Economic fundamentals and the exchange rate of the euro

This article provides an overview of the possible fundamental factors underlying the development of the exchange rate of the euro. It briefly reviews the empirical approaches applied in this context and discusses the extent to which different models – although all subject to a considerable range of caveats – can serve as a reference point for an exchange rate assessment. Taking a medium to long-term perspective, it becomes apparent that real exchange rates have been subject to significant fluctuations. In theory, a number of possible medium and long-term determinants of the exchange rate have been identified and may thus help to explain some of these movements. While models based on such economic fundamentals are not very successful in explaining short-term exchange rate movements, they are usually able to track quite well the evolution of the actual exchange rate in the medium to long run. Accordingly, they may trace a path for longer-term trends towards which the actual exchange rate converges. However, the uncertainty surrounding this path for the estimated exchange rate equilibrium is typically rather large and the results are often quite sensitive to the underlying assumptions. Therefore, the currently available empirical approaches cannot provide any precise value for an "equilibrium exchange rate", and the results, consequently, need to be interpreted with considerable caution. Nonetheless, the insights from the empirical approaches discussed in this article may serve as a basis for some more qualitative assessments of the relationship between the exchange rate and economic fundamentals.

1 Introduction

The development of the exchange rate of the euro since the start of Stage Three of Economic and Monetary Union (EMU) in 1999 has triggered many thoughts and considerations from various economic perspectives. Any analysis of exchange rate developments based on fundamentals, however, may need to take a somewhat longer-term view, consistent with the time horizon of such approaches. In the absence of historical data for the euro, the literature has generally adopted as a proxy prior to 1999 the so-called "theoretical" or "synthetic" euro.[1] There is, however, an important caveat to the use of such a proxy. While the euro was launched in 1999 under the condition of price stability in the euro area – reflecting a successful convergence process of previous years – the synthetic euro mechanically summarises the evolution of the legacy currencies which developed in the framework of rather heterogeneous monetary environments. This is particularly true as one goes further back in time. Therefore, any judgement on longer-term trends in the *nominal* exchange rate of the euro should be based on a (legacy) currency reflecting a high degree of internal stability, like the Deutsche Mark, for instance. Such a perspective is consistent with the mandate and the monetary policy strategy of the ECB, both of which are designed to maintain price stability in the euro area.

Most exchange rate analyses based on economic fundamentals, however, focus on the real exchange rate rather than on the nominal exchange rate. For the real exchange rate, differences in inflation rates between countries should be offset in the longer run by corresponding movements in nominal exchange rates. Accordingly, most of the empirical literature has used a "synthetic" surrogate for assessing long-term developments of the euro in *real* terms. It is well documented that real effective exchange rates of the synthetic euro (as well as of major legacy currencies) have been characterised by considerable medium-term swings. Given these swings in real exchange rates, the question arises as to whether these fluctuations in foreign exchange markets can be related to fundamental factors.

In order to examine this question, the article provides first an overview of potential

1 *This concept was described in more detail in "The nominal and real effective exchange rates of the euro", ECB Monthly Bulletin, April 2000.*

fundamental factors underlying the development of the exchange rate of the euro. It then goes on to briefly review the empirical approaches applied in this context and discusses the extent to which these models can serve as a reference point for an exchange rate assessment.

2 Fundamental factors underlying the exchange rate

Relevant fundamentals, their interaction and the time horizon for analysis

From a theoretical point of view, there are a number of medium to long-term factors underlying developments in exchange rates, such as trends in domestic and foreign prices, lasting changes in relative productivity growth, the international investment position, the terms of trade, fiscal variables and the interest rate differential. The relationship between these fundamentals and the exchange rate is, however, complicated by the fact that some of these factors affect the exchange rate permanently, while others give rise only to temporary or cyclical fluctuations around a long-term path. In essence, the distinction between medium and long-term fundamentals is mainly related to the underlying properties of the fundamentals under consideration rather than to a particular time horizon. In this context, the distinction between medium and long-term relationships may facilitate an intellectual categorisation.

It is also important to emphasise that some of the variables identified as factors underlying exchange rate movements are not necessarily exogenously determined but could actually be interrelated. For instance, developments in (real) long-term interest rates have been associated with fluctuations in the real exchange rate. Yet interest rates themselves are obviously also related to economic policy, the business cycle and stock market performance, which in turn can be influenced by exchange rate developments. In summary, some of the underlying factors may be simultaneously co-determined together with the exchange rate within the overall economic system rather than just being exogenous determinants of the exchange rate.

