



WORKING PAPER n.03.04

June 2003

Euro/Dollar Exchange Rates: A Multi-Country Structural Monthly Econometric Model for Forecasting

D. Sartore^a
L. Trevisan^a
M. Trova^b
F. Volo^c

^a University Ca' Foscari, Venice

^b Monte Paschi Asset Management Spa, Milan

^c GRETA Associati, Venice

Euro/Dollar Exchange Rates: A Multi-country Structural Monthly Econometric Model for Forecasting

Domenico Sartore

Università Ca' Foscari di Venezia, Venice
(sartore@unive.it)

For correspondence:

*Dip. di Scienze Economiche,
S. Giobbe 873,
30121 Venice.*

Lucia Trevisan

Università Ca' Foscari di Venezia, Venice

Michele Trova

Monte Paschi Asset Management Spa, Milan

Francesca Volo

Greta Associati, Venezia
(fvol@greta.it)

Abstract

In this paper a structural multi-country model for the Euro/Dollar Exchange rate is presented and compared with an area-wide model. The models are built in VECM form, after the full information cointegration analysis is applied in the presence of structural breaks. The results obtained give support to a specification of Mundell-Fleming type and the forecasting performances are satisfactory for both multi-country and area-wide specifications. The former is clearly better even in terms of economic effectiveness.

Keywords: Real Exchange Rates, Cointegration, Structural Breaks, Multi-country Model, Area-wide Model, Forecasting, Economic Effectiveness.

1. Introduction

As is widely known, the Euro is a fairly new currency, and building a model for the Euro/Dollar exchange rates requires a number of preliminary decisions, involving several structural economic and econometric issues.

First of all, a decision must be made regarding the geographical aggregation versus disaggregation of the data. Arguments in favour of each alternative can be given. For example, the area-wide model would be more parsimonious than the multi-country alternative by a factor of ten. On the other hand, the multi-country model can allow consideration of the fact that the Euro Area still includes economies characterised by differences in institutional features and economic structures (e.g. legal system, labour market, fiscal policies, etc.), as some recent economic events prove, even though under a single monetary policy some macroeconomic variables are the same across the Euro Area. We analyse which model performs better: an area-wide or a multi-country model, concentrating much more on the latter, and comparing the results obtained by applying it to the goal of forecasting the Euro/Dollar Exchange rate to those obtained by the application of the area-wide model presented in Sartore et al. (2002).

Second, but not less importantly, we consider the problems arising from the size and frequency of the sample data (monthly observations from 1990 to 2002). The length usually features non-stationarity, and it is nowadays well known that cointegration can remove unit roots in an integrated (by order one) system using a linear combination of variables.

After introducing the reasons for a multi-country versus an area-wide model in section 2, the theoretical economic model is outlined in the section 3. In section 4 we give the definition of the variables which enter the econometric model and the specification of which is presented in section 5. Using cointegration analysis, we are able to propose a VECM model in which the relevant economic variables are not necessarily of the same order of integration. Sections 6 and 7 show the long-run and short-run relationships among the selected real and financial variables and the Euro/Dollar exchange rate. In section 8, the forecasts are evaluated through the usual performance indexes and their economic effectiveness is considered. Finally, in section 9 we compare the multi-country versus the area-wide forecast performances and section 10 concludes.

2. Multi-country vs. Area-wide Model

Recent papers¹ analyse the aggregate of the Dollar/Euro Exchange rate; that is, EMU 12 macroeconomic and financial fundamentals are exploited to estimate the equilibrium paths of the

¹ See for example Alberola et al. (2002) and Sartore et al. (2002).

European currency vis-à-vis the Dollar. In this work we intend to move towards a disaggregated approach to model the Euro.

The fundamental reasons for this analysis lie in the fact that, despite the birth of the European Monetary Union on January 1st 1999, and its enlargement to Greece starting from January 1st 2000, throughout the 1990s, and even more recently, fiscal and economic policies in the EMU member countries have sometimes been substantially different. In spite of the increasing pro-cyclicality of their economies, this fact has obviously largely influenced, and will probably for some time continue to influence the behaviour of the EMU countries' macroeconomic and financial fundamentals: different growth rates, different shapes of the term structure of interest rates, because of the market pricing of country credit spreads, different levels and growth rate of fiscal and commercial imbalances, different impacts from the increases in commodity prices, different inflation rates, etc.

Thus, on the one hand we observe substantial differences in the economic structure of the eleven countries belonging to the EMU Area and, on the other, all these differences are somewhat "restricted" to respect a common trend in the monetary interest rate and currency market.

As a matter of fact, from an econometric point of view, it is particularly interesting to study the relative importance the different countries have in determining the level of the Euro currency versus the US Dollar (by definition the former "World currency") and of the debt markets' (long-term bond) interest rates.

We dealt with this issue by making reference to the theoretical model outlined in the subsequent section and extended it to take into account the afore-mentioned differences among countries belonging to the Euro Area. Because of the lack of data regarding some of the economic fundamentals and financial indicators considered in this paper, we restricted our analysis to three countries: Germany, France (representing Core Europe) and Italy, whose credit spreads vis-à-vis the United States and the Core Europe countries we believe should be able to explain some sudden fluctuations of both the European interest rates and the Euro currency.

3. The Economic Model

An important motivation in favour of the real, rather than the nominal exchange rate, is the failure (on empirical grounds) of the purchasing power parity (PPP), which states the long-run equilibrium between the exchange rates and the price levels.

Suppose S_t to be the US dollar/Euro exchange rate (price of one unit of Euro in terms of US dollars) and P_t the one country's price level, then the PPP relationship is:

$$(1) \quad S_t = P_{\$/P_{\epsilon t}}$$

or more generally:

$$(2) \quad S_t = Q_t P_{\$/\text{€}} / P_{\text{€}}$$

where Q_t is the US dollar/Euro real exchange rate supposed constant $\forall t$. An increment of the US inflation rate (versus that of the Euro Area) is followed by an increase of S_t , that is a depreciation of US dollar. The assumption of Q_t to be constant implies that the nominal exchange rate obeys (2) when monetary shocks occur. Should Q_t not be constant, as in the case of real shocks (e.g. oil shocks, productivity gaps between the two areas, etc.), then obviously the PPP relationship is no longer valid.

From (2) we obtain:

$$(3) \quad Q_t = S_t P_{\text{€}} / P_{\$/}$$

Using the log transform, (3) becomes:

$$(4) \quad q_t = s_t + p_{\text{€}} - p_{\$/}$$

where lower case notation indicates the logarithmic transformation of the variables in level. Here, an increase in q_t means a depreciation of the real US dollar followed by a depreciation of the nominal US dollar or a decrease of the US and Euro inflation rate differentials.

The *Uncovered Interest Parity condition* (UIP) states the long-run equilibrium between the money market and the foreign exchange market, that is:

$$(5) \quad E_t \Delta s_{t+k} = i_{\$/} - i_{\text{€}}$$

where i_t is the one country nominal interest rate and $E_t \Delta s_{t+k}$ is the exchange rate expected depreciation for the time $t+k$. Subtracting from both sides of (5) the expected inflation rate differential we obtain:

$$(6) \quad E_t \Delta s_{t+k} - E_t \Delta p_{\$/t+k} + E_t \Delta p_{\text{€}/t+k} = (i_{\$/} - E_t \Delta p_{\$/t+k}) - (i_{\text{€}} - E_t \Delta p_{\text{€}/t+k}).$$

Using (4), we obtain:

$$(7) \quad E_t \Delta q_{t+k} = r_{\$/} - r_{\text{€}}$$

where r_{jt} is the real interest rate for the j -th country, with $j=\$, \text{€}$, given by:

$$(8) \quad r_{jt} = i_{jt} - E_t \Delta p_{jt+k}.$$

Knowing that $E_t \Delta q_{t+k} = E_t q_{t+k} - q_t$, then (7) becomes:

$$(9) \quad q_t = E_t q_{t+k} - (r_{\$/} - r_{\text{€}}).$$

In formula (9), the unobservable component $E_t q_{t+k}$ is known as *Fundamentals Exclusive of the Real Interest Differential (FERID)* well represented by the long-run equilibrium exchange-rate. In our hypothesis, the long-run equilibrium exchange rate is driven by fundamentals, such as productivity variables (e.g. the ratio of Tradable to Non-tradable Goods), which should be able to capture the so-called Balassa–Samuelson effect, commodity shocks (such as the Real Price of Oil and relative

Terms of Trade) and budget policy (such as Fiscal Budget Surplus or Deficit and Net Foreign Assets).

The difference ($r_{\$t} - r_{€t}$) in formula (9) is usually known as the *Real Interest Differential (RID)* and is modelled in this paper as the real long-term interest rate differential (*RIRL*); therefore (9) it can lead to the foreign exchange market relationship written in the subsequent section.

The economic model is built considering the simultaneous equilibrium of exchange, money and goods markets. We therefore take into account the joint behaviour of the bilateral exchange rate, interest rate differential and growth rate differential. This approach imitates the well-known Mundell-Fleming model.

The Foreign Exchange Market

Given the previous considerations, the real foreign exchange rate's equilibrium behaviour is described by the Uncovered Interest Parity condition (equation (5)). Based on this condition, the real exchange rate depends on the expected real exchange rate and on the real interest rate differential (equation (9)). The expected real exchange rate, in turn, is affected in our model by the time path of several fundamental variables such as foreign trade efficiency, commodity shocks and budget policy as suggested in the recent works of MacDonald (1997) and MacDonald & Marsh (1999).

In this theoretical framework, the foreign trade efficiency is modelled as the differential between US and Euro ratio of consumer price index to the production price index (noted *TNT*). This variable should be able to capture the Balassa-Samuelson effect, probably the best-known source of systematic changes in the relative price of traded to non-traded goods across countries (Balassa (1964), Samuelson (1964)). The sign we expect for *TNT* is negative.

The fiscal budget, both in terms of direct expenditure and in terms of net foreign assets (national savings), also affects the equilibrium behaviour of the real exchange rate. The first effect is described, in the MacDonald equation, by the differential between US and Euro ratio of government surplus or deficit and the GDP (*FBAL*). The latter could be captured by the ratio of US to Euro ratio of net foreign asset to GDP (*NFA*). In this framework, a tight fiscal policy in the US implies, *ceteris paribus*, an increase of *FBAL* and an increase of *NFA*.

The effect of fiscal policy on the real exchange rate usually leads to the following question: "Will a positive fiscal budget strengthen or weaken the external value of a currency?" Unfortunately, there is no single answer. Following the traditional Mundell–Fleming two-country model, we assume that a tight fiscal policy, which increases the aggregate national savings, would lower the domestic interest rate and generate a permanent real exchange rate depreciation (an increase of q_t).

The commodity markets are the last source of shocks to the real equilibrium exchange rate. In our theoretical framework they are modelled by means of two variables: the term of trade (TOT), computed as the differential between domestic and foreign ratio of export unit value to the import unit value, and the real price of oil (*ROIL*).

Variations of TOT has uncertain effects on Q depending on what forces are prevailing both in the domestic and in the foreign economy.

Changes in the real price of oil can also have an effect on the relative price of traded goods, usually through their effect on the terms of trade described above. In comparing a country that is self-sufficient in oil resources with one which needs to import oil, the latter, *ceteris paribus*, will experience a depreciation of its currency vis-à-vis that of the former as the price of oil rises. More generally, countries that have at least some oil (and/or other commodities) resources could find their currencies appreciating relative to countries that are net importers of oil (and/or other commodities). Therefore, the sign we expect for *ROIL* is negative.

Taking these considerations into account, we model the long-run equilibrium real exchange rate as follows:

$$(10) \quad Q = h(TNT, FBAL, NFA, TOT, ROIL, RIRL)$$

where Q indicates the US dollar/Euro real exchange rate and *RIRL* (see end of previous subsection) the 10-year real interest rate differential. The precise form of the function $h(\cdot)$ is linear and the signs of the coefficients are derived from the description above and put in system (13).

The Money Market

We model the equation for the long-term real interest rate differential as follows:

$$(11) \quad RIRL = g(MG, Y)$$

where *MG* denotes the differential between the annual growth rate of the US and Euro real money supply and *Y* denotes the differential between the annual growth rate of the US and Euro GDP.

Economic theory tells us that an easy monetary policy, if perceived as leading expected inflation, usually induces an increase in the long-term interest rate. As to the output, an increase in output levels instead induces a rise in the volume of transactions and therefore in the demand for money, which will result in an increase in the level of interest rates.

The Goods Market

If we consider the goods market equilibrium as described in the Mundell-Fleming model, then the growth rate in each country is influenced by consumption, investments, public spending and net exports. Given the variables that usually influence these income components, the growth rate in

each country depends on: interest rate, income expectations, taxation level, public spending and world demand of goods. Concerning the growth rate differential, the dynamic equilibrium of the goods market has been formalised in the following way:

$$(12) \quad Y = f(RIRL, TNT, FBAL, NFA, TOT, ROIL)$$

We consider the long-term interest rate differential (*RIRL*) on the basis of the hypothesis that the firms borrow money on such maturity. According to classical economic theory, the impact of a tight monetary policy on the real gross domestic product growth is negative, in the sense that higher interest rate will discourage investments and, therefore, results in lower economic growth.

The ratio of tradable to non-tradable goods prices (*TNT*) that represents the productivity differential of the two countries can be interpreted as a proxy of technological progress that affects the income expectations. We argue that an increase in productivity denotes an improved ability to face competition across markets. This will result in an increase in the foreign demand of the country's products and therefore in an increase in the production and finally in the output.

