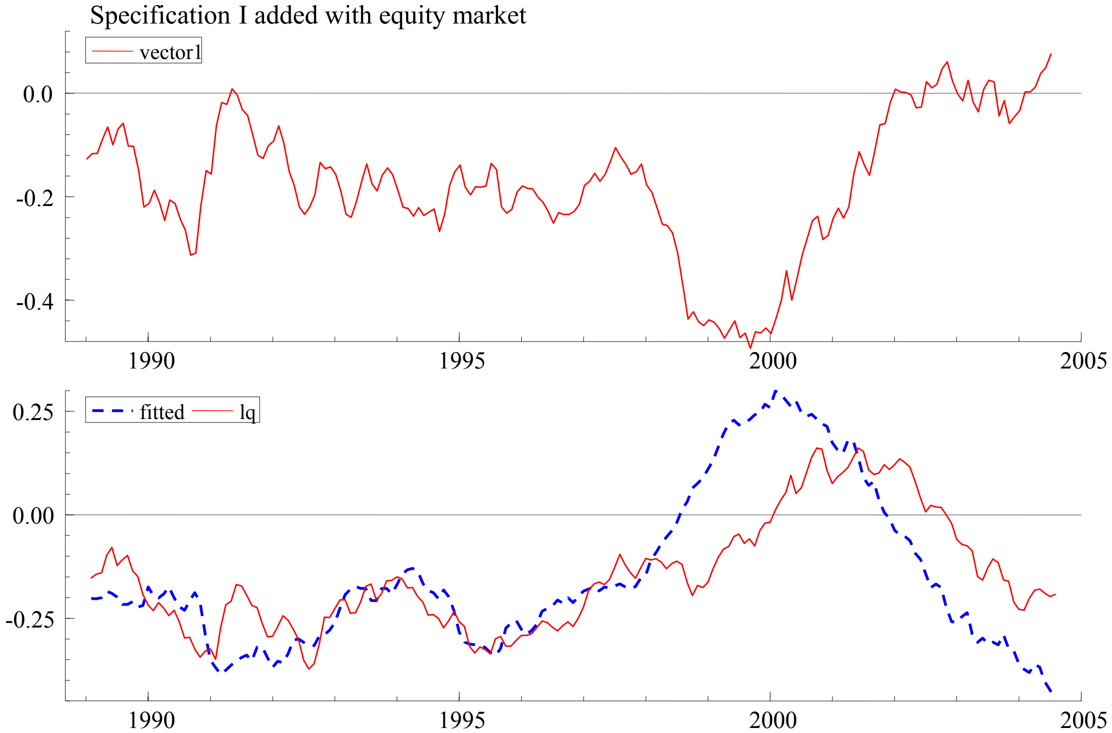


Figure A2a Specification II, BEER without equity market.