Before discussing medium and long-term factors in more detail, it is useful to distinguish them from approaches focusing on short-run pricing behaviour. Turning to this time horizon, it has been demonstrated in theoretical work that exchange rate "overshooting" is possible if wages and prices of goods and services adjust only slowly compared with prices in financial markets. Moreover, it has been documented in the literature that actions by foreign exchange traders may be temporarily governed by factors unrelated to fundamental analysis. This has been partly attributed to the existence of transaction costs, including the costs of gathering information, which create a range of values around the fundamental-based "equilibrium" within which the exchange rate can fluctuate without triggering any equilibrating forces. In these circumstances, exchange rates would converge to long-term values only when the deviation from "equilibrium" of fundamentally justified levels exceeds a certain threshold.

Moreover, the mere presence of heterogeneous agents in the foreign exchange markets may influence trends in exchange rates over prolonged periods. While the so-called "fundamentalists" rely more on economic models to predict exchange rate changes, "non-fundamentalist" or "chartist" traders form their expectations on currency prices mainly by extrapolating historical trends. It has been often claimed in the literature that, due to herding behaviour and bandwagon expectations, a predominance of non-fundamentalists, or changing proportions of the two types of traders in the market, can contribute to swings in asset prices that are more accentuated than would be justified by fundamentals. In this context, rather *ad hoc* "explanations" of exchange rate

behaviour have been frequently built on simple correlations between the exchange rate and a number of "explanatory" variables, which, however, generally tend to fail after a while for no apparent reason. In any case, if a consensus gradually emerges among market participants that the exchange rate has moved far away from what can be justified by economic fundamentals, then equilibrating forces should come increasingly into play, pulling it back towards its "equilibrium" level.

The obvious complexity of the relationships between the exchange rate and fundamentals as well as the existence of non-fundamental driving forces suggest that any empirical model attempting a precise quantification of the "fair value" of a currency based on economic fundamentals is characterised by a rather significant degree of uncertainty. Accordingly, while it appears feasible to identify a number of factors underlying exchange rate trends in the medium term, the derivation of a concrete value for the "equilibrium exchange rate" from these insights proves to be very problematic. Apart from significant uncertainties surrounding the available approaches to estimating the "fair value" of a currency, some of these approaches are also rather sensitive to changes in the underlying assumptions. Limited data availability and data uncertainty due to measurement error or to the use of proxies for some fundamentals complicate the issue further. In particular, factors that are difficult to quantify, such as adjustments in the portfolio allocation by investors in reaction to changes in financial market structures, may increase the uncertainty surrounding any estimate of an equilibrium exchange rate. Accordingly, while fundamental-based equilibrium exchange rate models may convey useful information, especially if the various approaches arrive at the same qualitative conclusion, such analyses may serve at best as a rough reference point against which actual developments in foreign exchange markets can be gauged.

The nominal exchange rate and price developments: an important but incomplete link

In exchange rate economics, asset market models of exchange rate determination play a central role. In these models the supply and demand for financial assets determine the medium-term path of the nominal exchange rate. In the context of the so-called monetary approach, the nominal exchange rate is determined by the supply and demand for money. In this framework it is assumed, however, that domestic and foreign assets are perfect substitutes. This assumption has been relaxed in portfolio balance models, which treat domestic and foreign assets as imperfect substitutes. In these models, it is not only the interaction between the money supply and money demand that is important for nominal exchange rate movements, but also the changes in the supply and demand for other financial assets. This approach also incorporates risk premium considerations, which are important in association with the international investment position that is discussed as an exchange rate fundamental below.

The standard monetary model is closely related to the theory of purchasing power parity (PPP) which is the universal starting point for exchange rate analysis. The theory of PPP in its relative version states that nominal exchange rates move in proportion to relative developments in domestic and foreign prices. The monetary model goes one step further by explaining inflation rates through changes in the respective supply and demand for money at home and abroad. Accordingly, both approaches imply that the equilibrium real exchange rate is a constant, at least in the long run, once price levels have completely adjusted. This is a crucial interim result to be pointed to in the context of the analysis presented further below.