The taxation level and the public spending effects are captured by *FBAL*. We observe that an easy fiscal policy (decrease of *FBAL* and decrease of *NFA*), if directed to investments, in the first step should increase the total output, while in the long-run, this fact could be perceived as an obstacle to growth (because of the expected tight policies in the future motivated from debt repayments) and therefore having a negative impact on the latter.

To take into account the world demand of goods, we consider the real oil price (*ROIL*) and the term of trade (*TOT*). For oil import-countries, an increase in the cost of oil leads to an decrease in the output growth. As for *Q* in the foreign exchange market, variations of *TOT* has uncertain effects on *Y* depending on what forces are prevailing both in the domestic and in the foreign economy.

The theoretical functions (10), (11) and (12) corresponding to the foreign exchange, money and goods markets equilibrium are utilised in the cointegration identification procedure. In fact, we intend to verify if the constraints suggested by these functions are able to identify the well-known long-run relationships in a VECM framework (Johansen (1995)).

4. Variables Definition

For the disaggregated approach, we took into consideration the monthly data from December 1987 to September 2002. The last eighteen observations (from March 2001 to September 2002) are used to produce ex-post forecasts and, therefore, to test the forecasting ability of the model, both in terms of the evaluation of the proximity of forecasted data to the observed ones (Root Mean Square Error, Mean Error, Mean Absolute Error, Theil's U) and in terms of ability of the model to capture the

signs of the changes in the real Dollar/Euro exchange rate (percentage of signs correctly forecasted), as well as to assess the economic effectiveness of the forecasts produced by the model. The variables used in the model are listed in Table 1. The real Dollar/Euro exchange rate (Q) used for this analysis is exactly the same as that in the aggregated one, i.e. the logarithm of the synthetic², nominal Dollar/Euro Exchange rate minus the differential between the logarithms of the Euro Area Consumer Price Index (base 1995 = 100) and the US Consumer Price Index (base 1995 = 100).

[Table 1 about here]

In order to take into account the well known Balassa-Samuelson effect, for each country in our sample (Germany, France, Italy and the US)³ we have built a proxy of the ratio of traded to non-traded prices as the logarithm of the ratio of Consumer Price Index to Producer Price Index (TNT)⁴. The structural differences in the fiscal policies ($FBAL$) of the different countries (the substantial motivation on which we based our disaggregated approach), we believe is adequately captured by taking into consideration the ratio of the real government surplus or deficit and the real GDP.

The NFA variable, computed as the ratio of each country total real net foreign assets to the real gross domestic product (in billions of dollars). It captures the fundamental dynamics of flows of funds and the effect of fiscal policy on the exchange rate as well as other factors more closely associated with private sector savings, such as demographics.

Two variables have been used to model the impact of the dynamics of commodity prices on both the gross domestic product growth (Y) and the real exchange rate (Q). They are the terms of trade (TOT), which are constructed as the ratio of US domestic export unit value to import unit value as a proportion of the equivalent effective European ratio, expressed in logarithms. The second variable is the real price of oil ($ROIL$), expressed in US Dollars per barrel and defined as the logarithm of the ratio of nominal price of crude oil (Brent) to the US producer price index.

The money and debt markets have been taken into consideration by means of two variables. The real money (MG) supplied to the economic system by the central banks of the countries involved in our analysis, is represented by the annual real (deflated by subtracting from the nominal growth rate

² The synthetic (before 1 January 1999) Dollar/Euro nominal exchange rate is that produced by Warburg Dillon Read.

³ The suffixes $USBD_$, $USFR_$ and $USIT_$ in the different tables indicate, respectively, the differential between US and Germany, US and France, US and Italy (in the case of NFA they indicate the ratio of the US NFA variable to the European country variable).

⁴ In the case of the presence of seasonal patterns in the time series, they have been removed by means of the usual ARIMA techniques.

the annual domestic inflation rate) M2 growth⁵. We believe that this variable is able to capture the differences in European and the US central banks as to the total amount of credit allowed to the system. The second variable, used to model more properly debt markets, is the real long-term interest rates differential (*RIRL*), computed as the differential between the US and European real 10-year benchmark interest rate. The real interest rate both for the Euro Area and the US has been computed as the nominal 10-year benchmark interest rate and a centred 13-month average of the annual inflation rate⁶. In the case of the Euro Area, the 10-year benchmark rate has been constructed as a GDP weighted average (with weights referred to the contribution of each currency to the formation of the 1996 Euro Area GDP) of the 10-year benchmark rates of Germany, France and Italy.

5. The Econometric Approach

As a first step, we consider the univariate Augmented Dickey-Fuller (*ADF*) tests under the null hypothesis that each time series considered in our estimation procedure contains a unit root.

From the analysis of the results⁷, we can conclude that all the time series we considered are integrated of order 1, *I(1)*, with the only exception of US/Italy real growth differential.

The theoretical partial economic equilibrium model, whose properties and fundamentals have been outlined in Section 3, has therefore been specified to take into account the increased amount of both endogenous and exogenous variables, and the information about the presence of unit roots in the autoregressive representations of the time series. It took (as to the long-run equilibrium) the following econometric structure:

$$(13) \quad Q_t = \beta_0 + \beta_1 USBD_TNT_t + \beta_2 USFR_TNT_t + \beta_3 USIT_TNT_t + \beta_4 USBD_FBAL_t + \beta_5 USFR_FBAL_t + \beta_6 USIT_FBAL_t + \beta_7 USBD_NFA_t + \beta_8 USFR_NFA_t + \beta_9 USIT_NFA_t + \beta_{10} USBD_TOT_t + \beta_{11} USFR_TOT_t + \beta_{12} USIT_TOT_t + \beta_{13} ROIL_t + \beta_{14} RIRL_t + \eta_{1,t}$$

$$RIRL_t = \delta_0 + \delta_1 USBD_MG_t + \delta_2 USFR_MG_t + \delta_3 USIT_MG_t + \delta_4 USBD_Y_t + \delta_5 USFR_Y_t + \delta_6 USIT_Y_t + \eta_{2,t}$$

⁵ Contrary to the area-wide model, the recent revision in some of the time series (concerning monetary aggregates) available to the public, induced us to switch from M3 (for which data were not available for all the countries we consider in the disaggregated model) to M2.

⁶ The lack of data for the period between October 2002 and March 2003 has been faced by the computation of six forecasts for the inflation rate of each country by means of ARIMA class models.

⁷ The univariate Augmented Dickey-Fuller (*ADF*) tests are available upon request.

$$USBD_Y_t = \gamma_0 + \gamma_1 USBD_NFA_t + \gamma_2 USBD_FBAL_t + \gamma_3 USBD_TOT_t + \gamma_4 USBD_TNT_t + \gamma_5 ROIL_t + \gamma_6 RIRL_t + \eta_{3,t}$$

$$USFR_Y_t = \phi_0 + \phi_1 USFR_NFA_t + \phi_2 USFR_FBAL_t + \phi_3 USFR_TOT_t + \phi_4 USFR_TNT_t + \phi_5 ROIL_t + \phi_6 RIRL_t + \eta_{4,t}$$

$$USIT_Y_t = \theta_0 + \theta_1 USIT_NFA_t + \theta_2 USIT_FBAL_t + \theta_3 USIT_TOT_t + \theta_4 USIT_TNT_t + \theta_5 ROIL_t + \theta_6 RIRL_t + \eta_{5,t}$$

where $\eta_t = (\eta_{1,t}, \eta_{2,t}, \eta_{3,t}, \eta_{4,t}, \eta_{5,t})'$ is a multivariate with noise with variance-covariance matrix denoted by Σ .

The econometric analysis of system (13) has been undertaken according to the framework of analysis outlined by *Johansen's* consolidated works (see Johansen (1988), Johansen (1991), Johansen and Juselius (1992)).

The second step of our analysis has been the estimation of the vector autoregression including all the 22 variables considered in our model and constant term and the evaluation of the number of cointegration relations among the set of variables taken into consideration by means of the usual tests on the rank of the matrix Π_{t-k} . The great number of variables forced us to undertake this step considering just three lags for the mentioned vector autoregression.

Results reported in Tables 2a, 2b, 2c show that for 3 lags, according to the test results obtained without including any exogenous variable, including just the constant and including both constant and trend, there is evidence of five cointegrating vectors⁸.

[Tables 2a, 2b, 2c about here]

This result is consistent with the number of relationships in the system (13), and therefore we can conclude that our hypothesis of a long-run dynamic equilibrium among both the endogenous and exogenous variables considered in our model is statistically accepted. Thus, our hypothesis concerning the impact of disaggregated country data on both the Dollar/Euro dynamics and the bond market interest rates dynamics is also accepted.

⁸ Coming from the difference between 22, the dimension of the matrix Π_{t-k} in our analysis and 17, the first rank for which the null hypothesis of rank p is rejected.

6. The Long-run Dynamics

As previously stated, the system was estimated over the sample period from December 1987 to March 2001, and then tested over the remaining eighteen months (from April 2001 to September 2002).

The results, reported in Tables 3-7, are quite satisfactory, both in terms of signs of the coefficients and in terms of the ability of the estimated equations to explain the equilibrium dynamics of the exchange and interest rates dynamics.

As to the analysis of the exchange rate equation (see Table 3 and Figure 1), we highlight its capacity to explain more than 85% of the variability of the Dollar/Euro real exchange rate (Q), and the important role played by the financial and macroeconomic fundamentals of the three European countries chosen to tackle the analysis: Germany, France and Italy.

The economic theory tells us that the overall coefficient of fiscal balances should be positive: The wrong sign of NFA could be explained by the fact that the reserves, included in this variable, are drastically reduced during the EMS crisis of 1992-93.

[Table 3 and Figure 1 about here]

The flows of funds effect enters our model in two different forms: the first is the negative coefficient of the real interest rate differential, perfectly consistent with economic theory, and the second is the overall positive coefficient on net foreign assets, which tells us that an increase in net overseas assets detained by residents usually induces a currency depreciation, since these financial resources are not used to invest in the domestic economy and therefore to increase a single country's aggregate level of both effective and potential wealth⁹.

The real price of oil also enters our model with the correct coefficient (negative). This, as expected, points to the important role of the commodity-markets linked flow of funds in driving the Dollar/Euro real exchange rate.

The motivations for a disaggregated approach to Euro modelling find an empirical confirmation if we consider the real long-term interest rates differential (see Table 4 and Figure 2). In this case, a common policy influenced variable (the long-term interest rates priced by bond market participants, $RIRL$) is explained by different monetary and fiscal/growth policies undertaken by the different European countries. Not unexpectedly (at least to some extent), the Core Europe's monetary and

⁹ The negative coefficient of the US-Italy ratio outlines the particularity of the Italian economy in the sample period considered which was characterised by the EMS crisis of 1992-93.

fiscal policy plays a central role in the determination of the credit spread of Euro denominated investments vis-à-vis those in US dollars. By looking more closely at the coefficients, we confirm our preliminary impression of two different European economies: on one hand, the Core Europe economy has the monetary and fiscal policies matching in sign (even if not in magnitude) with those of the United States; on the other hand, the Italian economy is driven out of the system, probably because its credit spread has not a cyclical macroeconomic background but rather a debt-linked origin. The total variability explained by this equilibrium relationship is over 75%.

[Table 4 and Figure 2 about here]

As to the equations regarding the output differentials, we intend to stress the satisfactory results obtained in terms of coefficient signs.

In the case of US-Germany real growth differential (see Table 5 and Figure 3), as expected for the reasons outlined commenting the equation of the real exchange rate, an increase in net foreign assets ratio (*NFA*), induces a decrease in output differential as well as an increase in the terms of trade (*TOT*), via foreign trade. The fiscal balance ratio (*FBAL*) shows an incorrect sign: a tighter fiscal policy in Germany with respect to US has positive influence (at least at the same time) on the growth rate differential. Exploring the data set, we can explain the wrong sign by considering that the sample period includes the structural change period 1989-91 of the German unification. The apparently disappointing sign obtained for the interest rates differential (*RIRL*) seems to be justified by the theory of the expectation hypothesis of the term structure of interest rates. Under the empirical point of view, in fact, a positive sign for the differential between long-term interest rates when explaining the real growth differential, indicates that the bond markets usually price in restrictive monetary policies for the (next or remote) future when real growth accelerates. The real oil price (*ROIL*), instead, exhibits a correct sign. The highest prices of oil (and of other commodities) has unfavourable effects on the differential between the US and Germany annual real GDP growth rates. In other words, the highest prices of oil is less favourable to German than US economy, the former being clearly a net importer of oil.

[Table 5 and Figure 3 about here]

In the case of the US-France real growth differential (see Table 6 and Figure 4), all the signs are perfectly in line with what is suggested by economic theory.

[Table 6 and Figure 4 about here]

With regard to the US-Italy gross domestic product growth differential (see Table 7 and Figure 5), all but the long-term interest rate differential (*RIRL*) have the expected signs. The same reasons mentioned in the case of the US-Germany GDP growth differential are valid to explain the positive impact of the *RIRL* variable.

[Table 7 and Figure 5 about here]

All things considered, therefore, the dynamic equilibrium equations are quite satisfactory both from the economic and from the statistical point of view, and that is particularly true for market equations (exchange and interest rates). The R^2 coefficients of those equations, in fact, are respectively equal to 87.50% for the real exchange rate, and 76.30% for the real interest rate differential. Residuals behave properly from the statistical point of view, as the reader can see by looking at Table 8. This table shows the correlations between each equation's residuals and tells us about their lack of statistical significance, with the only exception of the correlations of the growth differentials.

