

A SURVEY OF LITERATURE ON THE EQUILIBRIUM REAL EXCHANGE RATE AN APPLICATION TO THE EURO EXCHANGE RATE*

Sónia Costa **

1. INTRODUCTION

The two major purposes of the present article are, first, to describe and compare the approaches for determining the equilibrium real exchange rate mostly used in literature and, second, to present some results to the euro exchange rate. Since the concept of exchange rate equilibrium is not uniformly accepted nor clearly defined in the economic literature, the differences between the several approaches are not always easily understandable and thus the discussion of the methodological issues is important. In addition, the results for the euro exchange rate assume particular relevance since the euro has observed significant fluctuations over recent years and it is important to ascertain whether these movements were caused by changes in euro's fundamental determinants or not.

This article is organised as follows: Section 2 discusses the equilibrium exchange rate concept, highlighting its different horizons in empirical applications. Section 3 presents a description of the different approaches for determining the equilibrium exchange rate, starting with the PPP - Purchasing Power Parity, the simplest and traditional method. Subsequently, it describes several approaches for determining time-varying equilibrium real exchange rates, namely FEER - Fundamental Equilibrium Exchange Rate, BEER - Behav-

ioral Equilibrium Exchange Rate, PEER - Permanent Equilibrium Exchange Rate and NATREX - NATural Rate of Exchange. These are the methods mostly used in empirical applications since the early 1990s. The comparison between these latter approaches is made in Section 4. The first part of Section 5 describes the results of different applications of these approaches to the euro exchange rate. Since the results available in literature do not include the most recent period, the second part of Section 5 presents an application of the BEER/PEER approach to the euro effective exchange rate and to the euro/US dollar exchange rate, covering data up to the end of 2004. Section 6 presents the final conclusions.

2. EQUILIBRIUM EXCHANGE RATE CONCEPT

The usefulness of the calculation of the equilibrium real exchange rate is not unanimously recognised. According to Isard and Faruquee (1998), opinions on this subject may be divided into three groups. The first group considers that exchange rates are always in equilibrium, given that they clear the foreign exchange market and that their level reflects the current and expected macroeconomic situation. A second view recognises that exchange-rate misalignments may exist (persistent deviations of the exchange rate from a medium/long-term equilibrium situation, signalling imbalances in the economy), but acknowledges that, in practice, these deviations cannot be quantified. Finally, the third view, which is shared by those estimating equilibrium exchange rates, con-

* The opinions of this paper are those of the author and not necessarily those of Banco de Portugal.

The author wishes to thank Marta Abreu, Nuno Alves, Isabel Gameiro, José António Ferreira Machado, Maximiano Pinheiro and João Sousa for their comments and suggestions.

** Economic Research Department.

siders that the evaluating the level of exchange rates is useful, even though deviations from the medium/long-term equilibrium may or may not reflect an exchange-rate misalignment. Therefore, detecting exchange-rate misalignments cannot be merely the result of comparing the current values of the exchange rate with long-term equilibrium levels, but should also take into account that the exchange rates may deviate from that equilibrium level, due, for instance, to different cyclical situations in the domestic economy and abroad. Against this background, the following notions of equilibrium exchange rate are often found in the literature⁽¹⁾:

- short-term equilibrium exchange rate - exchange rate compatible with the current economic situation, excluding purely financial shocks;
- medium-term equilibrium exchange rate - exchange rate prevailing when its fundamental determinants are at sustainable medium-term values. Usually, this situation is characterised by the simultaneous existence of internal balance (i.e., a situation in which output is at its potential level and there are no inflationary pressures) and external balance (a situation in which the existing capital movements are sustainable in the sense that they are justified by the adjustment of the capital stock towards its long-term equilibrium level);
- long-term equilibrium exchange rate - exchange rate consistent with a situation of internal balance, in which there are no reasons for changes in capital movements and in which the ratio of net foreign assets to GDP remains constant.

These short and medium-term equilibrium concepts have the problem of reflecting subjective notions. Indeed, the definition of an equilibrium exchange rate as an exchange rate consistent with a situation of full employment of productive factors and the fulfilment of the inter-temporal external

budget constraint, only allows a unique definition to be made for the real exchange rate in a stationary situation, which is consistent with different adjustments for that long-term equilibrium value.

3. DESCRIPTION OF DIFFERENT APPROACHES

3.1. Purchasing Power Parity (PPP)

The traditional and simplest method to determine the equilibrium real exchange rate is based on the PPP theory. The relative PPP considers that the equilibrium real exchange rate is constant over time. Therefore, there is a real exchange-rate misalignment when, compared to a given base period when the global economy is considered to be in general equilibrium, the change in the relative price (or in the relative cost) differs from the change in the nominal exchange rate.

The PPP as a theory of real exchange rate behaviour in the long run has been widely tested. A number of papers can be found in the literature that survey the results (for instance, Froot and Rogoff (1995) and MacDonald (1995)). Since the 1990s, these tests have chiefly covered less demanding interpretations of the PPP, which assume two alternative types. The first one considers that the real exchange rate will likely revert to its mean in the long run, although it may depart from it for a long period (i.e., testing the stationarity of the real exchange rate). The second one only considers that there is a long-run relationship between the nominal exchange rate and prices in both economies (i.e., testing the existence of a cointegration relationship among the nominal exchange rate, domestic prices and external prices). The results obtained reveal, in most cases, a very slow speed of reversion of the exchange rate towards the PPP value⁽²⁾. The PPP theory points therefore, at best, to equilibrium values of the real exchange rate in the very long run, i.e., a longer horizon than that typically relevant for economic policy, and does not explain the existence of protracted deviations from that equilibrium value.

(1) See, for instance, Driver and Westaway (2004).

(2) For instance, according to MacDonald (2000), even the studies that use long time span data sets (with approximately 100 years of data) or panel data for the recent floating period obtain a half-life of approximately 4 years (period of time, following a shock, for the real exchange rate to adjust half the deviation from the constant level corresponding to the PPP).

3.2. Approaches determining time-varying equilibrium real exchange rate

The methods mostly used to determine the equilibrium exchange rates over recent years implicitly consider that even protracted deviations from the PPP may reflect adjustments of the fundamental relationships between economies, and thus are not necessarily associated with exchange-rate misalignments. In general terms, these approaches can be divided into two groups: structural approaches and direct approaches. Structural approaches are explicitly based on a given macroeconomic model, and the equilibrium real exchange rate is obtained as a solution of that model in a situation of internal and external balance. In direct approaches, the equilibrium exchange rate is obtained by estimating an ad-hoc specified equation for the real exchange rate as a function of its fundamental determinants, or by decomposing, with statistical or econometric techniques, the behaviour of the real exchange rate into equilibrium components and deviations from equilibrium. FEER can be included in structural approaches, while BEER and PEER correspond to direct approaches. NATREX is not clearly included in any of such categories, given that, although it is based on a specific macroeconomic model, its empirical applications consist, in most cases, and similarly to BEER, in the estimation of a reduced form equation for the real exchange rate.