Empirically, however, real exchange rates also exhibit prolonged fluctuations. While they often oscillate around a mean "in the long run", there are protracted deviations from

their PPP-based long-run means. Moreover, the adjustment speed of the exchange rate to any "equilibrium path", as mapped out by relative price developments, is extremely slow, so that prolonged deviations from purchasing power parity can occur. According to empirical studies, which take either a very long-term perspective by employing correspondingly long data series or use a panel data approach, the adjustment process is typically found to have a half-life of three to six years. This implies that following a shock, which drives the exchange rate away from its long-run PPP value, about half a decade is required for the exchange rate to revert half way back to this level. While some of these fluctuations could be attributed to transaction costs impeding arbitrage transactions in goods markets, the observed medium-term swings in the exchange rate are generally too large to be accounted for by these factors alone. In addition, some currencies, like the Japanese yen, for instance, exhibit a clear trend in their real effective exchange rate, requiring some additional explanation.

The real exchange rate and long-term fundamentals: productivity, external balances, terms of trade and fiscal developments

Owing to these limitations of PPP, several other fundamental determinants have been examined as a means of explaining long-term shifts in the real "equilibrium" exchange rate. These approaches usually focus on the real exchange rate and abstract from issues related to nominal rigidities and the linkages between the monetary and the real side of the economy. Four factors, in particular, have been discussed in the academic literature: (1) differing productivity developments, (2) the net foreign asset position, (3) terms of trade shocks, and (4) government spending.

Productivity advances should be associated with a real appreciation of the domestic currency. In the context of exchange rates between industrial countries, a more medium-term channel might be the more relevant, since rising overall productivity may support the exchange rate through higher real interest rates and better prospects for economic growth. In the long run, differential productivity developments in the traded goods sector may also lead to a gradual appreciation of the real exchange rate (the so-called Balassa-Samuelson effect), though this argument is likely to be more relevant for explaining trends in exchange rates between emerging market economies and industrial countries rather than between industrial countries. Following the rise in productivity in the traded goods sector, productivity-based real wages will tend to rise in this sector, inducing labour to move from the non-traded to the traded goods sector, until wages between the two sectors have been equalised again. As a result, the price of non-traded goods relative to the price of traded goods will have to rise, which can be achieved through an increase in the price of non-traded goods or a decline in the domestic currency price of traded goods associated with a nominal appreciation of the currency or a combination of both. Although a clear link between productivity developments and the real exchange rate exists in theory, measuring such a relationship appropriately is inherently difficult (see Box 1).

A second possible conduit through which fundamental factors may influence the real exchange rate in the long run is related to external balance considerations. According to this framework, the *long-run* equilibrium exchange rate is the exchange rate which ensures a stable long-run international investment position (relative to GDP). In theory, therefore, it can be expected that the equilibrium real exchange rate at each point in time is inversely related to the net external debt position (relative to GDP) of a country. Abstracting from valuation effects, there are, in principle, two channels that may be important for the relationship between the international investment position and the exchange rate: a risk premium and a balance of payments channel.

Box 1

Measurement problems

In econometrically-oriented approaches, the length of the time series and the internal consistency of the data are crucial for obtaining robust results. In this context, problems arise in particular in measuring appropriately diverging productivity trends, the international investment position and the real interest rate differential.

As regards *productivity differentials*, three alternative approaches have been followed in the academic literature to derive a proxy variable:

- A relatively direct measure relies on differences in total labour productivity between home and abroad, which is defined as real GDP divided by the number of employees. Since traded and non-traded goods sectors are not treated separately in this variable, this is a very broad economy-wide productivity measure. Limited data availability rules out the use of the more accurate output per hour worked instead of output per employee to account for diverse preferences for part-time work. In addition, the comparability of these data is subject to differences in accounting procedures.

- A proxy measure for total factor productivity rather than only labour productivity has been derived from a standard Cobb-Douglas production function (the so-called Solow residual). While this measure is theoretically plausible, it is very difficult to compile due to problems encountered in quantifying the capital stock adequately – given the issue of how to account for capital depreciation – and specifying the correct functional form for the production function to be employed in the estimation procedure. As a result, it has been used only in a limited number of studies.