[Table 8 about here]

7. The Short-run Dynamics

Having analysed the equilibrium relationships among variables in the previous section, we now intend to analyse the short-term dynamics jointly determining the behaviour of the real exchange rate, the real interest rate differential and the growth differentials.

To do that, we estimated, once again, over the period from December 1987 to March 2001 (leaving the last eighteen observations in our sample to test the forecasting ability of the model) a Vector Error Correction Model (VECM) involving the first simple differences (monthly percentage changes) of the endogenous variables considered in our analytic framework (noted as *DQ*, *DRIRL*, *DUSBD_Y*, *DUSFR_Y*, and *DUSIT_Y*)¹⁰, the first simple differences of the exogenous variables of our system (noted as *DTNT*, *DTOT*, *DROIL*, *DFBAL*, *DMG* and *DNFA*) and, finally, the first lag of the residuals from the long-run equilibrium equations (noted as *ECM(Q)*, *ECM(DRIRL)*, *ECM(USBD_Y)*, *ECM(USFR_Y)*, and *ECM(USIT_Y)*). The lag for the system estimation was set equal to one.

¹⁰ Suffixes have the same meaning as for the long-run equilibrium equations (see previous note 3).

[Table 9 and Figure 6 about here]

[Table 10 and Figure 7 about here]

[Table 11 and Figure 8 about here]

[Table 12 and Figure 9 about here]

[Table 13 and Figure 10 about here]

The analysis of the results obtained from the estimation of the short-run equations leads us to state that there are at least two interesting observations to be noted.

The first consideration is related to the causality direction concerning the disequilibrium. The financial markets disequilibria (in particular those concerning the exchange rate) tend to influence growth differentials, but the contrary is not true. In fact, the variable $ECM(Q)$ is statistically significant, with one period lag, for all the growth differential short-term equations and neither the US-Germany growth differential, nor the US-France growth differential, nor the US-Italy growth differential influences the real exchange rate or the real interest rate dynamics.

The second consideration is that it seems that a disaggregated approach to Dollar/Euro exchange rate modelling such as the one proposed in this work, gives us more insights into the links (and therefore the similarities) between the different countries belonging to the EMU. In particular, this model tells us that Germany and Italy are strongly different, without any reciprocal direct influence, while France is the link between them, influencing both Germany and Italy and being influenced by Italy.

The estimated model presents very satisfactory properties under the statistical point of view. Analysis of Table 14 shows that the model isolates non cross-correlated errors, with the exception of the US-France and US-Italy growth differentials. Analysis of Table 15 together with Figures 11-15 shows that residuals (at the 5% level) in four cases out of five may be considered as normally distributed, in three out of five, without autoregressive conditional heteroschedasticity (ARCH effects) and without statistically and economically significant autocorrelation structures according to Bartlett's bands test.

[Table 14 about here]

[Table 15 about here]

[Figure 11 about here]

[Figure 12 about here]

[Figure 13 about here]

[Figure 14 about here]

[Figure 15 about here]

The only exception to the optimality (if we decrease the significance to 1%) are the residuals coming from the equation of the US-France growth differential for which there is evidence of ARCH effects.

8. The Forecasting Performance

When talking about forecasts, it seems to be to some extent obvious to evaluate a model's forecasting performance by comparing it to some other model. Ever since the well-known seminal paper by Meese and Rogoff (1983) with their famous criticism of structural econometric models, the benchmark by which a fundamental-based econometric exchange rate model is assessed is given by the simple random walk.

The model was therefore, as mentioned above, estimated over the sample period from December 1998 to March 2001, and then the parameters maintained fixed to produce out-of-sample forecasts for the period from April 2001 to September 2002. The out-of-sample forecasts are constructed as "perfect foresight forecasts", in the sense that we use the actual observations of the exogenous variables to compute our one-step ahead forecast.

The results obtained for monthly percentage changes and levels of the real Dollar/Euro exchange rate, both from a graphical point of view (see Figures 16 and 17¹¹) and a numerical one (see Tables 16 and 17)), seem to lean particularly toward the use, in a forecasting optic, of the model described and estimated in past sections.

¹¹ In the Figure 17 the dot lines are plotted by segments to indicate the direction of the one-step ahead forecasts

[Figure 16 about here]

[Figure 17 about here]

[Table 16 about here]

[Table 17 about here]

Figures 16 and 17 show how the model avoid the problem of “*structurally*” overestimating, or underestimating the Dollar/Euro exchange rate changes or levels, while Tables 16 and 17 prove that, on average, the *absolute forecasting error* of the model is well below 2.00% and that the same is true for the *root mean square error*.

Particularly interesting are also the indications coming from the *correctly forecasted percentage of signs*: in this case the model is able to capture the direction changes of the exchange rate induced by market activity in the majority of cases: thirteen out of eighteen (72.22%). Signs are particularly satisfactory even for the other variables of our system: the model correctly forecasts the sign of ten out of eighteen monthly changes in the case of the interest rates differential (55.56%), fourteen in the case of the US-Germany growth differential (77.78%), fifteen in the case of the US-France growth differential (83.33%) and, surprisingly, seventeen in the case of the US-Italy growth differential (94.44%).

The analysis of the *Theil's U statistics* shows us that, in both cases, the estimated structural econometric model performs better than the random walk. The efficiency gain in the case of real exchange rate changes is around 28%, while it decreases to 15 % in the case of the exchange rate levels.

However, the fact that the model performs well in terms of efficiency gain vis-à-vis the random walk model, or in terms of correctly forecasted signs, is surely a necessary condition to exploit it in an operative environment, as it is also a sufficient one. We need to assess the economic effectiveness of the forecasts produced by the use of the model, and test whether they “produced wealth or not”. This kind of test is quite simple, and leads to the graphical content of Figure 18.

[Figure 18 about here]

Let us suppose that an investor had a wealth of 100 Euros at the end of March 2001. He has an investment horizon ending in September 2002 and three different investment strategies:

Buy and Hold strategy: he holds the original 100 Euros until the end of the investment period. In this case the total performance of the strategy is given by:

$$Tot.Perf. = 100 \prod_{i=1}^{18} (1 + r_i)$$

where r_i is the monthly change in the nominal Dollar/Euro exchange rate in the i -th forecasting period.

Random Walk strategy: he switches from Euro to Dollar according to the sign of the forecasts obtained by applying a simple random walk model.

Model Based strategy: he switches from Euro to Dollar according to the sign of the forecasts obtained by applying the model estimated in this work.

In the latter two cases, in particular, he converts his Euros into US Dollars if that currency is expected to appreciate versus the Euro and vice versa.

In these cases, r_i equals the absolute value of the monthly change in the nominal Dollar/Euro exchange rate in the i -th forecasting period if the sign of the forecast was correct, minus that value in the opposite case (when the “directional” forecasts was wrong).

By applying this simple test, we discover that our model outperforms both the random walk and the buy and hold strategies, resulting in a cumulated performance of 26.54% against a cumulated performance of 12.75% for the random walk model and 11.80% for the buy and hold strategy

9. Multi-country vs. Area-wide Model: Forecasting Comparison

The area-wide and multi-country models can be compared in terms of forecasting performance. In general, we expect a better performance from the multi-country model that is built on a wider set of information. If this model captures the information correctly, i.e., precisely explains the differences of the economic structures, then forecasts must turn out improved. On the other hand, if we allow the area-wide model to be more flexible by taking into account the structural breaks, then this last model could have chances to compete with the multi-country model.

For comparison purposes, the results obtained with the area-wide model presented in Sartore et al. (2002) are updated using the new sample size. The multivariate cointegration analysis in the presence of structural breaks leads to a similar structural model¹² to the one of the quoted paper.

¹² Publication constraints does not permit us to replicate here the complete cointegration analysis and the specification of the long-run and short-run dynamic models. All the results are available upon request.

Tables 18 and 19 and Figures 19 and 20 show that the forecasting performances of the monthly changes and levels of real Euro/Dollar exchange rate given by the area-wide are less good than those obtained in the multi-country model. Furthermore, the differences with the random walk forecasts are not substantial, even in terms of correct signs, with the exception of the nominal levels. Despite this poor performance, the area-wide model exhibits an economic effectiveness which doubled that of the random walk. The Figure 21 shows almost identical area-wide and random walk values for the first three forecasting periods. After that, the curve of area-wide model tends to follow the behaviour of the multi-country curve. In the end, the cumulate performance of the area-wide is 21.23% not so far from the 26.24% already seen for the multi-country case.

[Table 18 and Figure 19 about here]

[Table 19 and Figure 20 about here]

[Figure 21 about here]

10. Conclusions

It is well known that the challenge of macroeconomic models for the Dollar/Euro Exchange rate with respect to the random walk is a hard one. In spite of this, economic research has not given up proposing new models for a better interpretation of the fundamentals. Here, we combine a specification of Mundell-Fleming type with a disaggregated approach to model the Euro area.

The disaggregation is consistent with the substantial different fiscal and economic policies in the EMU member countries and, from an econometric point of view, it offers more information support to the model.

The obtained results show that the multi-country model outperforms both the random walk and the area-wide model, in term of forecasting behaviour.

Apart from the usual performance indexes, an useful comparison is given by a measure of economic effectiveness. It is crucial to answer the question whether the competitive model “produces wealth or not”. In this latter aspect, we can give an undoubting order of preference that confirms the superiority of the multi-country model followed by the area-wide model and, finally, the random walk.

These results are extremely important, since they prove that, contrary to the original statement by Meese and Rogoff, there is room for further research aimed at explaining the dynamic behaviour of

exchange rates by means of structural econometric models, which could give further ground for fundamentally or financially based analysis.

References

- Balassa, B. (1964) The Purchasing Power Parity Doctrine: a Reappraisal, *Journal of Political Economy*, 72, 584-596.
- Alberola, E., Garcia-Cervero, S., Lopez, H. and Ubide, A. (2002) Quo Vadis Euro?, *The European Journal of Finance*, Special Issue, Vol. 8, 4, 352-370.
- Johansen, S. (1988) Statistical Analysis of Cointegrating Vectors, *Journal of Economic Dynamics and Control*, Vol. 12, pp. 231-254.
- Johansen, S. (1991) Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, *Econometrica*, Vol. 59, No. 6, pp. 1551-1580.
- Johansen, S. and Juselius, K. (1992) Maximum Likelihood Estimation and Inference on Cointegration – With Applications to the Demand for Money, *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp. 169-210.
- Johansen, S. (1995) Identifying Restriction of Linear Equations with Applications to Simultaneous Equations and Cointegration, *Journal of Econometrics*, 69, 111-132.
- MacDonald, R. (1997) What Determines Real Exchange Rates? The Long and Short of It, *IMF Working Paper*, WP/97/21.
- MacDonald, R and Marsh, I. (1999) Exchange Rate Modelling, *Advanced Studies in Theoretical and Applied Econometrics*, 37, Kluwer Academic Publisher, Boston.
- Meese, R. and Rogoff, K. (1983) Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?, *Journal of International Economics*, Vol. 14, pp. 3-24.
- Samuelson, P. (1964) Theoretical Notes on Trade Problems, *Review of Economics and Statistics*, 46, 145-154.
- Sartore, D., Trevisan, L., Trova, M., Volo, F. (2002) Dollar/Euro Exchange Rate: A Monthly Econometric Model for Forecasting, *The European Journal of Finance*, Special Issue, Vol. 8, 4, 480-501.

Tables

Variables	Description
<i>Q</i>	Real Dollar/Euro exchange rate (logarithm)
<i>RIRL</i>	Differential between US and Euro 10-years real interest rate
<i>USBD_Y</i>	Differential between US and Germany annual real GDP growth rates (logarithms)
<i>USFR_Y</i>	Differential between US and France annual real GDP growth rates (logarithms)
<i>USIT_Y</i>	Differential between US and Italy annual real GDP growth rates (logarithms)
<i>USBD_TNT</i>	Differential between US and Germany ratio of consumer price index to producer price index (logarithms)
<i>USFR_TNT</i>	Differential between US and France ratio of consumer price index to producer price index (logarithms)
<i>USIT_TNT</i>	Differential between US and Italy ratio of consumer price index to producer price index (logarithms)
<i>USBD_FBAL</i>	Differential between US and Germany ratio of government surplus or deficit and the GDP (logarithms)
<i>USFR_FBAL</i>	Differential between US and France ratio of government surplus or deficit and the GDP (logarithms)
<i>USIT_FBAL</i>	Differential between US and Italy ratio of government surplus or deficit and the GDP (logarithms)
<i>USDB_TOT</i>	Ratio of US to Germany ratio of export unit value to import unit value (logarithms)
<i>USFR_TOT</i>	Ratio of US to France ratio of export unit value to import unit value (logarithms)
<i>USIT_TOT</i>	Ratio of US to Italy ratio of export unit value to import unit value (logarithms)
<i>ROIL</i>	Real price of oil expressed in US Dollar per barrel
<i>USBD_MG</i>	Differential between US and Germany annual real M3 growth rates (logarithms)
<i>USFR_MG</i>	Differential between US and France annual real M3 growth rates (logarithms)
<i>USIT_MG</i>	Differential between US and Italy annual real M3 growth rates (logarithms)
<i>USBD_NFA</i>	Ratio of US to Germany ratio of real net foreign asset to real GDP (logarithms)
<i>USFR_NFA</i>	Ratio of US to France ratio of real net foreign asset to real GDP (logarithms)
<i>USIT_NFA</i>	Ratio of US to Italy ratio of real net foreign asset to real GDP (logarithms)