3.2.1. Fundamental Equilibrium Exchange Rate (FEER)

The fundamental equilibrium exchange rate (FEER) introduced by Williamson (1983) intends to determine the real exchange rate path that is consistent with the existence of internal and external macroeconomic equilibrium. In this approach, external equilibrium is obtained by imposing a balanced fundamental account, which is defined as the sum of the current account and net inflows of stable capital. Therefore, this approach takes into consideration that when domestic saving is different from domestic investment opportunities evaluated at the global interest rate, countries may observe capital imports or exports over a number of years, and thus maintain lasting current account imbalances.

FEER is usually considered a medium-term approach. In effect, on the one hand, it ignores short-term disturbances and cyclical factors and, on the other hand, it takes into account the existence of capital flows among the different economies. As mentioned in Section 2, the medium-term equilibrium corresponds to a subjective concept, as it is not uniquely defined. Theoretically, the existence of external equilibrium only requires net external debt to be sustainable, so that the economy may be able to comply with its liabilities and does not overaccumulate assets. This is consistent with the different paths for the fundamental account. Therefore, the imposition of a permanently balanced fundamental account reflects a strict notion of external equilibrium, which may be justified by concerns about the behaviour of the current account in the short run. In this sense, FEER is a normative concept.

In most cases, FEER is determined on the basis of a partial equilibrium model, in which an equation is estimated for the current account (or for the trade account). This equation is solved for the real exchange rate that makes the trend current account (i.e., the current account corresponding to a situation in which its other determinants are at their "equilibrium" levels proxied by trend values) equal to its exogenously determined target level (i.e., stable net capital outflows). This approach does not require the existence of stock-flow equilibrium and it does not take into account the interaction between deviations from equilibrium and the equilibrium path itself. As a result, FEER is subject to a hysteresis effect.

The results obtained with the FEER approach reveal high sensitivity to the hypotheses considered - for instance, the trade elasticities and the level of stable capital flows. Therefore, it is only possible to identify with some certainty very significant misalignments. Major differences among the different applications of this methodology are related to the manner in which stable capital flows are determined, given that in most cases a large judgement component is involved. Theoretically, stable capital flows should correspond to capital flows responding to differentials between the yields of long-term domestic and external investments, or reflecting changes in portfolio preferences, that may persist for a number of years before a new portfolio equilibrium is reached. In sev-

eral applications, stable capital flows are determined on an ad-hoc basis, corresponding to the values of the capital account items with more structural characteristics (frequently, direct investment net flows)⁽³⁾.

3.2.2. Behavioural Equilibrium Exchange Rate (BEER)

The BEER approach is based on the estimation of an equation for the real exchange rate, as a function of its fundamental determinants. In this approach, the equilibrium path of the exchange rate corresponds to the fitted values of that equation, using the observed values of the economic fundamentals assumed to have long run effects.

In general, the BEER is estimated using the Johansen's cointegration analysis. The differences between the several empirical applications of this approach consist mainly in the exchange rate determinants considered. These variables are usually selected on an ad-hoc basis, and are motivated by different theories of determining the exchange rate, often including the Balassa-Samuelson productivity hypothesis, the uncovered interest rate parity theory and/or the assets model developed by Frenkel and Mussa (1984). Thus, the real exchange rate is often expected to appreciate in the long run if, all other things being equal, the productivity in the tradable goods sector, when compared to that of the non-tradable goods sector, increases more in the domestic economy than abroad, if net foreign assets increase, if there is a persistent improvement in terms of trade (most often proxied by the real oil price) or if there is a greater permanent improvement of the public finance situation in the domestic economy than abroad. In addition, a widening of the real interest rate differential between domestic and foreign

economies, or an increase in the relative demand for non-tradable goods to tradable goods is deemed to cause a real appreciation of the exchange rate in the short/medium term. This latter effect may be due to the short-term positive impact on demand associated to an increase in public consumption.

3.2.3. Permanent equilibrium exchange rates (PEER)

The BEER determines an exchange rate trajectory that reflects the observed behaviour of its determinants. This does not necessarily mean that it defines sustainable levels for the exchange rate. In this sense, BEER is sometimes referred to as "current equilibrium exchange rate". A number of articles are intended to compute the BEER for a situation in which the exchange rate determinants stand at their sustainable equilibrium levels. In these cases the exchange rate obtained would be referred to as BEER/PEER.

The BEER/PEER has assumed alternative forms in the literature. A simple solution used, for instance, by Faruqee (1994) consists in considering the exchange rate determinants at their long-term values, computed on the basis of filters or estimated trends. The disadvantage of this approach is that, when determining the long-term equilibrium, it disregards the information contained in the estimated cointegration relationship. In order to overcome this limitation, most recent articles resort to the decomposition of Gonzalo and Granger (1995), which breaks down the cointegration relationship into a non-stationary permanent component and a stationary transitory component. In this context, the permanent component of the real exchange rate is deemed to describe its equilibrium path and the transitory component is considered to reflect the deviations from equilibrium.

The PEER denomination has also been used in other than BEER approaches. In a survey of the literature by MacDonald (2000), these applications are grouped in two classes. The first group includes the studies that use the univariate or multivariate Beveridge and Nelson decomposition to decompose real exchange rates into permanent and transitory components. These studies are based on the statistical properties of the real exchange rate, and are often called APPER (Atheoretical Permanent Equilibrium Exchange

(3) The IMF developed a methodology to evaluate deviations of the exchange rates from their equilibrium values. It reflects an extension of FEER, which intends to introduce more rigour in determining stable capital flows (Isard and Faruqee (1998)). In practice, this approach formalizes the methodology to determine stable capital flows followed by Williamson (1991). In effect, it explicitly considers that the current account can be viewed as the difference between domestic saving and investment, and that these, in the medium/long-term, are determined for instance by factors associated with life-cycle and debt-cycle theories. Therefore, in such applications, the target level for current account corresponds to the estimated level of net savings in a medium-term situation.

Rate) due to the absence of any specific economic theory on the behaviour of the exchange rate. The second group includes the studies following the methodology proposed in Clarida and Gali (1994), which is based on the estimation of structural VAR models. This method allows the change in the real exchange rate to be broken down into a number of components associated with different types of shocks. In these studies, the real exchange rate component that is determined by supply shocks is sometimes interpreted as its permanent component.

3.2.4. NATural Rate of EXchange (NATREX)

The NATREX approach determines the medium-term equilibrium exchange rate and its adjustment towards long-term equilibrium, based on modelling the stock-flow interaction in dynamic growth models for open economies, whose specifications vary according to the characteristics of the economies in question (Stein et al (1995)). Similarly to FEER, the theoretical framework of NATREX is based on the medium-term macroeconomic equilibrium defined as a situation in which the current account is equal to the sustainable capital flows determined by net savings in a context of internal equilibrium. The models incorporate structural equations for the current account, savings and investment. The major factor behind savings is the rate of time preference, whereas the major factor behind investment is Tobin's q ratio, which is determined by productivity. These models are more general than the macroeconomic equilibrium models used in FEER. On the one hand, the flows are explained by the capital stock and net foreign assets (i.e., investment depends on the capital stock while saving depends on wealth stock, defined as the sum of net foreign assets and capital stock). On the other hand, the flows determine the endogenous movements of the stocks in the transition to the long run (the current account corresponds to the rate of change of net foreign assets, whereas investment corresponds to the change in the capital stock). Similarly to the models frequently used to motivate the selection of exchange-rate determinants in BEER studies, the flow-stock interaction ensures the consistency of the medium-term equilibrium with a notion of long-term equilibrium in which net external debt

is stable and the capital stock has converged to the stationary level. Thus the theoretical framework of NATREX approach overcomes one of the limitations of FEER.