- A rather indirect measure taking sectoral developments in the economy into account is based on relative price developments in the traded and the non-traded goods sectors. The relative prices of non-traded and traded goods are, under reasonable assumptions, inversely related to the ratio of productivity gains in the two sectors. However, the dividing line between traded and non-traded goods is at the margin ambiguous. Therefore, as a rather rough measure, prices in the non-traded goods sector have been commonly approximated in most of the literature by the consumer price index, while producer or wholesale prices are used as proxies for the traded goods prices. This method draws on the fact that the proportion of non-traded goods in the basket underlying consumer prices is considerably larger than the proportion in the basket underlying producer prices. A significant drawback of this variable is, however, that changes in taxes – and in particular value added taxes – as well as the effects of domestic demand shocks on prices in non-traded goods sectors may conceal the actual productivity information conveyed by this variable.

Regarding the *international investment position*, data published for the euro area is limited to the last four years, at present, thus hampering its use in econometric models. Accordingly, the net international investment position could, in principle, be approximated by cumulating the current account balance (in relation to GDP) of individual countries (or regions). This procedure also has some important caveats:

- Computing such an aggregate for the euro area before 1997 has to rely on the aggregation of national data, but intra-euro area components of the current account positions, which should cancel out in theory, do not do so in practice.

- It ignores effects of debt reduction and forgiveness, reinvested earnings and, probably even more importantly for the euro area, valuation issues. In the case of debt instruments recorded as assets and liabilities of the economy, the valuation of stocks is strongly affected mainly by changes in the exchange rate but also by changes in prices. For some instruments such as equity in portfolio or direct investment, the quantification of the valuation effect is complex, since determining the current market value of these investments is not straightforward, particularly if unlisted companies are concerned.

- In addition, mis-measurement issues may be relevant in this context owing to the "errors and omissions" item in the balance of payments statistics, which tends to capture unrecorded current account or financial account flows.

Overall, some studies find evidence that, for many industrial countries, the cumulated current account provides a good representation of trends in the net foreign asset position. However, the more accurate international investment position as computed by the ECB for the years from 1997 to 2000, which adjusts for these factors, differs substantially, at least over this short period, from the levels and patterns derived through the accumulated current account approach, suggesting a very cautious interpretation of this variable in empirical applications.

Finally, the computation of the *real interest rate differential* also suffers from several data deficiencies:

- It usually ignores changes in the risk premia among assets, which could have contributed to a persistent and time-varying wedge in the real interest rate differential.

- Since the real interest rate is computed as the difference between the nominal interest rate and expected inflation, it requires an assumption regarding inflation expectations. For analysing the relationship between real interest rate differentials and the real exchange rate, information contained in inflation-indexed bonds can be exploited to this end. While this measure of inflation expectations also has some deficiencies, it should be comparatively uncontroversial, since it is directly extracted from financial market data. However, since these data are not available over a long sample span their use is limited in empirical exchange rate analyses. As a consequence, it has been common practice instead to employ the current rate of inflation or to use a filtering method to calculate inflation expectations on the basis of actual inflation rates. These measures may represent only a rough approximation of inflation expectations, thereby adding again to the uncertainty in the computations.

The first channel is related to portfolio balance considerations. If the international investment position (relative to GDP) of a country deteriorates, internationally diversifying investors will demand – for the associated adjustment of their portfolio structure – a higher yield in order to provide the capital inflow necessary to finance the corresponding current account deficit. At given interest rates, this increase in the risk premium requires a depreciation of the debtor country's currency. The second channel by which the international investment position can affect the real exchange rate relates to the accumulation of net external debts. The interest that has to be paid on the debt accumulated through "excessive" current account deficits needs to be offset in the long run by a corresponding surplus in the trade balance (in goods and services). This surplus can be achieved through increased international price competitiveness via a depreciation of the currency, thereby rendering exports more attractive. The proceeds from the higher net exports can then be used to service the higher interest payments.

In this context, one approach to compute a medium to long-term "fair value" of a currency is to determine a sustainable current account deficit which is consistent with such a steady-state international investment position (relative to GDP), but which also takes into account other elements. In this context, factors like the demographic profile and intertemporal consumption preferences of a country may be relevant for determining its long-term or sustainable current account position. The change in the exchange rate necessary for the current account to converge to this position – assuming that the economy operates at its potential level – is derived on the basis of the elasticities of

import and export volumes to changes in exchange rates. The computation of a sustainable current account position in itself entails significant uncertainties. Hence, the resultant "equilibrium exchange rate" might be rather sensitive to the assumptions underlying this computation. As regards the empirical application, the use of data on the international investment position for such purposes raises some difficulties (see Box 1). Ultimately, these problems may also account for the failure of the proxies normally used in empirical research for the international investment position – such as the accumulated current account position – to qualify sometimes as an underlying factor of the real exchange rate.