Table 1: Description of variables utilised in the model

Ho:rank=p	-Tlog(1-\mu)	using T-nm	95%	-T\Sum log(.)	using T-nm	95%
p == 0	206.60	124.70		1796.00	1084.00	
p <= 1	176.90	106.80		1589.00	958.90	
p <= 2	161.90	97.71		1412.00	852.10	
p <= 3	151.50	91.40		1250.00	754.40	
p <= 4	132.60	80.05		1099.00	663.00	
p <= 5	124.90	75.34		966.00	582.90	
p <= 6	114.40	69.03		841.20	507.60	
p <= 7	102.70	61.98		726.80	438.60	
p <= 8	90.34	54.52		624.10	376.60	
p <= 9	85.27	51.46		533.70	322.10	
p <= 10	74.85	45.17		448.40	270.60	
p <= 11	63.40	38.26		373.60	225.40	
p <= 12	56.45	34.06	65.30	310.20	187.20	255.30
p <= 13	51.36	30.99	59.10	253.70	153.10	212.70
p <= 14	46.34	27.97	53.70	202.40	122.10	175.80
p <= 15	39.68	23.94	48.00	156.00	94.16	141.20
p <= 16	32.68	19.72	41.50	116.40	70.22	110.00
p <= 17	27.65	16.69	36.40	83.68	50.50	82.50
p <= 18	21.37	12.89	30.00	56.03	33.81	59.50
p <= 19	16.00	9.65	23.80	34.67	20.92	39.90
p <= 20	9.88	5.96	17.90	18.67	11.27	24.30
p <= 21	6.89	4.16	11.40	8.79	5.30	12.50
p <= 22	1.89	1.14	3.80	1.89	1.14	3.80

Number of lags used in the analysis: 3

Table 2a: Cointegration Analysis of System

Variables entered unrestricted: None – Sample Size: 156 – Observations from 1988 (4) to 2001 (3)

Ho:rank=p	-Tlog(1-\mu) using T-nm	95%	-T\Sum log(.) using T-nm	95%	
p == 0	216.70	130.80	1884.00	1137.00	
p <= 1	174.10	105.10	1667.00	1006.00	
p <= 2	163.10	98.44	1493.00	900.90	
p <= 3	153.30	92.51	1330.00	802.40	
p <= 4	139.50	84.16	1176.00	709.90	
p <= 5	126.20	76.17	1037.00	625.80	
p <= 6	121.60	73.37	910.70	549.60	
p <= 7	110.90	66.95	789.20	476.20	
p <= 8	94.38	56.95	678.20	409.30	
p <= 9	89.72	54.14	583.80	352.30	
p <= 10	80.11	48.34	494.10	298.20	
p <= 11	72.63	43.83	414.00	249.80	
p <= 12	62.22	37.55	341.40	206.00	277.70
p <= 13	56.07	33.83	279.10	168.50	233.10
p <= 14	48.92	29.52	223.10	134.60	192.90
p <= 15	40.54	24.46	174.20	105.10	156.00
p <= 16	35.19	21.24	133.60	80.63	124.20
p <= 17	30.60	18.46	98.43	59.40	94.20
p <= 18	27.13	16.37	67.83	40.93	68.50
p <= 19	16.84	10.16	40.70	24.56	47.20
p <= 20	15.11	9.12	23.86	14.40	29.70
p <= 21	8.75	5.28	8.76	5.28	15.40
p <= 22	0.00	0.00	0.00	0.00	3.80

Number of lags used in the analysis: 3

Table 2b: Cointegration Analysis of System

Variables entered unrestricted: Constant – Sample Size: 156 – Observations from 1988 (4) to 2001 (3)

Ho:rank=p	-Tlog(1-\mu)	using T-nm	95%	-T\Sum log(.)	using T-nm	95%
p == 0	218.30	131.70		1972.00	1190.00	
p <= 1	177.60	107.10		1753.00	1058.00	
p <= 2	166.80	100.70		1576.00	950.90	
p <= 3	160.70	96.96		1409.00	850.30	
p <= 4	146.80	88.61		1248.00	753.30	
p <= 5	129.40	78.08		1102.00	664.70	
p <= 6	121.50	73.32		972.10	586.60	
p <= 7	111.90	67.53		850.70	513.30	
p <= 8	105.50	63.68		738.70	445.80	
p <= 9	94.10	56.79		633.20	382.10	
p <= 10	89.45	53.98		539.10	325.30	
p <= 11	78.92	47.62		449.70	271.30	
p <= 12	70.50	42.54	71.70	370.70	223.70	296.00
p <= 13	60.79	36.68	66.10	300.20	181.20	250.80
p <= 14	53.49	32.28	60.30	239.40	144.50	209.00
p <= 15	41.35	24.95	54.30	186.00	112.20	170.80
p <= 16	39.30	23.71	48.50	144.60	87.26	136.60
p <= 17	30.14	18.19	42.50	105.30	63.55	104.90
p <= 18	24.41	14.73	36.40	75.17	45.36	77.70
p <= 19	19.09	11.52	30.30	50.76	30.63	54.60
p <= 20	14.23	8.59	23.80	31.67	19.11	34.60
p <= 21	12.19	7.35	16.90	17.44	10.52	18.20
p <= 22	3.25	3.17	3.70	3.25	3.17	3.70

Number of lags used in the analysis: 3

Table 2c: Cointegration Analysis of System

Variables entered unrestricted: Constant and Trend – Sample Size: 156 – Observations from 1988 (4) to 2001 (3)

<i>Equation 1 for Q</i>				
<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>RIRL</i>	-4.1289	0.7153	-5.7720	0.0000
<i>USIT_TNT</i>	-3.0087	0.3881	-7.7530	0.0000
<i>USFR_TNT</i>	2.0108	0.2866	7.0160	0.0000
<i>USFR_FBAL</i>	2.1683	0.4517	4.8010	0.0000
<i>USIT_FBAL</i>	0.4450	0.2193	2.0290	0.0440
<i>USBD_NFA</i>	111.8000	15.7290	7.1080	0.0000
<i>USFR_NFA</i>	33.3080	9.7052	3.4320	0.0008
<i>USIT_NFA</i>	-116.3700	10.0230	-11.6040	0.0000
<i>ROIL</i>	-0.0391	0.0196	-2.0020	0.0468
<i>USBD_TOT</i>	-1.4506	0.1632	-8.8900	0.0000
Constant	0.4054	0.0582	6.9660	0.0000
$\sigma = 0.0462$				

Table 3: Equilibrium Dynamics – The Real Exchange Rate

<i>Equation 2 for RIRL</i>				
<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>USBD_MG</i>	0.0369	0.0134	2.7610	0.0064
<i>USFR_MG</i>	0.0527	0.0203	2.6000	0.0101
<i>USBD_Y</i>	1.2479	0.1981	6.3010	0.0000
<i>USFR_Y</i>	1.4407	0.2594	5.5540	0.0000
<i>Constant</i>	-0.0090	0.0019	-4.7110	0.0000
$\sigma = 0.0187109$				

Table 4: **Equilibrium Dynamics** – The Real Interest rate Differential

<i>Equation 3 for USBD_Y</i>				
<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>USBD_FBAL</i>	0.4456	0.1802	2.4730	0.0144
<i>USBD_NFA</i>	-0.2619	0.0480	-5.4590	0.0000
<i>USBD_TOT</i>	-0.0348	0.0152	-2.2900	0.0232
<i>ROIL</i>	-0.0194	0.0057	-3.4360	0.0007
<i>RIRL</i>	0.4179	0.1368	3.0550	0.0026
<i>Constant</i>	0.0639	0.0168	3.8130	0.0002
$\sigma = 0.0177558$				

Table 5: **Equilibrium Dynamics** – The US-Germany Real Growth Rate Differential

<i>Equation 4 for USFR_Y</i>				
<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>USFR_FBAL</i>	-0.0526	0.0242	-2.1710	0.0313
<i>USFR_NFA</i>	-0.2339	0.0392	-5.9600	0.0000
<i>USFR_TOT</i>	-0.0631	0.0252	-2.5040	0.0132
<i>ROIL</i>	-0.0170	0.0049	-3.4740	0.0006
<i>Constant</i>	0.0553	0.0150	3.7010	0.0003
$\sigma = 0.0137173$				

Table 6: **Equilibrium Dynamics** – The US-France Real Growth Rate Differential

Equation 5 for USIT_Y

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>USIT_FBAL</i>	-0.0401	0.0245	-1.6400	0.1028
<i>USIT_NFA</i>	-0.1231	0.0447	-2.7550	0.0065
<i>USIT_TOT</i>	-0.0787	0.0225	-3.5030	0.0006
<i>ROIL</i>	-0.0173	0.0055	-3.1180	0.0021
<i>RIRL</i>	0.3498	0.0759	4.6090	0.0000
<i>Constant</i>	0.0623	0.0166	3.7480	0.0002

$\sigma = 0.015395$

Table 7: **Equilibrium Dynamics** – The US-Italy Real Growth Rate Differential

Correlation of Residuals

	<i>Q</i>	<i>RIRL</i>	<i>USBD_Y</i>	<i>USFR_Y</i>	<i>USIT_Y</i>
<i>Q</i>	1.0000				
<i>RIRL</i>	-0.0149	1.0000			
<i>USBD_Y</i>	0.1742	-0.5396	1.0000		
<i>USFR_Y</i>	0.2109	0.2701	0.6589	1.0000	
<i>USIT_Y</i>	0.1563	0.2016	0.5892	0.8690	1.0000

Table 8: **Features of Conditional VECM residuals**– Correlations

Equation 1 for DQ

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>DQ_1</i>	0.177	0.069	2.566	0.0112
<i>DRIRL_1</i>	-1.783	0.780	-2.285	0.0236
<i>DUSFR_TNT</i>	1.155	0.378	3.053	0.0026
<i>DUSIT_TNT</i>	-1.150	0.440	-2.614	0.0098
<i>DUSFR_FBAL</i>	-1.107	0.320	-3.463	0.0007
<i>DUSIT_FBAL</i>	0.270	0.135	2.007	0.0464
<i>DUSBD_NFA</i>	41.675	19.617	2.124	0.0351
<i>DUSIT_NFA</i>	-42.263	19.633	-2.153	0.0328
<i>ECM(Q)_1</i>	-0.280	0.047	-5.967	0.0000
<i>DUSBD_MG_1</i>	-0.345	0.158	-2.191	0.0299
<i>ECM(RIRL)_1</i>	-2.158	0.463	-4.665	0.0000

$\sigma = 0.0254642$

Table 9

<i>Equation 2 for DUSBD_Y</i>				
<i>Variable</i>	<i>Coefficient</i>	<i>Std.Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>DQ_1</i>	-0.021	0.007	-2.830	0.0052
<i>DUSBD_Y_1</i>	0.722	0.045	15.860	0.0000
<i>DUSFR_TNT_1</i>	0.100	0.041	2.424	0.0164
<i>DUSIT_TNT_1</i>	-0.115	0.048	-2.400	0.0175
<i>ECM(Q)_1</i>	0.013	0.004	2.901	0.0042
<i>DUSBD_MG</i>	0.070	0.018	3.916	0.0001
<i>ECM(USBD_Y)_1</i>	-0.111	0.018	-6.188	0.0000
<i>ECM(USFR_Y)_1</i>	0.047	0.023	2.054	0.0416
$\sigma = 0.00302001$				

Table 10

<i>Equation 3 for DUSFR_Y</i>				
<i>Variable</i>	<i>Coefficient</i>	<i>Std.Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>DUSFR_Y_1</i>	0.711	0.043	16.685	0.0000
<i>DUSFR_TOT_1</i>	-0.020	0.010	-1.946	0.0533
<i>ECM(Q)_1</i>	0.012	0.003	3.549	0.0005
<i>ECM(USIT_Y)_1</i>	0.048	0.022	2.126	0.0349
<i>ECM(USFR_Y)_1</i>	-0.113	0.026	-4.380	0.0000
$\sigma = 0.00237837$				

Table 11

<i>Equation 4 for DUSIT_Y</i>				
<i>Variable</i>	<i>Coefficient</i>	<i>Std.Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>DUSIT_Y_1</i>	0.654	0.042	15.536	0.000
<i>DUSIT_FBAL</i>	-0.021	0.012	-1.755	0.081
<i>DUSBD_TOT_1</i>	-0.031	0.011	-2.669	0.008
<i>ECM(Q)_1</i>	0.015	0.004	3.605	0.000
<i>DUSBD_MG_1</i>	-0.031	0.014	-2.186	0.030
<i>ECM(USIT_Y)_1</i>	-0.154	0.028	-5.462	0.000
<i>ECM(USFR_Y)_1</i>	0.095	0.032	2.969	0.003
$\sigma = 0.00289158$				

Table 12

<i>Equation 5 for DRIRL</i>				
<i>Variable</i>	<i>Coefficient</i>	<i>Std.Error</i>	<i>t-value</i>	<i>t-prob</i>
<i>DUSBD_FBAL</i>	0.333	0.103	3.246	0.0014
<i>DUSBD_FBAL_1</i>	0.170	0.101	1.686	0.0937
<i>DUSIT_FBAL_1</i>	0.028	0.012	2.305	0.0224
<i>DUSBD_TOT</i>	-0.033	0.014	-2.269	0.0245
<i>DUSFR_TOT</i>	0.039	0.016	2.394	0.0178
<i>DUSIT_TOT_1</i>	-0.018	0.009	-1.863	0.0642
<i>DUSFR_MG</i>	0.029	0.016	1.785	0.0760
<i>ECM(RIRL)_1</i>	-0.089	0.034	-2.602	0.0101
<i>Constant</i>	0.000	0.000	-0.224	0.8230

$\sigma = 0.00241915$

Table 13

<i>Correlation of Residuals</i>					
	<i>DQ</i>	<i>DRIRL</i>	<i>DUSBD_Y</i>	<i>DUSFR_Y</i>	<i>DUSIT_Y</i>
<i>DQ</i>	1.0000				
<i>DRIRL</i>	-0.2599	1.0000			
<i>DUSBD_Y</i>	0.1090	0.0983	1.0000		
<i>DUSFR_Y</i>	0.0290	0.1518	0.3903	1.0000	
<i>DUSIT_Y</i>	0.0101	0.0638	0.3625	0.5897	1.0000

Table 14

<i>Normality, Autocorrelation and ARCH effect Tests for Residuals</i>					
<i>Equation</i>	<i>Residuals - Normality Test</i> (χ^2 Test)		<i>Residuals - ARCH Test</i> (F-form Test)		<i>Residuals - Autocorrelated</i> (Bartlett's Test - Significant Lags)
<i>DREUR</i>	0.6971	[0.4053]	0.6970	[0.4053]	Lags 4, 6, 20
<i>DRIRL</i>	1.2542	[0.5341]	3.3988	[0.0523]	Lags 9, 15, 20
<i>DUSBD_Y</i>	6.6038	[0.0368]	4.2867	[0.0404]	Lags 2, 9
<i>DUSFR_Y</i>	0.9110	[0.6341]	20.950	[0.0000]	Lags 4, 8, 14
<i>DUSIT_Y</i>	5.5673	[0.0618]	1.1602	[0.2834]	Lags 5, 9

Values in parenthesis indicate the significance level.