According to NATREX, the real exchange rate is determined in the long run by the rate of time preference and by productivity in the domestic economy and abroad and in the case of small economies, also by terms of trade and by the real interest rate. In the medium-term, in addition to these variables, the exchange rate also depends on the capital stock and on net foreign assets, variables that are endogenous in the long run. According to the NATREX models, a rise in the time preference rate (i.e., a decline in savings) determines an appreciation of the real exchange rate in the medium term and its depreciation in the long term, whereas an increase in productivity (i.e., a rise in investment) induces an appreciation in the medium term and has an ambiguous effect in the long run.

There are some attempts to estimate the structural model underlying NATREX. However in most empirical applications, only a reduced form is estimated for the real exchange rate with cointegration techniques. This makes the NATREX approach similar to the approaches previously defined as direct methods.

4. COMPARISON OF THE DIFFERENT APPROACHES

As mentioned in Section 3, the BEER is often referred to as a short-term or current equilibrium exchange rate, FEER as a medium-term equilibrium rate, PEER as a medium/long-term equilibrium rate and NATREX as a methodology that, being centred on the transition from medium to long term, makes it possible to determine both types of equilibrium rates. In effect, the classification of the different approaches according to the time horizon is not simple. For instance, the fact that when determining FEER only sustainable capital flows are included means that this approach implicitly has a notion of long-term equilibrium, in which some capital inflows or outflows will never be reversed. In addition, the equilibrium notions implied in different approaches for the same horizon are not always equivalent. In the theoretical models motivating BEER, BEER/PEER and NATREX, the real

exchange rate adjusts so that the current account is voluntarily financed by wealth holders. Reflecting this, empirical applications of these approaches estimate a cointegration relationship between the real exchange rate and its determinants, instead of imposing “equilibrium values” for the current account, as happens in FEER. The estimates obtained reflect exchange rate values that are justified by the behaviour of the fundamental variables identified as relevant in economic models, but that do not necessarily represent the behaviour of the exchange rate in a situation of medium/long-term macroeconomic equilibrium. This situation is all the more apparent in BEER applications, where the observed values of the variables are used. However, even the transformation of variables into moving-averages in NATREX and the use of the permanent component of the estimated exchange rate in BEER/PEER do not unquestionably ensure the existence of external equilibrium, perceived as the sustainability of the rate of accumulation of net foreign assets. The medium-term equilibrium rates determined in BEER/PEER and in NATREX are therefore not directly comparable to FEER exchange rates. This is even more apparent if we consider atheoretical PEER, or PEER obtained from structural VAR models.

In addition to differing in terms of equilibrium concepts, the different approaches can also be distinguished by the type of variables used. These differences, however, do not reflect conflicting views on the theory of determining the exchange-rate, but are chiefly the result of differences at the level of complexity of the models underlying each approach. In simple terms, FEER, BEER and NATREX can be considered to have the same type of formalisation for the external equilibrium, which is more simplified in FEER than in BEER and in BEER than in NATREX. In effect, whereas in FEER the equilibrium exchange rate is the exchange rate which makes the underlying current account equal to an exogenously determined sustainable value, in BEER and NATREX that value is determined by the behaviour of different variables, such as the stock of net foreign assets, which is considered exogenous in BEER and endogenous in the long run in NATREX. In turn, internal equilibrium is defined in a more simple way in FEER and NATREX than in BEER. Indeed, in BEER, a distinction is usually made between

tradable and nontradable goods. In this case the internal equilibrium is defined as the equilibrium in the nontradable goods market, which depends on factors that affect the relative supply and demand of both types of goods. In FEER and in most cases in NATREX, no distinction is made among the different types of domestically produced goods, and therefore factors such as the Balassa-Samuelson effect are not explicitly taken into account.

5. EMPIRICAL APPLICATIONS TO THE EURO EXCHANGE RATE

5.1. Some recent results

Table 1 presents a summary of the results obtained in different studies for the euro equilibrium exchange rate, grouped by type of approach. Most of these studies refer to the euro effective exchange rate, but some of them estimate equilibrium rates for the euro/US dollar and the euro/yen exchange rates.

Some of these studies estimate trends for the euro equilibrium exchange rate that are very similar to the observed exchange rate, suggesting that they may reflect a notion of current equilibrium rather than a notion of medium/long-term equilibrium. As one might expect, this behaviour is most frequently found in the results obtained with BEER and BEER/PEER, approaches in which the variables used in determining the equilibrium are selected according to their power to explain the exchange rate.

Reflecting the dominant weight of the United States in the euro area external relationships, the results obtained are similar in the cases of the euro effective exchange rate and of the euro/US dollar exchange rate. Some results point to an equilibrium appreciation of the euro effective exchange rate in the second half of the 1980s. There are no clear indications about the direction of the equilibrium trajectory for the other periods, because even in applications using the same approaches and identical explanatory variables, the results obtained are mixed. Nevertheless, in the latter years of the 1990s and in 2000, most results point to the stability of the equilibrium exchange rate, or at the best to its appreciation, while the euro actually depreciated in that period.

In terms of the deviations from the equilibrium, most results suggest that the euro was increasingly underappreciated from the early 1980s to mid-1980s and was somewhat overappreciated, albeit less markedly, in some sub-periods from the end of the 1980s to the early second half of the 1990s. These situations coincide with the strengthening of the dollar before the 1985 Plaza agreement and with its subsequent depreciation. As regards the most recent period, evidence suggests that the euro was underappreciated in 1999, and that such underappreciation became more marked in 2000, apparently assuming a higher magnitude in the euro/US dollar exchange rate than in effective terms. As presented in Table 1 the available studies point to a very wide range for the degree of euro underappreciation in this period, which shows the high uncertainty associated with the calculation of the equilibrium exchange rate, even when similar approaches are used. This uncertainty would be even more apparent if the confidence intervals of the results were considered. In general terms, as stressed in Detken et al (2002), larger deviations from equilibrium seem to be found in approaches in which higher economic structure is imposed in estimation (approaches that might be interpreted as determining the equilibrium for a longer horizon) than in approaches that estimate reduced forms for the exchange rate. At the end of 2000, the euro effective exchange rate deviations from equilibrium were higher than 20 per cent in FEER and NATREX studies⁽⁴⁾ and stood at approximately 10 per cent, on average, in BEER, BEER/PEER and PEER. The fact that the underappreciation of the euro tends to be smaller in the results for a shorter-term equilibrium concept is consistent with the possibility that the euro was experiencing a more unfavourable cyclical position in this period (assessed by the deviations of output from the potential level) than its major trading partners.