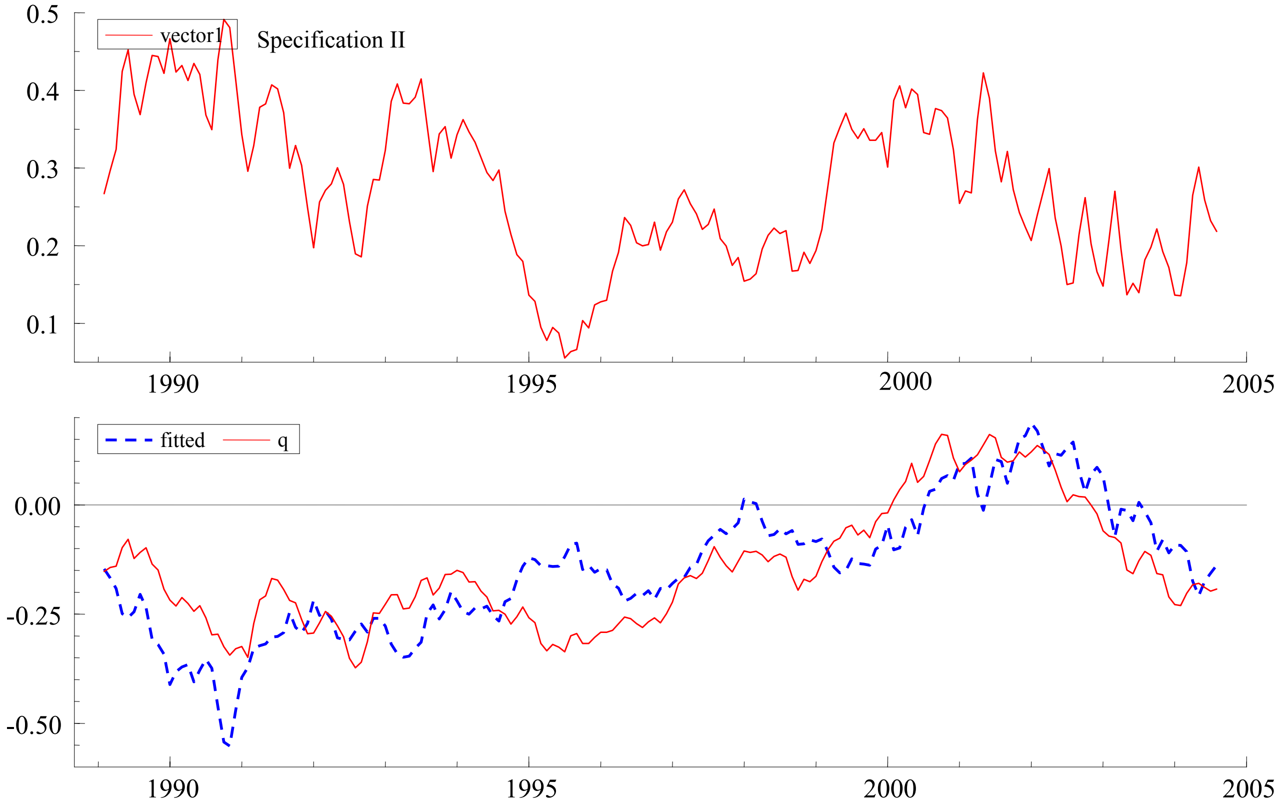


Figure A2b Specification II, restricted cointegrating vector, BEER added with equity market.

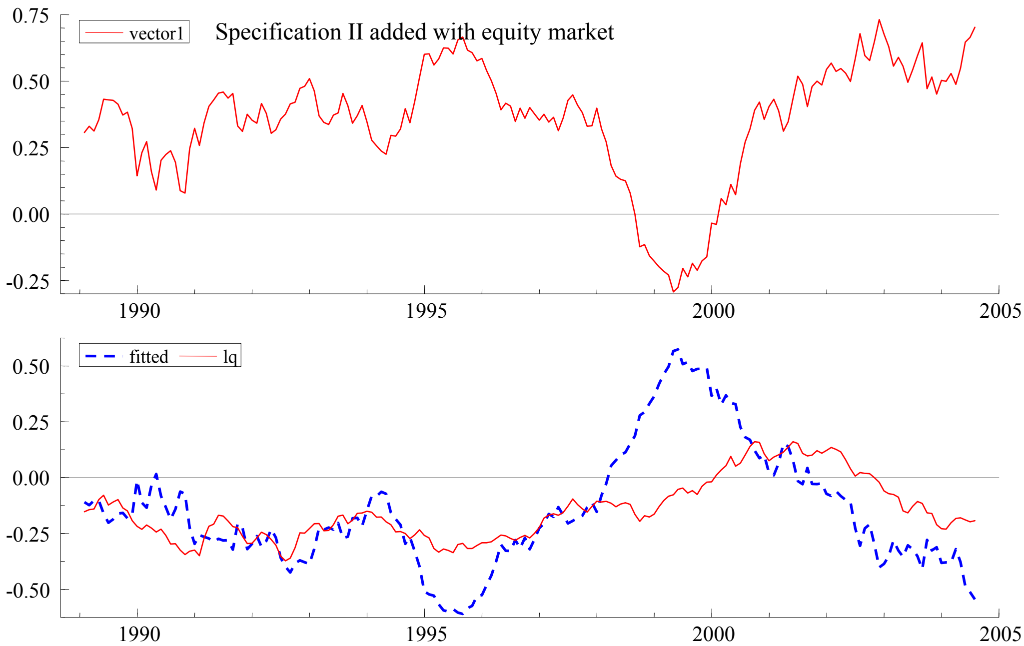


Figure A3a Specification III, BEER without equity market.