Table 15

<i>Date</i>	<i>Actual</i>	<i>Forecasted</i>	<i>Error</i>	<i>Actual Change Sign</i>	<i>Forecasted Change Sign</i>
03/01	-0.0346				
04/01	0.0033	0.0024	-0.0008	(+)	(+)
05/01	-0.0417	-0.0065	0.0352	(-)	(-)
06/01	-0.0010	0.0122	0.0132	(-)	(+)
07/01	0.0324	0.0059	-0.0265	(+)	(+)
08/01	0.0374	0.0130	-0.0244	(+)	(+)
09/01	0.0013	0.0090	0.0077	(+)	(+)
10/01	-0.0126	-0.0083	0.0043	(-)	(-)
11/01	0.0006	-0.0057	-0.0063	(+)	(-)
12/01	-0.0058	-0.0035	0.0023	(-)	(-)
01/02	-0.0262	-0.0083	0.0178	(-)	(-)
02/02	0.0070	0.0004	-0.0065	(+)	(+)
03/02	0.0029	0.0035	0.0006	(+)	(+)
04/02	0.0311	-0.0167	-0.0477	(+)	(-)
05/02	0.0376	0.0149	-0.0227	(+)	(+)
06/02	0.0572	0.0174	-0.0398	(+)	(+)
07/02	-0.0093	0.0056	0.0149	(-)	(+)
08/02	-0.0045	0.0078	0.0124	(-)	(+)
09/02	0.0070	0.0018	-0.0052	(+)	(+)

Mean Error:	-0.0040
Root Mean Square Error:	0.0210
Mean Absolute Error:	0.0160
Theil's U Statistics:	0.7220
Signs Correctly Forecasted:	72.22%

Table 16: *Multi-country Model Forecasting Performance* – Monthly Changes of Real US dollar/Euro Exchange Rate

<i>Date</i>	<i>Actual</i>	<i>Forecasted</i>	<i>Error</i>	<i>Actual Change Sign</i>	<i>Forecasted Change Sign</i>
03/01	0.8436				
04/01	0.8463	0.8456	-0.0007	(+)	(+)
05/01	0.8117	0.8408	0.0291	(-)	(-)
06/01	0.8109	0.8217	0.0108	(-)	(+)
07/01	0.8376	0.8158	-0.0219	(+)	(+)
08/01	0.8696	0.8486	-0.0210	(+)	(+)
09/01	0.8707	0.8775	0.0068	(+)	(+)
10/01	0.8598	0.8635	0.0037	(-)	(-)
11/01	0.8603	0.8549	-0.0054	(+)	(-)
12/01	0.8554	0.8573	0.0020	(-)	(-)
01/02	0.8333	0.8482	0.0150	(-)	(-)
02/02	0.8391	0.8336	-0.0055	(+)	(+)
03/02	0.8415	0.8420	0.0005	(+)	(+)
04/02	0.8681	0.8276	-0.0405	(+)	(-)
05/02	0.9013	0.8811	-0.0202	(+)	(+)
06/02	0.9544	0.9172	-0.0372	(+)	(+)
07/02	0.9456	0.9598	0.0142	(-)	(+)
08/02	0.9413	0.9531	0.0117	(-)	(+)
09/02	0.9479	0.9430	-0.0049	(+)	(+)

Mean Error:	-0.0035
Root Mean Square Error:	0.0183
Mean Absolute Error:	0.0139
Theil's U Statistics:	0.8478
Signs Correctly Forecasted:	72.22%

Table 17: *Multi-country Model Forecasting Performance* – Monthly Levels of Real US dollar/Euro Exchange Rate

<i>Date</i>	<i>Actual</i>	<i>Forecasted</i>	<i>Error</i>	<i>Actual Change Sign</i>	<i>Forecasted Change Sign</i>
03/01	-0.0346				
04/01	0.0033	-0.0156	-0.0189	(+)	(-)
05/01	-0.0417	0.0099	0.0516	(-)	(+)
06/01	-0.0010	-0.0040	-0.0030	(-)	(-)
07/01	0.0324	0.0003	-0.0321	(+)	(+)
08/01	0.0374	0.0113	-0.0262	(+)	(+)
09/01	0.0013	0.0003	-0.0010	(+)	(+)
10/01	-0.0126	-0.0127	-0.0001	(-)	(-)
11/01	0.0006	-0.0002	-0.0008	(+)	(-)
12/01	-0.0058	0.0025	0.0083	(-)	(+)
01/02	-0.0262	0.0028	0.0290	(-)	(+)
02/02	0.0070	0.0126	0.0057	(+)	(+)
03/02	0.0029	0.0073	0.0044	(+)	(+)
04/02	0.0311	-0.0008	-0.0319	(+)	(-)
05/02	0.0376	0.0108	-0.0269	(+)	(+)
06/02	0.0572	0.0045	-0.0527	(+)	(+)
07/02	-0.0093	0.0226	0.0319	(-)	(+)
08/02	-0.0045	-0.0021	0.0025	(-)	(-)
09/02	0.0070	-0.0194	-0.0264	(+)	(-)

Mean Error:	-0.0048
Root Mean Square Error:	0.0257
Mean Absolute Error:	0.0196
Theil's U Statistic:	0.8831
Signs Correctly Forecasted:	55.56%

Table 18: *Area-wide Model Forecasting Performance* – Monthly Changes of Real US dollar/Euro Exchange Rate

<i>Date</i>	<i>Actual</i>	<i>Forecasted</i>	<i>Error</i>	<i>Actual Change Sign</i>	<i>Forecasted Change Sign</i>
03/01	0.8436				
04/01	0.8463	0.8305	-0.0158	(+)	(-)
05/01	0.8117	0.8547	0.0430	(-)	(+)
06/01	0.8109	0.8085	-0.0024	(-)	(-)
07/01	0.8376	0.8112	-0.0264	(+)	(+)
08/01	0.8696	0.8471	-0.0225	(+)	(+)
09/01	0.8707	0.8698	-0.0009	(+)	(+)
10/01	0.8598	0.8598	-0.0001	(-)	(-)
11/01	0.8603	0.8596	-0.0007	(+)	(-)
12/01	0.8554	0.8624	0.0071	(-)	(+)
01/02	0.8333	0.8577	0.0245	(-)	(+)
02/02	0.8391	0.8438	0.0048	(+)	(+)
03/02	0.8415	0.8452	0.0037	(+)	(+)
04/02	0.8681	0.8408	-0.0273	(+)	(-)
05/02	0.9013	0.8775	-0.0239	(+)	(+)
06/02	0.9544	0.9054	-0.0490	(+)	(+)
07/02	0.9456	0.9762	0.0306	(-)	(+)
08/02	0.9413	0.9437	0.0023	(-)	(-)
09/02	0.9479	0.9233	-0.0247	(+)	(-)

Mean Error:	-0.0043
Root Mean Square Error:	0.0227
Mean Absolute Error:	0.0172
Theil's U Statistic:	1.0510
Signs Correctly Forecasted:	55.56%

Table 19: Area-wide Model Forecasting Performance – Monthly Levels of Real US dollar/Euro Exchange Rate