According to the BEER and BEER/PEER approaches the main factors behind the behaviour of the real euro exchange rate⁽⁵⁾ are relative produc-

tivity⁽⁶⁾, long-term real interest rate differential, real oil price, and, chiefly in the case of the euro/US dollar exchange rate, also relative public consumption. Net foreign assets are frequently excluded from estimation⁽⁷⁾. As expected, an increase in relative productivity, in the interest-rate differential favourable to the euro area or in net foreign assets determine an appreciation of the euro exchange rate. In turn, an increase in real oil price or in relative public consumption contributes to its depreciation. This seems to reflect, in the former case, the higher dependence of the euro area economy on oil imports, when compared to the economies of its major trading partners and, in the latter case, the predominance of the negative effect expected in the long run over the short run positive effect determined by the increase in demand.

5.2. Estimation of BEER/PEER for the euro exchange rate using recent data

For the purpose of obtaining estimates for the euro equilibrium exchange rate in the most recent period, the BEER/PEER methodology was applied to the real euro effective exchange rate and to the real euro/US dollar exchange rate. The BEER/PEER was selected for reasons of its simplicity and because it is a methodology widely used in the literature and is therefore a natural way of extending the existing results. The sample consists of quarterly data for the 1981-2004 period, in the case of the effective exchange rate, and for the 1980-2004 period, in the case of the euro/US dollar exchange rate. The explanatory variables were: the ratio of net foreign assets to GDP, productivity (proxied by the average labour productivity or by

(4) The NATREX computed in Detken et al (2002) results from the estimation of a small structural model, which contrasts with most applications of NATREX that consist in the estimation of a reduced form equation.

(5) In the other approaches, the factors explaining the real exchange rate are defined a priori.

(6) In most cases, an indirect measure of productivity in the tradable goods sector, vis-à-vis the nontradable goods sector was included. This measure consists of the internal relative price (nontradables vis-à-vis tradables), and, in general, corresponds to the ratio of consumer prices to wholesale prices. In some studies, as an alternative it was included labour productivity, which is computed as the ratio of GDP to employment.

(7) As highlighted in several of these studies, this result may be influenced by the fact that net foreign assets are measured by accumulated current account positions, which disregards the effects from debt reduction and debt forgiveness, reinvested earnings, valuation issues and, in the case of the euro area, it may reflect not only net assets against countries outside the region.

Table 1

SUMMARY OF SOME EMPIRICAL APPLICATIONS FOR THE CALCULATION OF THE EQUILIBRIUM EURO EXCHANGE RATE

| Study | Estimated exchange rate ^(a) | Sample period used in the estimation | Determinants of the equilibrium rate(b)(c) | Other tested variables ^(b) | Deviation of the euro from the equilibrium (reference period) ^(d) |
|--|--|--------------------------------------|---|---|--|
| FEER | | | | | |
| Wren-Lewis and Driver (1998) ^(e) | EUR/USD | - | Trend current account and target level for the current account; elasticity of imports and exports to the exchange rate | - | 0-22% (1995); -20 to -34% (2000) |
| Detken <i>et al</i> (2002) | REER | - | Simulation of a macroeconomic model for the euro area steady-state solution consistent with a balanced trade account | - | -24% th (4 th Q 2000) |
| BEER | | | | | |
| Clostermann and Schnatz (2000) ^(e) | EUR/USD | 1975-98 (Quart.) | LT: int; pet; g-g* ST: rlp-rlp* | f | LT: -7% (3 rd Q 1999) ST: -13% (3 rd Q 1999) |
| Koen <i>et al</i> (2001) | REER | 1981-99 (Sem.) | LT: dep-dep*; pet ST: rlp-rlp*; ypc-ypc*; int; pet | f; g-g*; pexp/pimp | LT: -9% (2 nd Sem. 2000) ST: -5% (2 nd Sem. 2000) |
| Maeso-Fernandez <i>et al</i> (2001) | EUR/USD | 1976-99 (Sem.) | LT: g-g*; pet ST: rlp-rlp*; g-g*; pet | f; pexp/pimp; int; dep-dep*; ypc-ypc* | LT: -15% (2 nd Sem. 2000) ST: slightly more underappreciated than in the LT (2 nd sem. 2000) |
| Maeso-Fernandez <i>et al</i> (2001) | REER | 1975-00 (Quart.) | 4 specifications for LT | rcp-r*cp; pref temp; f | LT: Underappreciated in 2000 -5% to -20% (4 th Q 2000) |
| Detken <i>et al</i> (2002) | REER | 1973-00 (Quart.) | (1) yemp-yemp*; pet; (2) yemp-yemp*; rlp-rlp* (3) int; pet; g-g*; (4) int; rlp-rlp*; g-g* | rcp-r*cp; pref temp; f | LT: Underappreciated in 1999-2000 (-10% (4 th Q 2000)) |
| Osbat <i>et al</i> (2003) | EUR/JPY | 1975-01 (Quart.) | LT: int; rlp-rlp* LT: pet; f*; g-g*; yemp-yemp* | yemp-yemp*; wr-wr*; ca-ca*; f*; s-s* rlp-rlp*; int | LT: underappreciated (1999-00); close to balance (4 th Q 2001) |
| BEER/PEER (Gonzalo and Granger decomposition) | | | | | |
| Alberola <i>et al</i> (1999) | REER | 1980-98 (Quart.) | LT: int; f | - | LT: REER: from -3.8% to 5.1% (4 th Q 1998) |
| Hansen and Roeger (2000) | EUR/USD EUR/JPY | 1980-99 (Quart.) | LT: int; f | - | LT: EUR/USD: -7.5% (4 th Q 1998) LT: EUR/JPY: 6.2% (4 th Q 1998) |
| Maeso-Fernandez <i>et al</i> (2001) | REER | 1975-00 (Quart.) | 4 specifications for LT (1) yemp-yemp*; pet; (2) yemp-yemp*; rlp-rlp* (3) int; pet; g-g*; (4) int; rlp-rlp*; g-g* | rcp-r*cp; pref temp; f | LT: Underappreciated in 2000 -2% a -10% (4 th Q 2000) |
| PEER (structural VAR) | | | | | |
| Detken <i>et al</i> (2002) | REER | 1970-00 (Quart.) | Labour supply, productivity and public consumption shocks | - | -5 a -12% (4 th Q 2000) |
| NATREX | | | | | |
| Detken <i>et al</i> (2002) | REER | 1970-00 (Quart.) | Different variables determining consumption, investment and trade account | - | LT: -2.3% (4 th Q 1998); -27.7% (4 th Q 2000) MT: -0.7% (4 th Q 1998); -25.4% (4 th Q 2000) |
| Stein (2001) | EUR/USD | 1971-00:1 (Quart) | LT: yemp-yemp*; pref. temp. MT: LT determinants + error correction term | - | LT: underappreciation since 1997; MT: underappreciation since early 1999 (-10% (1 st Q 2000)) |