A third possible channel underlying developments in real exchange rates, which is of a more exogenous nature, relates to lasting terms-of-trade shocks. These can affect the real exchange rate via the balance of trade, which is one of the building blocks of the current account balance. A persistent deterioration in the terms of trade of a country – which can, for instance, be associated with a shift in preferences or a lasting change in commodity prices – should result in a lower real exchange rate of that country in order to keep its export sector competitive. While preference shocks are difficult to measure, the effects of terms-of-trade shocks have been commonly captured in the empirical literature by oil price developments. The rationale for this proxy for the terms of trade to have an influence on the exchange rate is that an increase in the price of oil tends to improve the international price competitiveness of a country that is relatively less dependent on oil. It should be kept in mind, however, that oil prices exhibit frequent swings, hence they include a rather strong medium-term component.

A fourth possible channel relates to fiscal variables, which may also have an influence on real exchange rate movements. In the long run, an increase in government spending could weigh on the real exchange rate. To begin with, a rise in government spending is often assumed to be associated with a simultaneous increase in the budget deficit. Assuming that the private sector does not offset this fall in public savings through increases in its own savings, overall domestic savings will be lowered. Consequently, the current account and the net foreign asset position would deteriorate in parallel, weighing in the longer term – as outlined above – on the real exchange rate. In a broader perspective, unbalanced government spending has been interpreted in the literature as an "economic distortions catch-all" type of variable, having, on balance, a negative impact on the potential for economic growth and the real exchange rate in the long run. This is closely related to the idea that increasing government spending and indebtedness could undermine confidence in a currency because of expectations of possible future distortionary tax increases. Over a shorter time horizon, however, higher government spending could exert an upward impact on the real exchange rate via higher real interest rates as well as via the demand side (see below).

The real exchange rate and medium-term economic fundamentals: real interest rates, growth expectations and stock market valuations

There are also fundamental factors which may give rise to temporary or cyclical fluctuations around the long-term path examined above. Three interrelated factors, in particular, have been discussed in this context: (1) the (real) interest rate differential, (2) relative growth expectations, and (3) stock market developments.

Given the increasingly free flow of capital across national borders, the exchange rate should also be affected by investment decisions driven by international interest rate differentials. Theoretically, this channel is usually represented by the uncovered interest rate parity condition, according to which rising interest rates in one country

temporarily drive up the value of that country's currency. The resulting expectation of a future depreciation will in the end offset the (risk-adjusted) interest rate differential, rendering investment at home and abroad equally attractive. Applied to trends in inflation-adjusted variables, this concept implies a relatively close link between the real exchange rate and the real interest rate differential. Accordingly, the real interest rate differential is then seen as gradually moving the real exchange rate to its long-term equilibrium value. The empirical examination of this relationship is complicated by the fact that the computation of the real interest rate differential suffers from several data deficiencies (as discussed in Box 1).

The observed real interest rate differential may, however, reflect more than just asset return arbitrage between different currency areas. The cyclical pattern of this variable over the medium term may display, to some extent, the relative business cycle position of the countries or areas under consideration as well as their relative growth prospects. In view of that, it appears plausible also to examine survey data on expected growth differentials directly. While survey data on expected real GDP growth in different regions indeed appear to portray exchange rate trends over the last three years even better than indicators based on real interest rate differentials, consistent data are not available for a period long enough to draw firm conclusions. Moreover, at the current juncture it is too early to assess to what extent these growth expectations have been driven by cyclical or structural considerations. This distinction is crucial in evaluating currency valuations, however. To the degree that the expected growth differential has reflected temporary differences in the business cycle in the euro area and abroad, the exchange rate would need to revert to its long-term path over the medium term. By contrast, a structural or permanent shift in economic growth could have required a long-term adjustment in the exchange rate level.