Figures

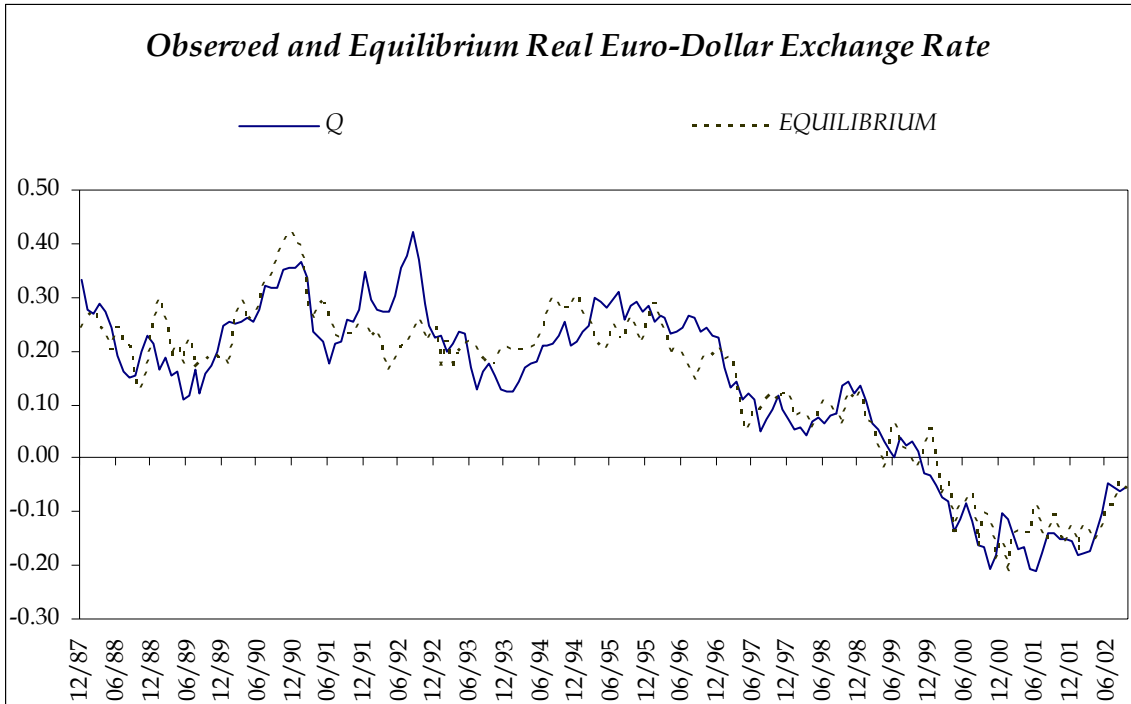


Figure 1

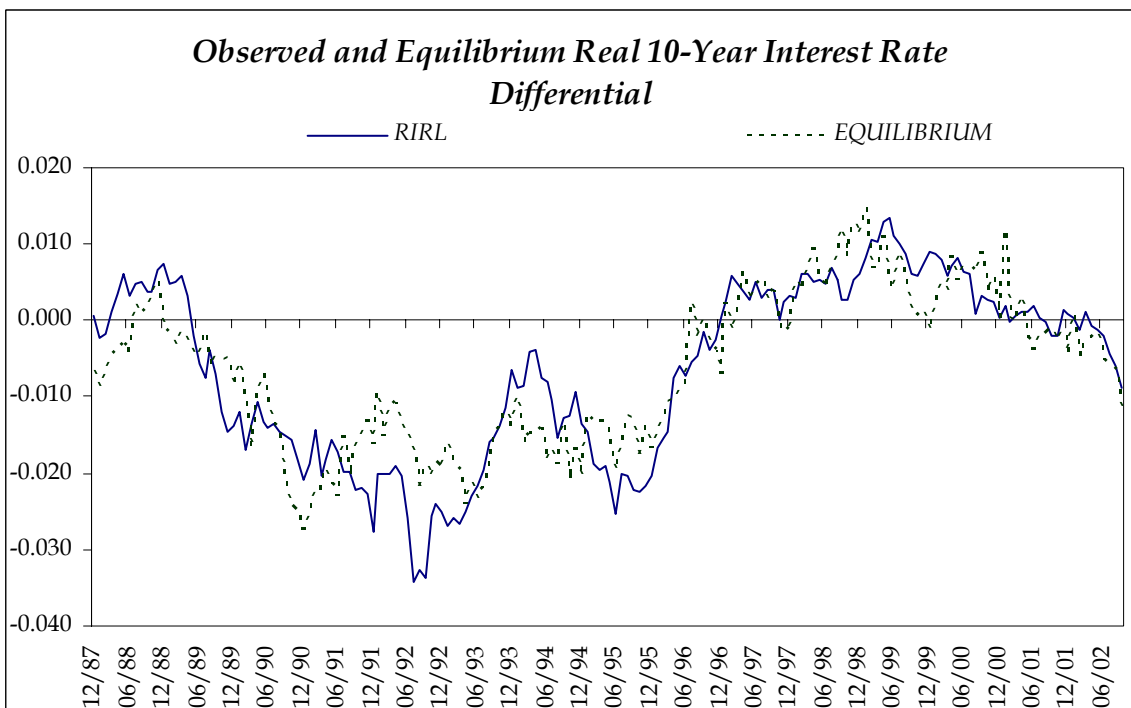


Figure 2

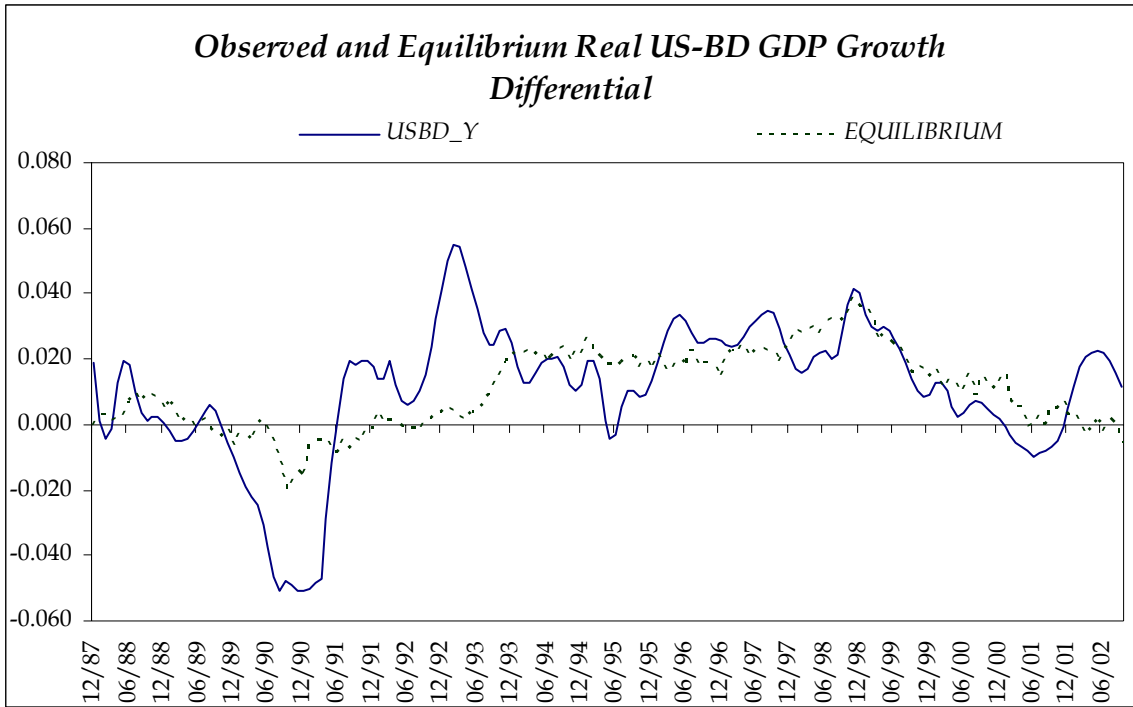


Figure 3

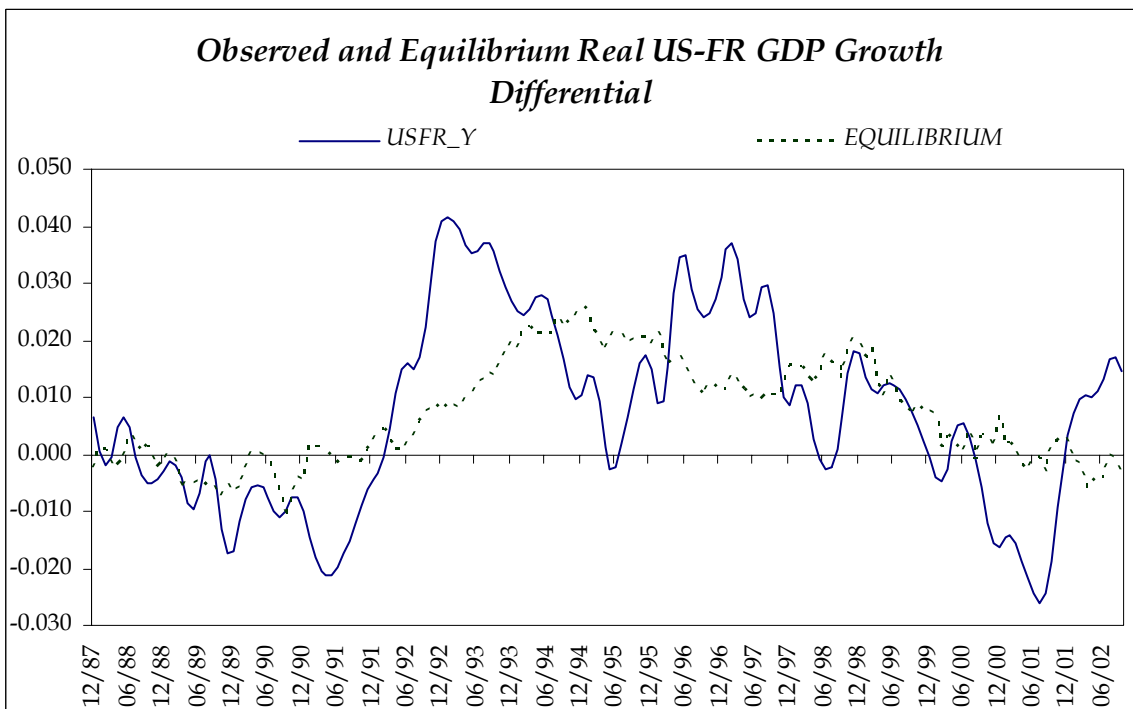


Figure 4

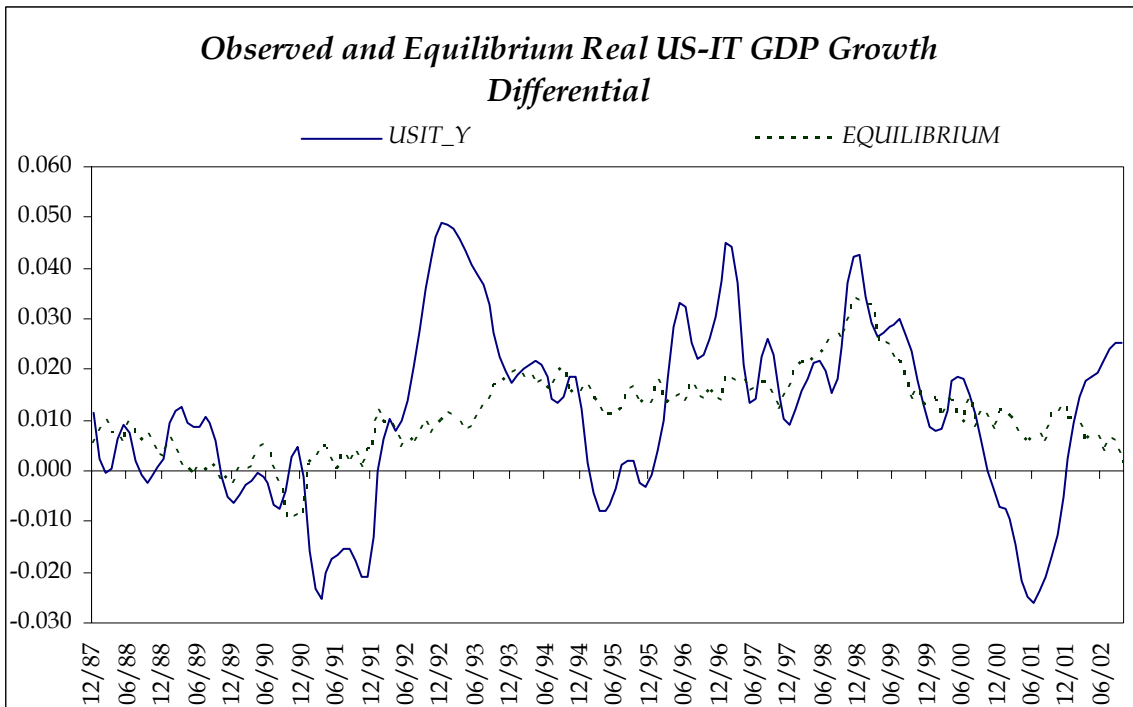


Figure 5

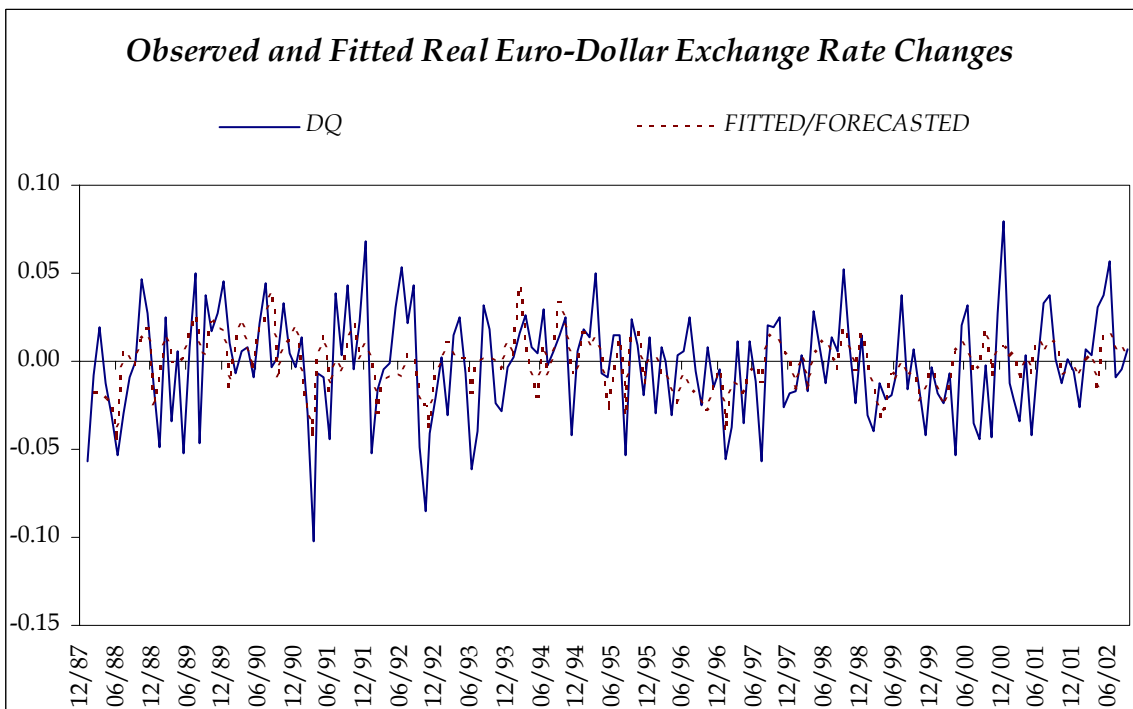


Figure 6

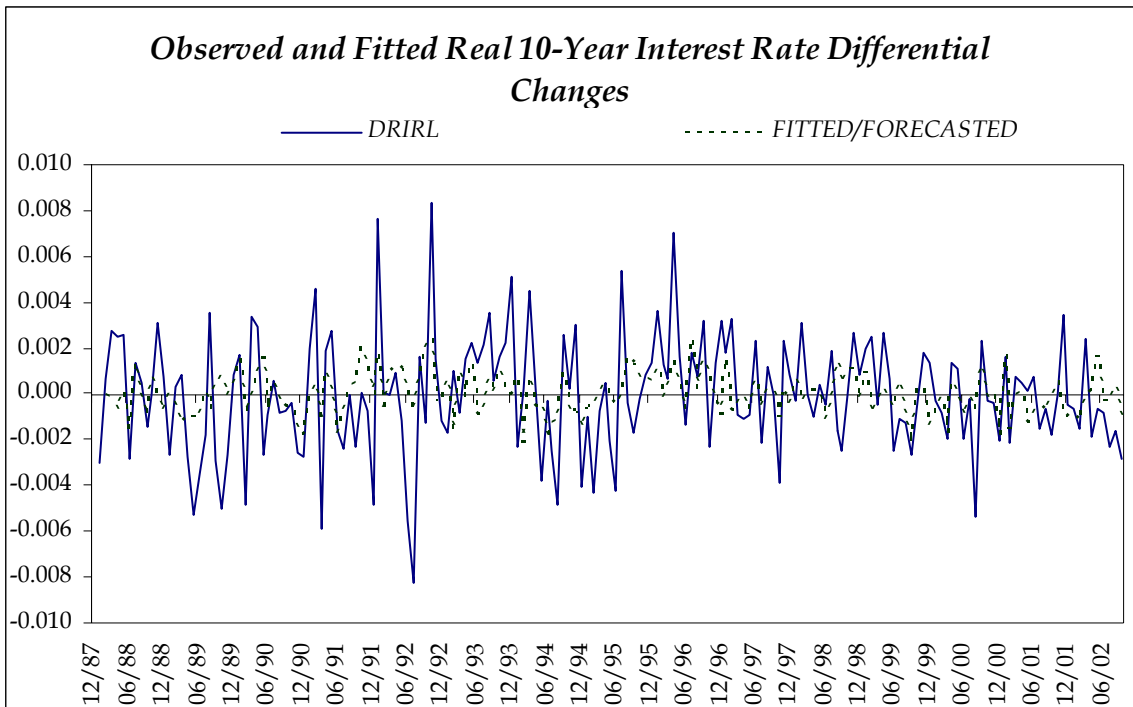


Figure 7