Notes:

- (a) The exchange rates differ in the various works. Excluding Wren-Lewis and Driver (1998), the exchange rates used in the estimations result from the aggregation of the currencies of the countries that joined the euro. In Wren-Lewis and Driver (1998), the equilibrium EUR/USD exchange rate results from an aggregation of the equilibrium DEM/USD, FRF/USD and JTL/USD exchange rates, based on the weights of these currencies in the ECU in 1995. In the calculation of the REER index, in Maeso-Fernandez *et al* (2001), Alberola *et al* (1999) and Hansen and Roeger (2000), Koen *et al* (2001) and Detken *et al* (2002) 12, 11, 6 and 4 trading partners were considered, respectively. Nominal rates were deflated on the basis of consumer price indices, excluding Detken *et al* (2002) and Hansen and Roeger (2000), where the GDP deflators were used.
- (b) The acronyms are described in table 2, where x-x* is the differential between x in the domestic economy and x abroad.
- (c) The acronyms LT and ST in the BEER and BEER/PEER applications mean that the variables were included in the cointegration relationship or in the short-term dynamics, respectively, and that the estimated rates were calculated using the cointegration relationship or of the dynamic equation, respectively, and do not necessarily correspond to the equilibrium estimates identified in these studies for such horizons. The acronyms LT and MT in the NATREX applications mean the estimates identified in the studies in question with long and medium-term, respectively.
- (d) A positive (negative) value corresponds to an overappreciation (underappreciation) of the euro.
- (e) Deviations from equilibrium were calculated on the basis of the euro/dollar equilibrium rates presented in these studies.

Table 2

**DESCRIPTION OF THE EXPLICATIVE VARIABLES AND THEIR EFFECTS ON THE REAL
EURO EXCHANGE RATE**

| Explicative variables | Estimated effects on the euro exchange rate ^(a) |
|---|--|
| tnt: Domestic relative price (nontradable goods vis-à-vis tradable goods) in the domestic economy vis-à-vis abroad. | + |
| yemp: Output per worker | + |
| ypc: Output per capita | + |
| wr: Real wage | + |
| f: Net foreign assets as a % of GDP | + |
| dep: Dependency ratio (non-working age population/working age population) (savings negative determinant) | - |
| pref. temp: Rate of time preference (total consumption/GDP) | - |
| s: Savings rate | + |
| ca: Current account as a % of GDP | + |
| g: Ratio of public expenditure to GDP | - except in Osbat et al (2003) |
| rlp: Real long-term interest rate | + |
| rcp: Real short-term interest rate | + |
| pexp/pimp: Ratio of export prices to import prices | + |
| pet: Real price of oil | - in the case of the REER index and EUR/USD; + in the case of EUR/JPY |

Note:

(a) + (-) corresponds to an appreciation (depreciation) of the euro.

the ratio of prices in the non-tradable goods sector to prices in the tradable goods sector), the ratio of public consumption to GDP, the long-term real interest rate and the real oil price. All variables, except the real oil price and, in the case of the estimation of the effective exchange rate, net foreign assets, were defined in relative terms in comparison with abroad⁽⁸⁾.

Both the graphical behaviour of the variables and the unit root tests suggest that the series are integrated of order 1. Therefore the estimation was based on cointegration techniques using Johansen methodology. BEER/PEER corresponds to the permanent component of the estimated exchange rate, which was computed using the estimated coefficients and the decomposition of Gonzalo and Granger (1995)⁽⁹⁾.

(8) See the Annex for a description of the method of construction of variables.

(9) Alternative specifications of the vectorial autoregressive (VAR) model were estimated including different sets of explanatory variables. The VAR order was selected, so that the models would not show autocorrelation in residuals. Autocorrelation was tested with the Lagrange multiplier test for autocorrelation of order four. The existence of cointegration was tested with the maximum eigenvalue test and with the Johansen trace statistics adjusted for a small sample size. After determining the number of cointegration vectors, both the exclusion of the variables from the cointegration relationship and its weak exogeneity were tested.

In the case of the euro real effective exchange rate, the best specification obtained suggests that in the long run the appreciation of the euro is determined by an increase in the ratio of the euro area net foreign assets to GDP⁽¹⁰⁾, by an increase in productivity (measured as the ratio of prices in the nontradable goods sector to prices in the tradable goods sector) in the euro area vis-à-vis abroad and by a rise in the ratio of public consumption to GDP in the euro area vis-à-vis abroad (Table 3). The signs of the estimated effects on the real exchange rate are in line with those theoretically expected and described in Section 3.2.2., in the case of net foreign assets and productivity. In the case of public consumption the signal of the estimated coefficient suggests that, in the sample period, the positive short/medium-term effect dominates the negative long-term effect. According to the coefficient of the error-correction term in the exchange-rate equation, after a shock, the deviation of the exchange rate from its long-term value determined by the cointegration relationship will take one year to be reduced by one half. This adjustment speed, which is in line with the estimates

(10) The inclusion of net foreign assets in the long-run cointegration relationship is unusual in literature and this might be justified by the way this variable was measured. Here the series used was built using annual values of net foreign assets, instead of the proxy more commonly used which is computed as the accumulation of current account balances.

Table 3

RESULTS OF THE ESTIMATION OF THE VECM MODEL FOR THE REAL EFFECTIVE EXCHANGE RATE

(t-ratios in brackets)

| | Long-term coefficients | | Adjustment terms | |
|--|--------------------------------------|-----------------|------------------------------|-----------------|
| | reer ^(a) | 1 | | -0.18 |
| | | - | (-3.28) | |
| f | -2.86 | | - | |
| | (-6.00) | | | |
| tnt | -0.11 | | - | |
| | (-2.25) | | | |
| g-g* | -1.24 | | 0.11 | |
| | (-3.34) | | (4.70) | |
| rlp-rlp* | - | | -3.42 | |
| | | | (-3.35) | |
| Half-life | | | -4.14 | |
| Number of lags in VAR | | | 4.00 | |
| Restriction tests (p-value) ^(b) | | | 0.49 | |
| AR (1-4) (p-value) | | | 0.52 | |
| | Cointegration tests (p-value) | | | |
| | Without small-sample correction | | With small-sample adjustment | |
| | Trace | Max. eigenvalue | Trace | Max. eigenvalue |
| 0 | 0** | 0.001** | 0.017* | 0.038* |
| 1 | 0.018* | 0.135 | 0.211 | 0.451 |
| 2 | 0.083 | 0.155 | 0.326 | 0.412 |

Notes:

(a) An increase (decrease) corresponds to an appreciation (depreciation) of the euro.

(b) Null hypothesis that the rlp-rlp* does not belong to the cointegration relationship and that f and tnt are weakly exogenous.