In addition to the variables mentioned above, stock market valuations have been mentioned in association with exchange rate developments. From a supply-side perspective, a favourable economic outlook should be related to rising stock market valuations, possibly along with rising real interest rates. If the improvement in the business conditions, leading to higher expected returns on investment in the long term, is perceived as being a permanent phenomenon, the stock markets may settle at this higher level for the foreseeable future. A rise in equity valuations tends to raise wealth and in general could entail a positive wealth effect on domestic demand, which could increase the current account deficit financed by strong capital inflows. In this context, however, both capital flows and exchange rate adjustments are variables which may be affected endogenously by the same underlying factors, so that any visible correlation between them should not be interpreted in a causal sense. In this respect, an important question relates to the factors underlying equity valuations. In recent discussions, two factors have been mentioned: a decline in equity risk premia, which would be more structural, or an overvaluation of stock prices. Temporarily, both factors could have the same macroeconomic effects, but they would call for completely different interpretations, requiring a generally cautious reading of this argument. On the one hand, a decline in the equity risk premium could imply a reasonable rise in stock prices. On the other hand, an overvaluation of stock prices would suggest that the related decline of the euro could no longer be interpreted as an "equilibrium" phenomenon. In such a case, an imbalance in one market (stock market) would have caused an imbalance in another market (foreign exchange market).

3 Empirical approaches to exchange rate modelling

Advanced concepts for assessing exchange rates use several explanatory variables

Although the preceding discussion has shed light on how movements in the fundamental factors listed above could be linked to the exchange rate of the euro, a variable-by-variable analysis of such relationships is unlikely to be helpful in uncovering the overall effect of individual influences on the exchange rate. If the individual fundamentals suggest different directions for the development of the exchange rate, such an analysis will not even allow a qualitative assessment of the likely development of the exchange rate, as the relative strength of the contribution of the various variables is unknown. For instance, over the past three years, the real interest rate differential between US and euro area bonds has initially narrowed and later moved in favour of the euro area, an occurrence which should have supported the euro. In contrast, given the higher oil dependency of the euro area compared with its major trading partners, the rising oil prices have led to a deterioration in the euro area's terms of trade which has been consistent with the decline of the euro since early 1999. Overall, the evaluation of developments in foreign exchange markets on the basis of simple correlations between individual variables and the exchange rate was at best only temporarily successful and these "relationships" lost their explanatory power before long.

Against this background, the joint interaction of these variables should be analysed using more sophisticated statistical methods. Overall, there are numerous concepts available for assessing the relevance of these factors as exchange rate determinants and for subsequently deriving a "fair value" for the exchange rate. These approaches can be broadly categorised according to the length of the time horizon under consideration. In the following, three broad categories are distinguished: (1) "current" or "cyclical", (2) medium-term, and (3) long-term.

Regarding the short to medium term, a "current" or "cyclical" "equilibrium exchange rate" can be obtained by combining the theories of purchasing power parity and (real) interest rate parity. Contingent on the actual statistical properties of the real interest rate differential, this approach could be used to explain transitory or more persistent deviations of the exchange rate from its path as mapped out by the inflation differential. Another frequently used framework on which estimates of equilibrium exchange rates are based is the monetary approach to exchange rate determination. According to this model the nominal exchange rate depreciates in the event of a relative increase in the money supply or a decrease in the money demand, both exerting upward pressure on prices. In this connection, monetary aggregates like M1 regularly represent the money supply in academic studies, while base money or currency in circulation are too narrow to qualify as exchange rate fundamentals. In addition, various factors determining the demand for money – such as various income terms, interest rates and the rate of inflation – have been employed as determinants of the exchange rate. Occasionally, this approach has also been broadened to allow for diverging productivity developments at home and abroad.

Also related to this category of "current" and "cyclical" equilibrium exchange rates is the so-called "behavioural equilibrium exchange rate" (BEER) concept. This approach is not based on a specific structural model but encompasses several of the economic relationships outlined above. In the spirit of the "cyclical equilibrium exchange rates", BEER models often include fundamentals that have medium-run effects on the exchange rate, but wash out in the longer run. Such factors include variables reflecting business cycle conditions such as the (real) interest rate differential. More durable shifts in the

underlying economic environment, like differences in productivity, trends in terms of trade or fiscal balances as well as the net foreign asset position have also been used to supplement the analysis in BEER models. These models provide some information about the dynamic path of the exchange rate in relation to actual changes in economic fundamentals, while the question of whether the nature of these changes is transitory or permanent is not directly addressed.

Other approaches are more focused on the medium term and aim at deriving an equilibrium exchange rate on the assumption that the driving variables themselves are at their medium-term level. For policy considerations, such an approach yields a level for the equilibrium exchange rate that is purged of cyclical or transitory influences, as the underlying fundamentals are assumed to be at their medium-term sustainable levels. From a technical point of view, the transition to this medium-term perspective can be accomplished in two ways: (i) through further statistical refinements which aim at extracting the medium-term values of the underlying fundamentals ("statistical approach"), or (ii) by defining explicitly the sustainable levels of these fundamentals on the basis of internal and external balance considerations ("structural approach").