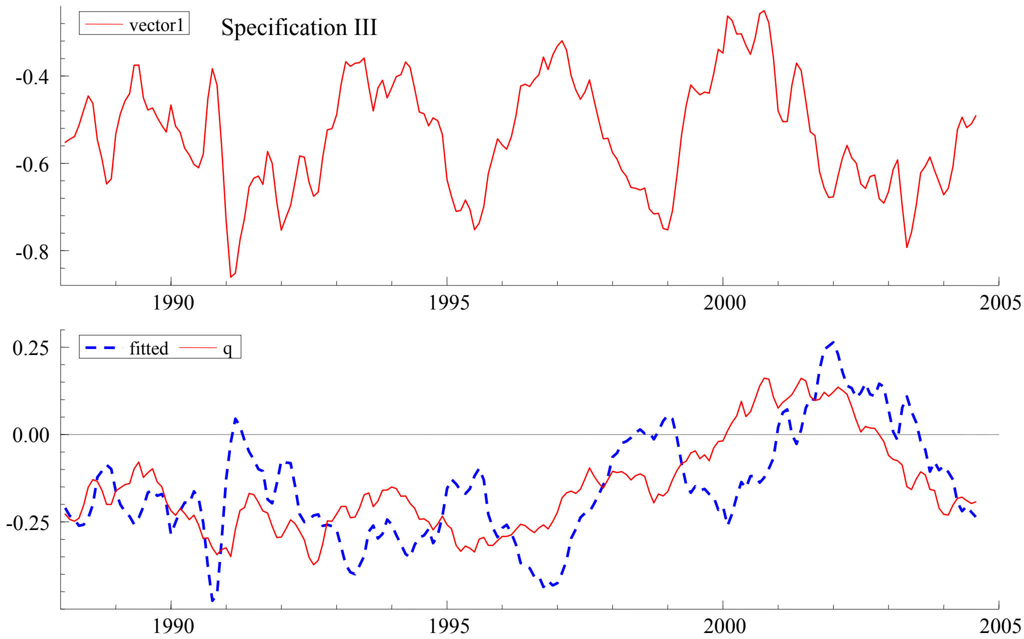


Figure A3b Specification III, restricted cointegrating vector, BEER added with equity market.

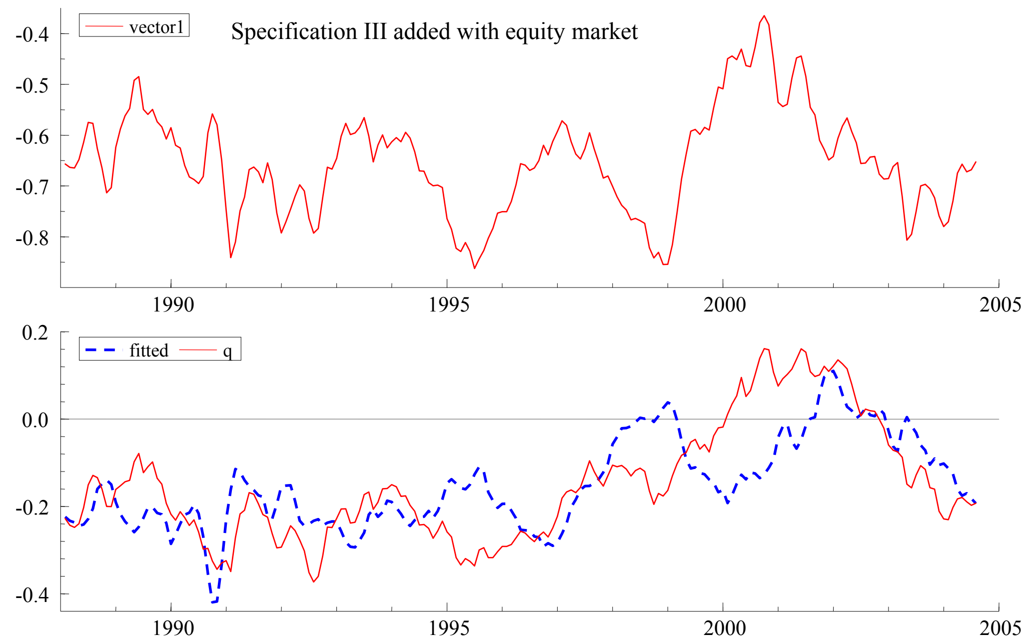


Figure A4a Specification IV, BEER without equity market.