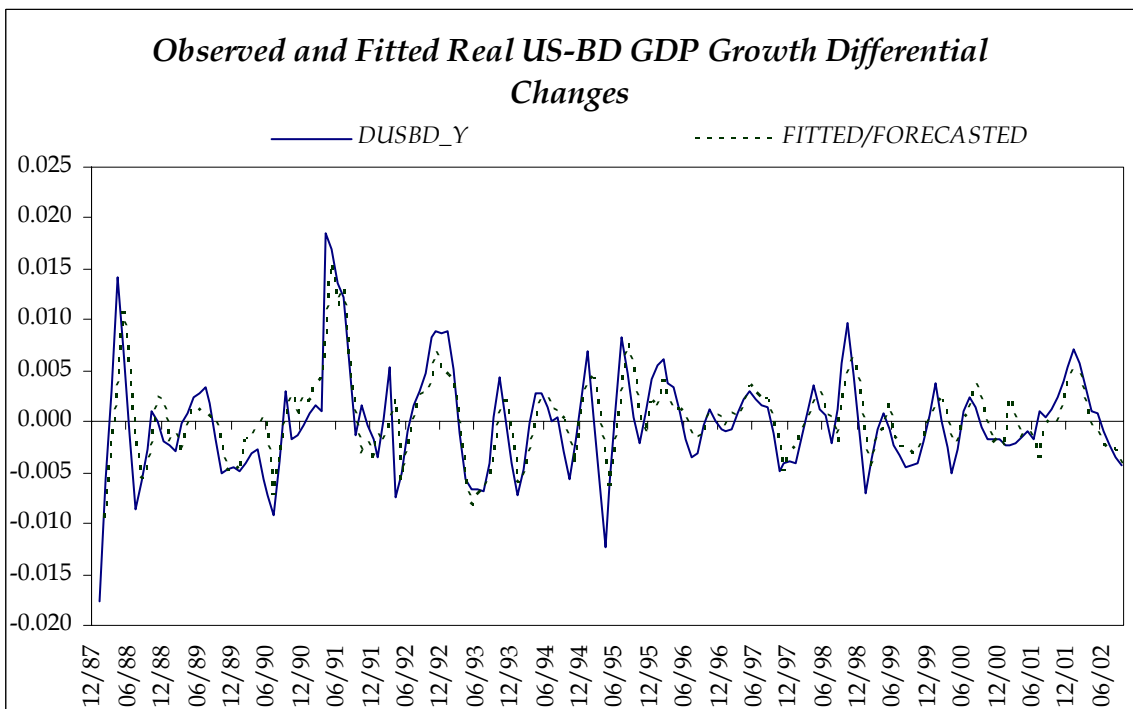


Figure 8

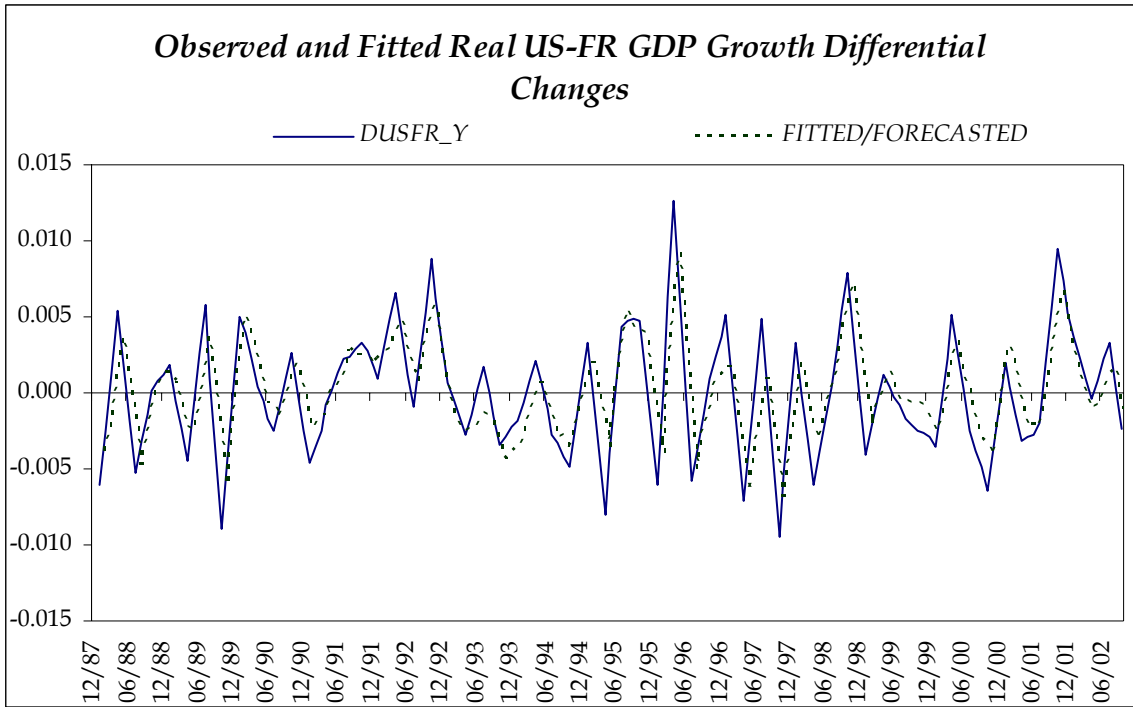


Figure 9

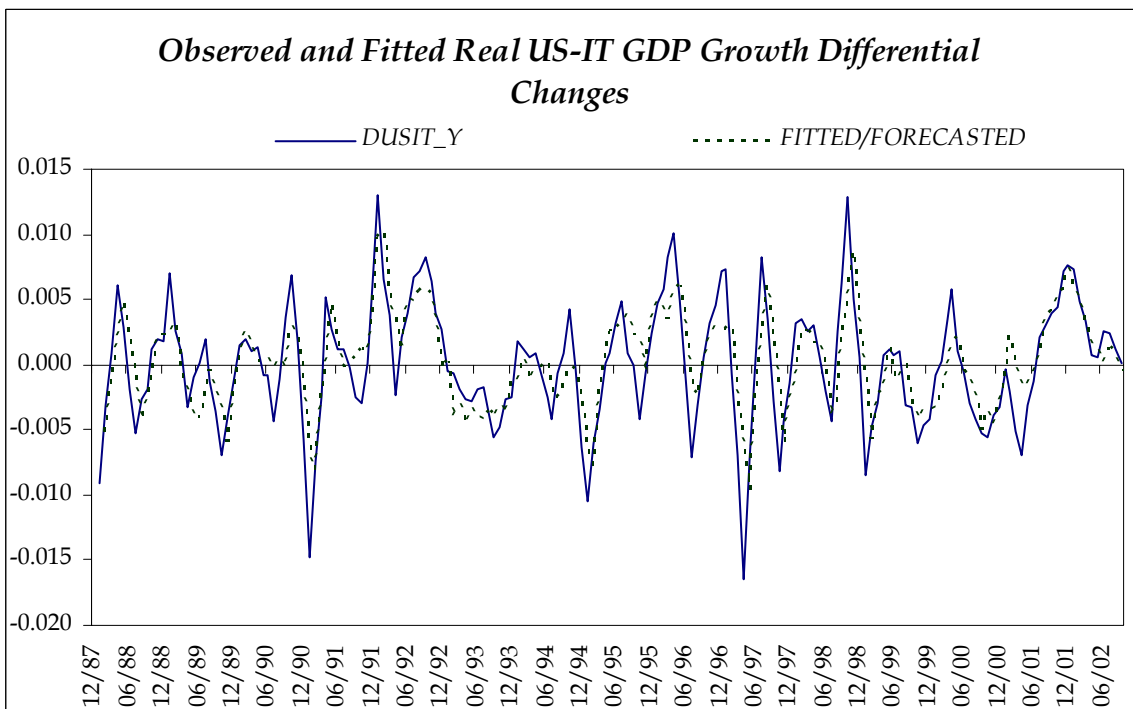


Figure 10

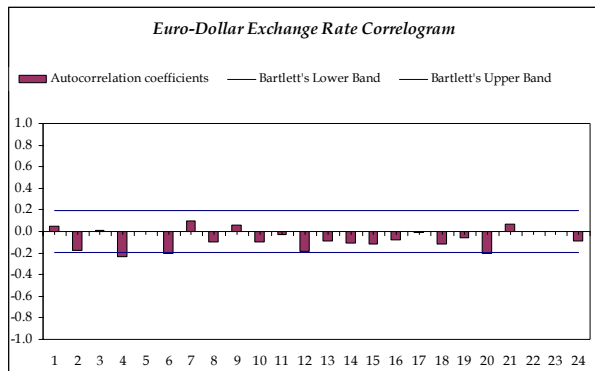


Figure 11

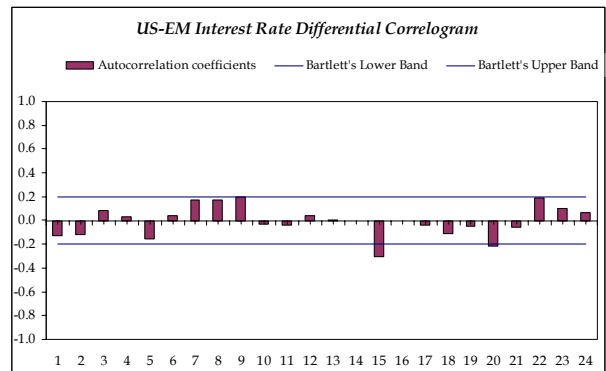


Figure 12

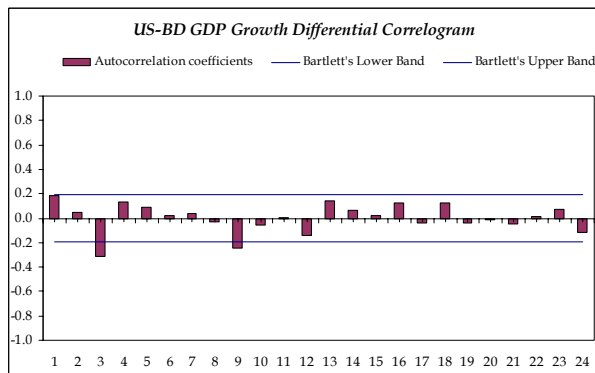


Figure 13

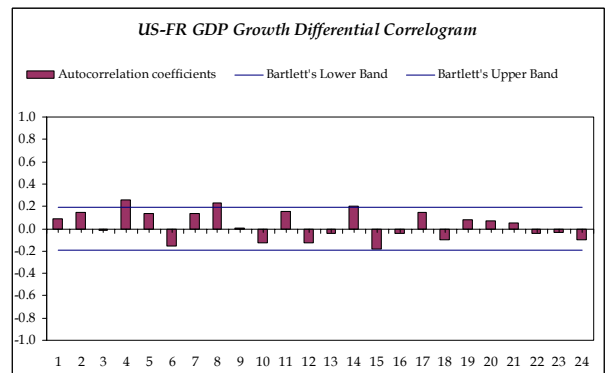


Figure 14