Table 4

RESULTS OF THE ESTIMATION OF THE VECM MODEL FOR THE EURO/US DOLLAR REAL EXCHANGE RATE

(t-ratios in brackets)

| | Long-term coefficients | | Adjustment terms | |
|---|--------------------------------------|-----------------|------------------------------|-----------------|
| | EUR/USD real ^(a) | 1.00 | | -0.16 |
| | | | (-3.52) | |
| f-f* | -1.45 | | - | |
| | (-5.82) | | | |
| yemp-yemp* | -5.28 | | 0.03 | |
| | (-5.49) | | (3.95) | |
| Half-life | | | -4.57 | |
| Number of lags in VAR | | | 5.00 | |
| Restriction tests (p-values) ^(b) | | | 0.90 | |
| AR (1-4) (p-value) | | | 0.75 | |
| | Cointegration tests (p-value) | | | |
| | Without small-sample correction | | With small-sample adjustment | |
| | Trace | Max. eigenvalue | Trace | Max. eigenvalue |
| 0 | 0.010** | 0.001** | 0.053 | 0.006** |
| 1 | 0.936 | 0.921 | 0.964 | 0.954 |
| 2 | 0.642 | 0.642 | 0.670 | 0.670 |

Notes:

(a) An increase (decrease) corresponds to an appreciation (depreciation) of the euro.

(b) Null hypothesis that the f-f* is weakly exogenous.

Chart 1
REER OF THE EUR AND BEER/PEER

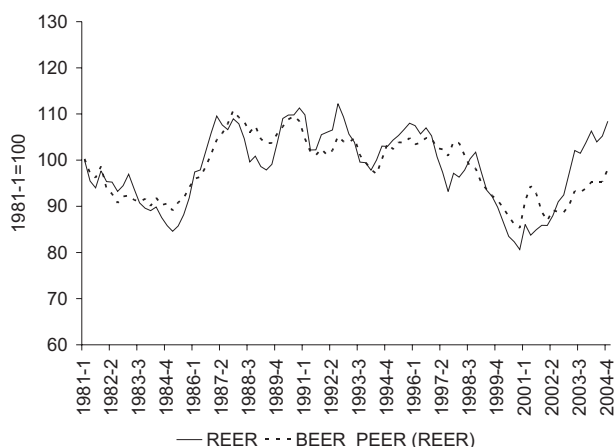


Chart 2
REAL EUR/USD AND BEER/PEER

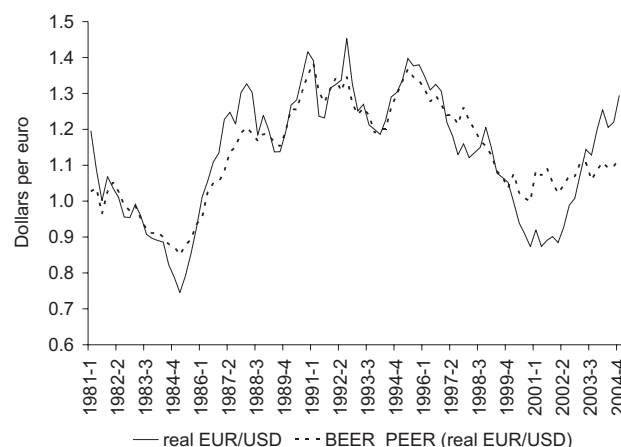
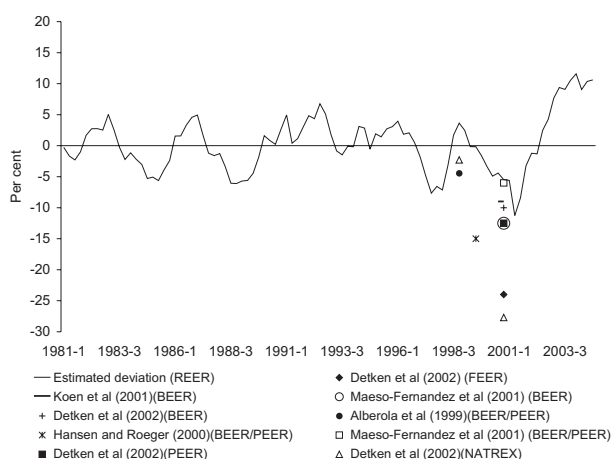
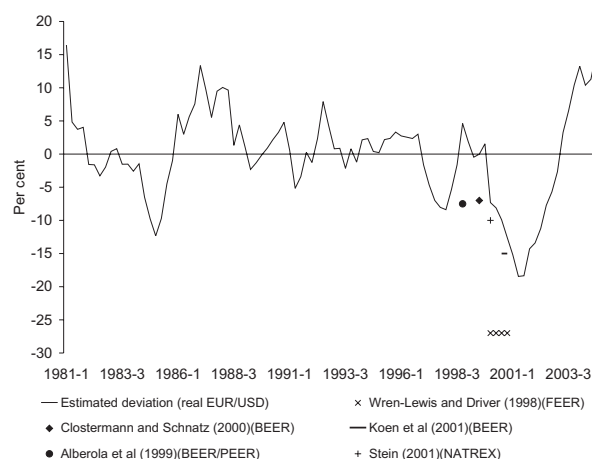


Chart 3
ESTIMATES FOR THE EUR REER DEVIATIONS FROM EQUILIBRIUM^(a)



Nota: (a) The values shown correspond to a simplified version of the results presented in table 1. In the cases in which there are equilibrium estimates for different time horizons, only those referring to the longer horizon are considered (ex: LT instead of ST) and in the cases in which the same study presents different estimates for the same time horizon the mean of such results is considered.

Chart 4
ESTIMATES FOR THE REAL EUR/USD DEVIATIONS FROM EQUILIBRIUM^(a)



Nota: (a) The values shown correspond to a simplified version of the results presented in table 1. In the cases in which there are equilibrium estimates for different time horizons, only those referring to the longer horizon are considered (ex: LT instead of ST) and in the cases in which the same study presents different estimates for the same time horizon the mean of such results is considered.

usually found in this type of model, is, as expected, rather faster than that associated with PPP theory.

In the case of the real euro/US dollar exchange rate, some specifications included the real oil price, the real interest-rate differential and/or relative public consumption in the long-run relationship. However, in such cases the econometric results were unsatisfactory, namely in terms of sta-

bility of the parameters. In the best specification obtained, the real euro/US dollar exchange rate is determined by relative productivity (measured by the average labour productivity) and the ratio of net foreign assets to GDP in the euro area compared to the United States (table 4). In the long-run relationship both variables are quite significant and, as in the case of the effective exchange rate, the estimated coefficients are positive

as expected. The speed of the exchange rate adjustment towards the long-term equilibrium is similar to that estimated for the effective exchange rate.