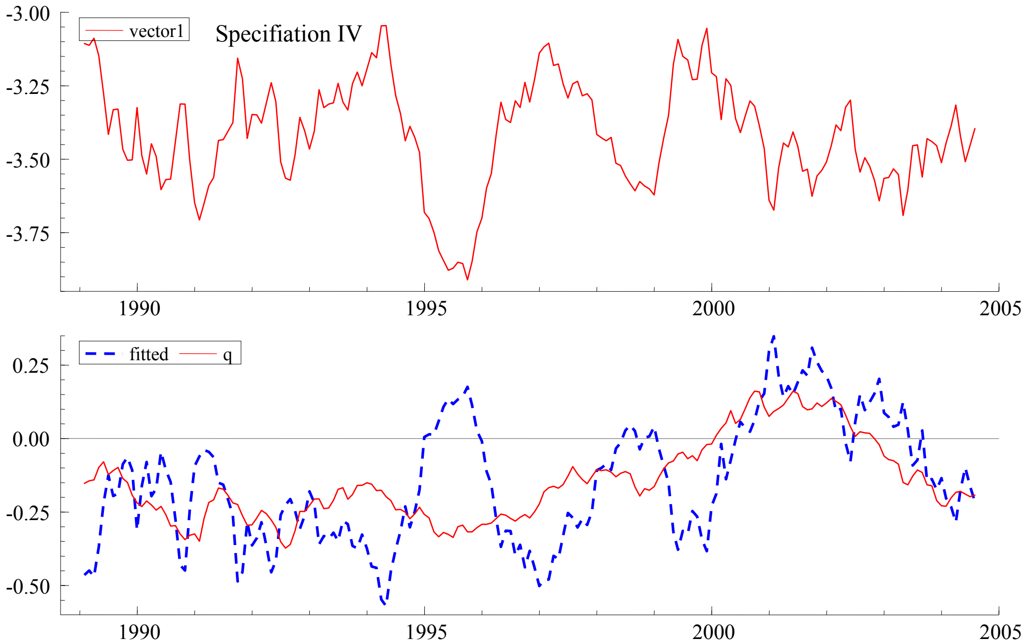


Figure A4b Specification IV, restricted cointegrating vector, BEER added with equity market.