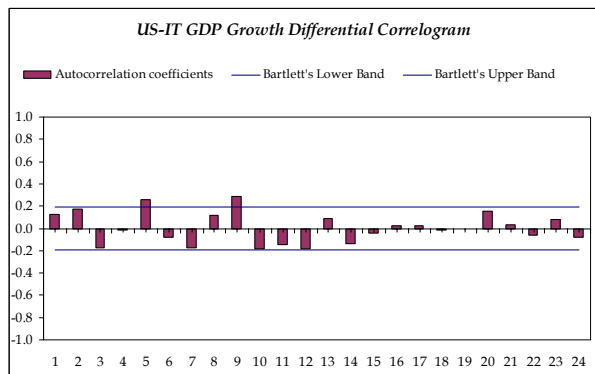


Figure 15

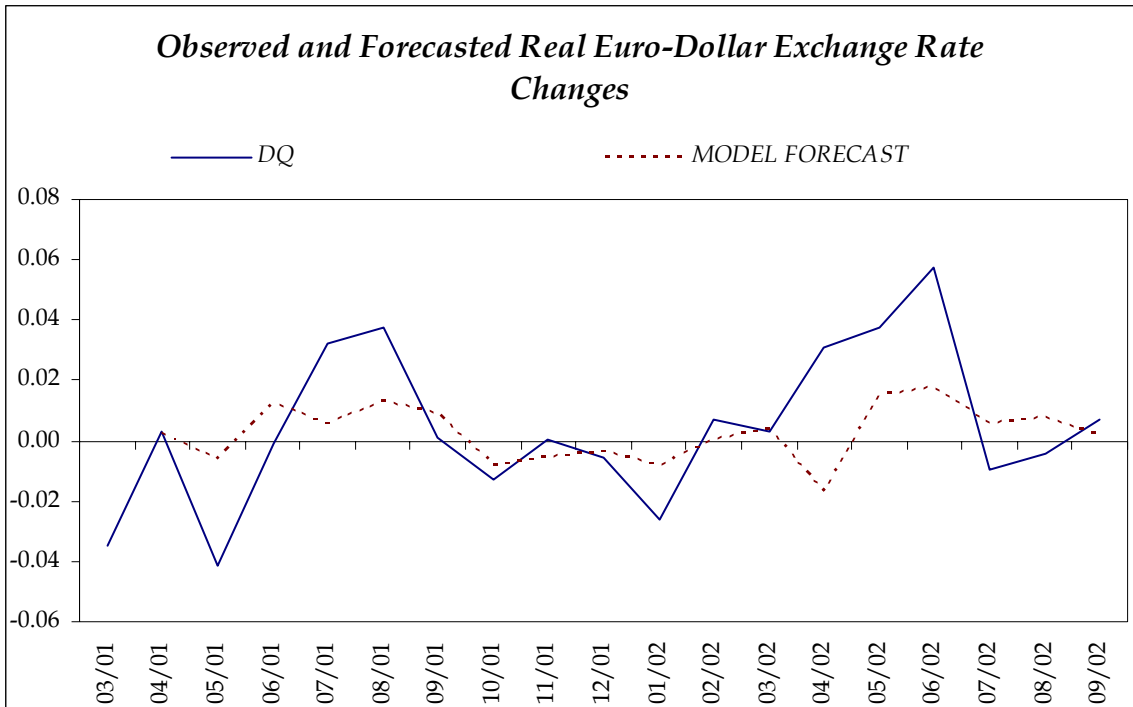


Figure 16

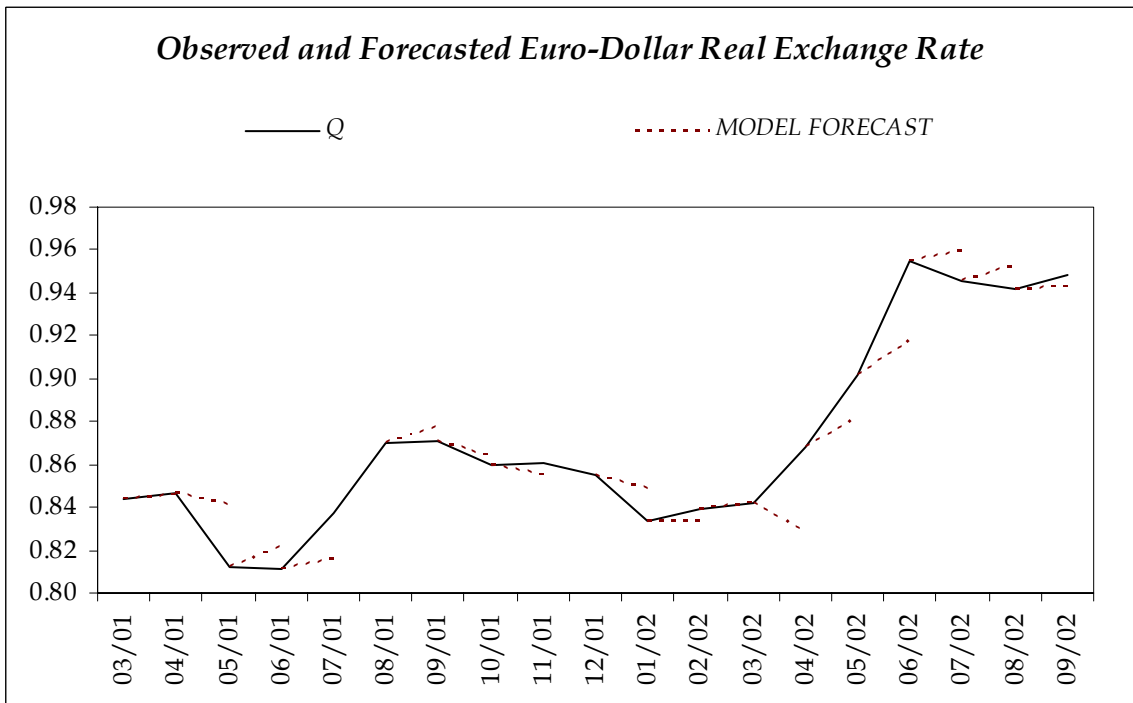


Figure 17

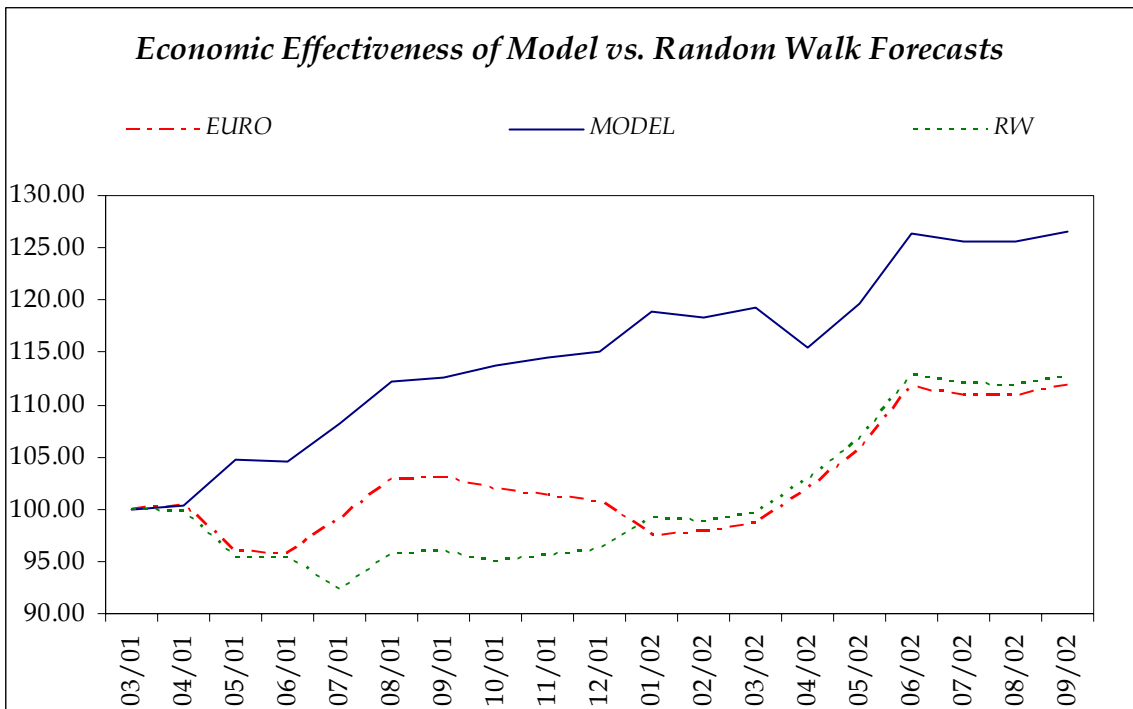


Figure 18

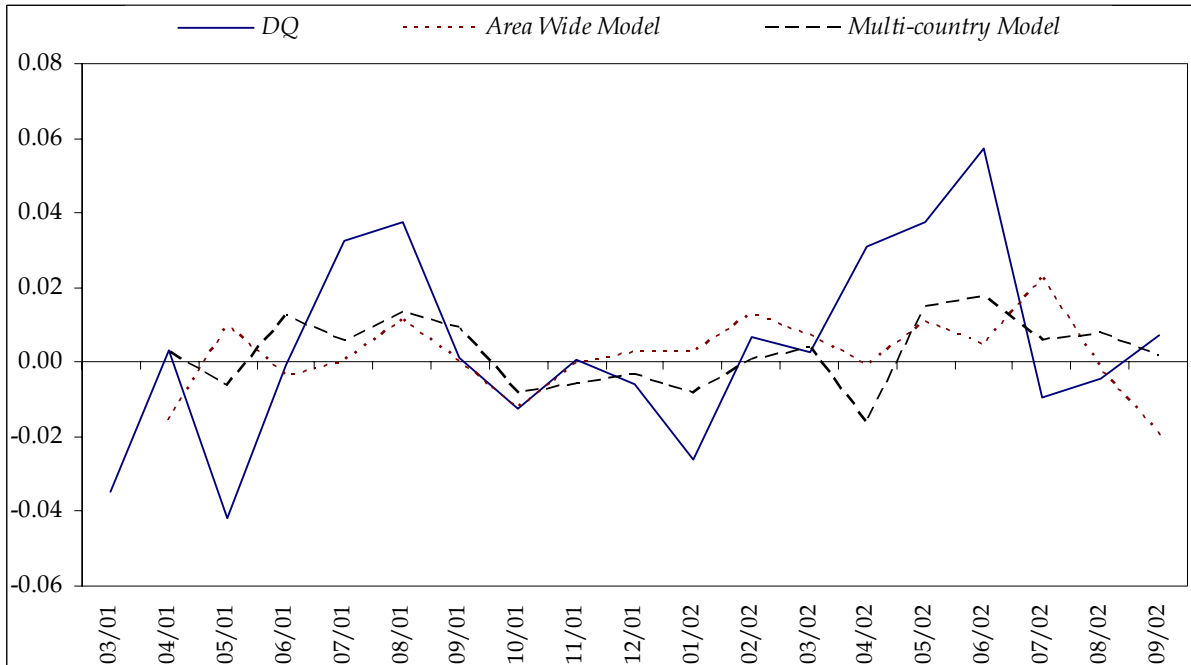


Figure 19

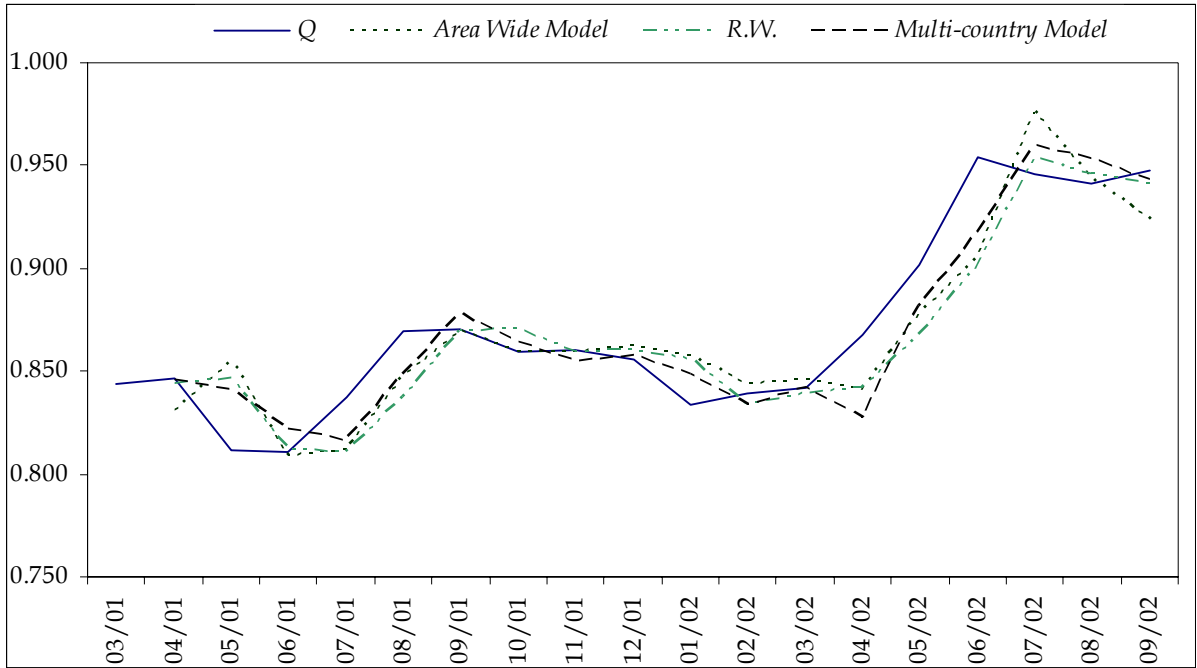


Figure 20

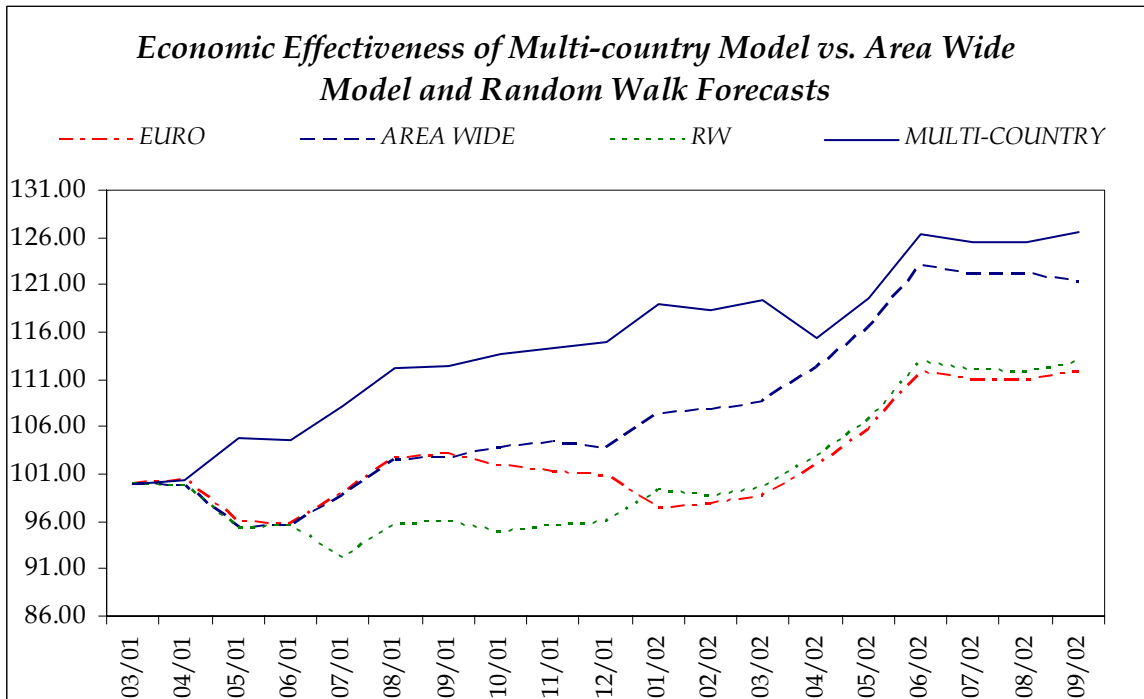


Figure 21