Charts 1 and 2 compare the current values for the exchange rates with the estimated BEER/PEER. Charts 3 and 4 show the estimated deviations jointly with the results mentioned in the previous section for the late 1990s and for the year 2000. In general terms, the results obtained in this section are in line with the results in literature, pointing in particular to a possible underappreciation of the euro in 2000, of a higher magnitude in the case of the euro/US dollar exchange rate than in effective terms. This underappreciation seems to have been sharper in the first half of 2001, reaching approximately 11 per cent in effective terms and around 18 per cent against the dollar. From late 2001 to late 2002 (from mid 2002 to mid 2003) the euro effective exchange rate (the euro/US dollar) was relatively close to the levels justified by the long-term behaviour of its determinants. The continued appreciation of the euro has nonetheless contributed to the recent emergence of signs of a possible overappreciation, both in effective terms and against the dollar. In the fourth quarter of 2004, the estimated deviations stood at 11 and 16 per cent in the case of the effective exchange rate and of the euro/US dollar, respectively. In this period, the estimated equilibrium rates present an appreciating trend, that can be partly explained by the more favourable behaviour of net foreign assets in the euro area than in its trading partners and, in the case of the effective exchange rate, also by the higher growth of the ratio of public consumption to GDP. However the appreciation of the equilibrium rate has been more moderate than the appreciation actually observed.

6. FINAL CONCLUSIONS

The PPP (Purchasing Power Parity) is a good proxy for the equilibrium exchange rate in a situation where monetary shocks predominate. However, given the protracted deviations of the real exchange rate from the PPP, the usefulness of such concept to evaluate the exchange rate is small. Therefore, most empirical applications estimate trends for the equilibrium real exchange rate that are determined by the behaviour of the real vari-

ables. The difficulties in defining the equilibrium exchange rate, in a situation in which the real variables are non stationary, contributes to the emergence of different approaches to this issue in the literature. These approaches generate results that are difficult to compare among each other and that are subject to criticism, due to the fact that they are the result of normative solutions (such as FEER - Fundamental Equilibrium Exchange Rate) or because it is not clear that they ensure the existence of internal and external equilibrium (such as BEER - Behavioural Equilibrium Exchange Rate, PEER - Permanent Equilibrium Exchange Rate and NATREX - NATural Rate of EXchange). The distinction among the different approaches based on the equilibrium time horizon is too simplistic, since the equilibrium notions implied in different approaches for the same time period are not equivalent.

The comparison of the different methods for determining the equilibrium exchange rate does not lead to a consensual conclusion as to the best methodology to be adopted. FEER is a useful approach to quantify possible deviations from the equilibrium in situations in which there are concerns about the external equilibrium, but it has a limited capacity to explain the factors underlying changes in the equilibrium trend, such as, for instance, the existence of Balassa-Samuelson effects. BEER and BEER/PEER are more flexible, making it possible that factors associated with different theories of determining the exchange rate may be tested simultaneously. An atheoretical PEER is a simple approach, in the sense that it is less demanding in terms of data. Structural VARs allow the relative importance of different shocks to be evaluated in explaining the exchange rate behaviour. Finally, NATREX introduces more economic rationality in the distinction between different equilibrium notions, than does the decomposition into permanent and transitory components, used in PEER. In addition to these motivations, the choice among the different methods depends obviously on the availability of data.

Irrespective of the methodology adopted, the estimates obtained are subject to a high degree of uncertainty, due to the econometric uncertainty, to the variable measurement problems and, in the case of the structural approaches, such as FEER, to the sensitivity of the results to changes in the as-

sumptions. In effect, studies with the same methodology gave often rise to very different results in terms of magnitude and of sign of the deviations from equilibrium. This uncertainty is amplified by the lack of consensus on the adequate equilibrium exchange rate concept. In these circumstances, the conclusion that a deviation of the exchange rate from equilibrium exists is usually based on obtaining deviations in the same direction, and of a significant magnitude with different approaches.

In the case of the euro, the results available in literature seem, in general, to indicate that in 2000 it was undervalued both in effective terms and against the dollar. The results obtained in this article confirm such conclusion and suggest that the appreciation of the euro in the last two years was sharper than would be justified by the fundamental determinants, leading to a possible overappreciation, chiefly against the dollar, but also in effective terms. This evaluation is not expected to change much when considering 2005 data, since the magnitude of euro depreciation in 2005 was small, when compared with the estimated deviations in this article. These conclusions may, however, be induced by the fact that changes in the euro exchange rate in this period have reflected factors that are not included in this type of approach, or structural breaks. Indeed, it is possible that there may be structural breaks associated for instance with the launch of the euro area.

REFERENCES

- Alberola, E., S. Cervero, H. Lopez and A. Ubide (1999), "Global Equilibrium Exchange Rates: Euro, Dollar, "Ins", "Outs", and Other Major Currencies in a Panel Cointegration Framework", *IMF Working Paper* 175, December.
- Clarida, R. and J. Gali (1994), "Sources of Real Exchange Rate Fluctuations: How Important are Nominal Shocks?", *Carnegie-Rochester Conference Series on Public Policy*, Vol. 41, pp.1-56, December.
- Cloestermann, J. and B. Schnatz (2000), "The Determinants of Euro-dollar Exchange Rate - Synthetic Fundamentals and a Non-existing Currency", Economic Research Group of the Deutsche Bundesbank, *Discussion paper* 2.
- Detken, C., A. Dieppe, J. Henry, C. Marin and F. Smets (2002) "Model Uncertainty and the Equilibrium Value of the Real Effective Euro Exchange rate", *ECB Working Paper* No. 160, July.
- Driver, R. L. and Westaway, P. F. (2004), "Concepts of Equilibrium Exchange Rates", Bank of England *Working Paper* no. 248.
- Faruqee, H. (1994), "Long run Determinants of the Real Exchange Rate: A Stock-Flow Perspective", International Monetary Fund, *WP/94/90*, August.
- Frenkel, J. A. and Mussa (1984), "Asset Markets, Exchange Rates and the Balance of Payments", National Bureau of Economic Research, *Working Paper* No. 1287, March.
- Froot, K. A. and K. Rogoff (1995), "Perspectives on PPP and Long-Run Real Exchange Rates", *Handbook of International Economics*, Vol. III, Elsevier Science.
- Gonzalo, J. and C. Granger (1995), "Estimation of Common Long-Memory Components in Cointegration Systems", *Journal of Business & Statistics*, Vol. 13, No. 1, January.
- Hansen, J. and W. Roeger (2000), "Estimation of Real Equilibrium Exchange Rates", European Commission *Economic Papers*, 144.
- Isard, P. and H. Faruqee (1998), "Exchange Rate Assessment: Extensions of Macroeconomic Balance Approach, *IMF Occasional Paper* No. 167.
- Koen, V., L. Boone, A. de Serres and N. Fuchs (2001), "Tracking the Euro", OECD Economics Department *Working Papers* no. 298.
- MacDonald, R. (1995), "Long-Run Exchange Rate Modelling: A Survey of the Recent Evidence", International Monetary Fund, *WP/95/14*, January.
- MacDonald, R. (2000), "Concepts to Calculate Equilibrium Exchange Rates: An Overview", Economic Research Group of the Deutsche Bundesbank, *Discussion Paper* 3/00, July.
- Maeso-Fernandez, F., C. Osbat, and B. Schnatz (2001) "Determinants of the Euro Real Effective Exchange rate: a BEER/PEER approach," *ECB Working Paper* No. 85, November.
- Milesi-Ferretti, M. and P. Lane (1999), "The External Wealth of Nations: Measures of Foreign Assets and Liabilities for Industrial and Developing Countries", International Monetary