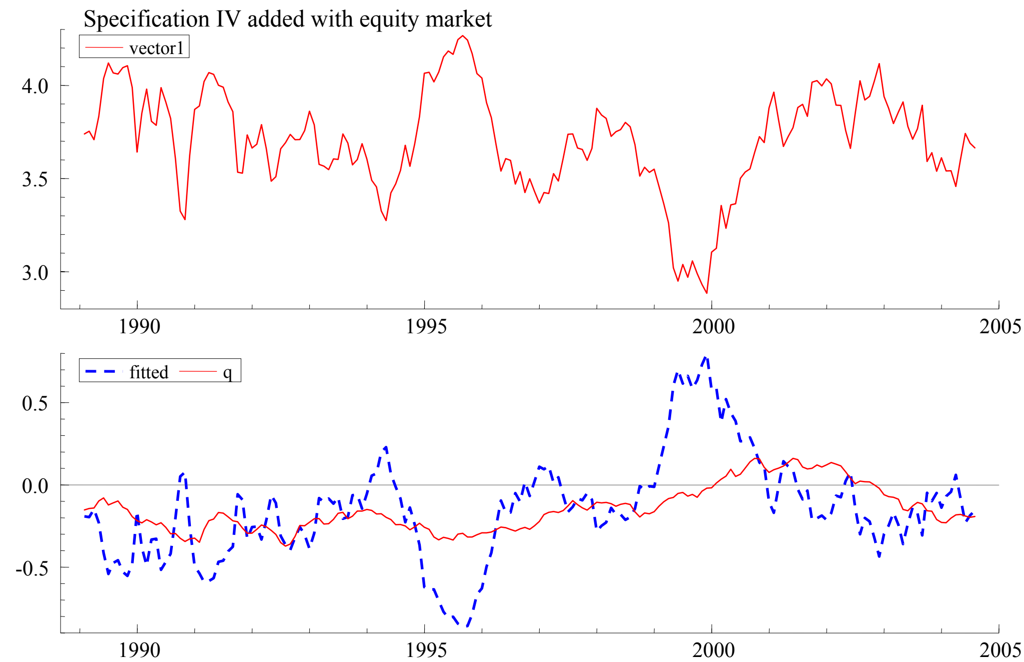
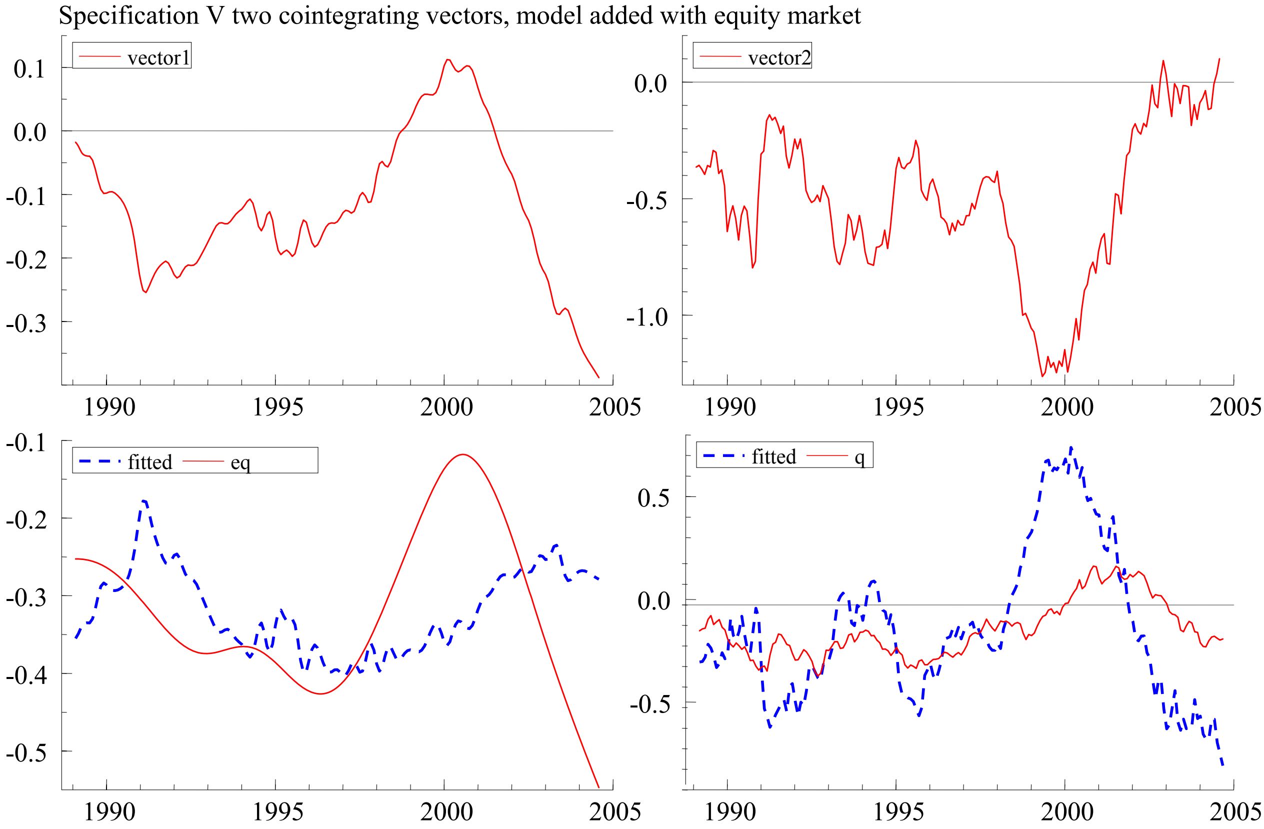


Figure A5 Specification V, restricted cointegrating vector, BEER added with equity market, two cointegrating vectors.



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