- Fund, WP/99/115, August.
- Osbat, C. R. Ruffer and B. Schnatz (2003), "The Rise of the Yen vis-à-vis the ("Synthetic") Euro: is it supported by economic fundamentals?", *ECB Working Paper* No. 224, April.
- Stein, J. L. (2001), "The Equilibrium Value of the Euro/\$ US Exchange Rate: an Evaluation of Research", *CESifo Working Paper* No. 525, July.
- Stein J. L., P. R. Allen and associates (1995), "Fundamental Determinants of Exchange Rates", Oxford University Press.
- Williamson, J. (1983), "The Exchange Rate System", *Policy Analysis in International Economics*, nº 5, Institute for International Economics, Washington D.C.
- Williamson, J. (1991), "Equilibrium Exchange Rate: An Update", Institute for International Economics, Washington D.C..
- Wren-Lewis, S. and R. L. Driver (1998), "Real Exchange Rates for the Year 2000", Institute for International Economics, *Policy Analyses in International Economics*, 54, May.

ANNEX

DESCRIPTION OF THE VARIABLES USED IN THE ESTIMATION OF BEER/PEER

Every series, except on net foreign assets and on interest rate differentials, were defined in logarithms for estimation purposes.

- **Euro real effective exchange rate**

Real effective exchange rate index (deflated by consumer prices) calculated by the ECB for the narrow group of countries (12 trading partners, representing approximately 60 per cent of manufacturing trade in the area do euro: Australia, Canada, Denmark, Hong Kong, Japan, Norway, Singapore, South Korea, Sweden, Switzerland, United Kingdom and United States of America). The weights used in the construction of the index are calculated as a weighted average of export double weights and import simple weights, on the basis of manufacturing trade data. The index is based on 1995-1997 weights up to 1998, and on 1999-2001 weights after 1999.

- **Real euro/US dollar exchange rate**

Nominal euro/US dollar exchange rate deflated by consumer prices. The index used for the euro area was the harmonised index of consumer prices and for the United States was the consumer price index (sources: for the euro area, EUROSTAT data retroplated for the period prior to 1990:I with ECB data; for the United States, Department of Labour). Prior to 1999, the nominal exchange rate corresponds to the exchange rate of the ECU (source: ECB).

- **Ratio of net foreign assets to GDP**

In the construction of quarterly series of net foreign assets for the euro area and for the United States, the value in dollars considered for net foreign assets in the last quarter of each year was the annual value for these series (which are available up to 2003)⁽¹⁾. The values for the other quarters were obtained assuming for each year the same quarterly structure of the accumulated current account in dollars. The values for 2004 are the result of the accumulation of current account values in dollars. The current account series of the euro area corresponds, up to 1996, to the sum of the current

accounts in dollars of euro area countries (source: International Financial Statistics of the IMF) and, since 1997, to the ECB series for the current account converted into dollars. In the case of the United States, data for the current account correspond to those published by the Department of Commerce. In the estimation of the euro effective exchange rate (euro/US dollar exchange rate) the explanatory variable used was the ratio of net foreign assets to GDP in the euro area (the differential between the ratios of net foreign assets to GDP in the euro area and in the United States). Nominal GDP corresponds, in the case of the United States, to that published by the Department of Commerce and, in the euro area, to the series published by EUROSTAT, retroplated with year-on-year rates of change of ECB data.

- **Productivity**

Two alternative productivity measures were considered: a direct measure corresponding to the average labour productivity and an indirect measure corresponding to the ratio of prices in the nontradable goods sector to prices in the tradable goods sector. The direct measure was calculated as the ratio of GDP in volume to employment, and the indirect measure as the ratio of consumer prices to producer prices. The explanatory variable used in the estimation of the euro effective exchange rate (euro/US dollar exchange rate) was the ratio of the productivity measure in the euro area to the productivity measure abroad (in the United States). Direct and indirect productivity measures abroad were calculated as geometrical averages of such measures in the countries whose

(1) These data were kindly supplied by Milesi-Ferretti and correspond to an updated preliminary version for 2003 of Milesi-Ferretti and Lane's database (1999) for net foreign assets of euro area countries, of the euro area as a whole and of the United States. These data reflect the net value of the international investment position less the value of gold assets. The euro area series is only available for the period after 1999, and was retroplated, on the basis of the annual changes of the series resulting from the sum of net foreign assets of euro area countries.

currencies are included in the calculation of the real effective exchange rate (excluding Hong Kong in the case of the indirect measure and Hong Kong and Singapore in the case of the direct measure, due to lack of data). The weights of the euro effective exchange rate index were used in these calculations. In the case of the euro area, data for GDP, employment and the harmonised index of consumer prices correspond to the EUROSTAT series retroplated with the year-on-year rates of change of ECB series, whereas data for the producer price index correspond to the series calculated by the EUROSTAT. For the United States, data from the Department of Commerce were used for GDP, from OECD for employment and from the Department of Labour for the consumer and producer price indices. In the cases of countries belonging to the euro effective exchange rate index, data from the Main Economic Indicators of the OECD were used for GDP, from the Economic Outlook of the OECD for employment and from International Financial Statistics of the IMF for price indices .

- **Ratio of public consumption to GDP**

The explanatory variable used in the estimation of the euro effective exchange rate (euro/US dollar exchange rate) was the ratio of public consumption to GDP in the euro area and abroad (in the United States), calculated in nominal terms. The ratio of public consumption to GDP abroad was obtained as a geometric average of this measure in countries whose currencies are included in the calculation of the real effective exchange rate index (excluding Singapore, due to lack of data). The sources used were EUROSTAT and ECB for the euro area, the Department of Commerce for the United States and International Financial Statistics of the IMF for countries included in the calculation

of this variable abroad, except Denmark, which resorts to EUROSTAT data.

- **Long-term real interest rate**

Nominal interest rates of long-term government bonds deflated by the year-on-year rate of change of the consumer price index. The explanatory variable used in the estimation of the euro effective exchange rate (euro/US dollar exchange rate) was the differential between the long-term real interest rate in the euro area and abroad (in the United States). The long-term real interest rate abroad was obtained as an arithmetic average of this measure in countries whose currencies are included in the calculation of the real effective exchange rate index (excluding Singapore and Hong Kong, due to lack of data). The sources used for the nominal interest rates were the ECB for the euro area, Bloomberg for the United States and the International Financial Statistics of the IMF for the countries that are included in the calculation of this variable abroad.

- **Real oil price**

The explanatory variable used in the estimation of the euro effective exchange rate (euro/US dollar exchange rate) was the ratio of the oil price in euros to the harmonised index of consumer prices in the euro area (the ratio of the oil price in dollars to the producer price index in the United States). After 1989:I, the oil price in dollars corresponds to the series of the oil price in the London market (Brent) (source: Thomson Financial Datastream), which was retrapolated with the quarter-on-quarter rates of change of the average oil price in dollars published in the International Financial Statistics of the IMF.