The "statistical approach" builds on the BEER methodology and decomposes the modelled variables into permanent and transitory components, deriving the so-called "permanent equilibrium exchange rate" (PEER). The "structural approach" to modelling the medium-term equilibrium exchange rate assumes that the economy is at internal and external balance. Internal balance is obtained when a country is operating at a level of output consistent with full employment and low inflation, while external balance corresponds to a sustainable current account position. The so-called "fundamental equilibrium exchange rate" (FEER) approach is in this vein of thinking. Compared with the BEER and the PEER, the FEER methodology places more structure in a normative sense on the computations and delivers an equilibrium exchange rate that is consistent with "ideal" economic conditions. The macroeconomic balance framework advocated by the IMF could also be considered as a variant of this methodology.

The so-called NATREX (Natural Real Exchange Rate) approach aims at theoretically closing the gap between the medium and the long run as it is founded on a more rigorous modelling of the stock-flow interaction in a macroeconomic growth model. A distinction is made between a medium-term equilibrium, where external and internal balance prevails (equivalent to the FEER approach discussed above), and the long-run equilibrium, where net foreign debt is constant and the capital stock is at its steady state level. In empirical terms, however, a time series approach similar to the BEER discussed above is typically employed, with the most important exogenous factors within the NATREX model being a thrift parameter, capturing consumption preferences – often measured by relative consumption spending ratios – and productivity developments. Recently, however, the NATREX theory has also been estimated within a structural setting.

Empirical applications of models to the euro and caveats

As regards the exchange rate of the euro, many empirical studies applying one or another of these concepts identify a statistically significant association between the exchange rate of the euro and various economic fundamentals (see Box 2). Owing to the above-mentioned limitations of the PPP concept, these studies generally apply more advanced approaches, modelling the real exchange rate as a function of economic fundamentals. Technically speaking, the idea that the real exchange rate should eventually revert to a constant has been replaced by a time-varying equilibrium path of the real exchange rate. Although these empirical applications are built on fairly sophisticated statistical methods, it is well known that all

Box 2

Survey of recent studies on the equilibrium exchange rate of the euro

As there is a wide range of approaches for calculating equilibrium exchange rates, the studies reviewed below are organised according to the equilibrium concept applied. The studies surveyed can be broadly classified in two categories: the first includes those applying time series techniques to empirically establish the relationship between economic fundamentals and the exchange rate and to derive an exchange rate equilibrium on the basis of these links. The second category includes studies which rely more on the presumed theoretical structural relationships and simulate on that basis the exchange rate adjustment needed to reach internal and external equilibrium. For the more structural approaches under this category, the interactions between the variables are often rather complex, so that no explicit reference to driving fundamentals is made.

Study	Methodology	Fundamentals	Reference currency and period	"Equilibrium" rate or under(-)/over(+) valuation
		Econometric approaches		
van Aarle et al. (2000)	Monetary model	– Monetary fundamentals	USD, 2000 Q2	Roughly USD/€ 1.07
Chinn, Alquist (2001)	Monetary model	– Monetary fundamentals – Productivity (indirect)	USD, June 2000	USD/€ 1.17 to 1.23
Gern et al. (2000)	BEER, UIP	– Interest rate differential	USD, 2000 Q1	Around USD/€ 1.03
Clostermann, Schnatz (2000)	BEER	– Productivity (indirect) – Interest rate differential – Government spending – Oil prices	USD, 1999 Q4	USD/€ 1.13
Teïletche (2000)	BEER	– Productivity derived from production function – Government spending – Interest rate differential	USD, June –2000	USD/€ 1.09
Lorenzen, Thygesen (2000)	BEER	– Net foreign assets – Dependency ratio – Productivity (indirect) – R&D expenditures	USD, 1999	Long-term: USD/€ 1.28
		– Interest rate differential (filtered)	USD, end-1999	Medium-term: USD/€ 1.19
		– Output gap – Interest rate differential	USD, mid-2000	Short-term: USD/€ 1.09
Koen et al. (2001)	BEER	– GDP per capita – Dependency ratio – Interest rate differential – Oil prices	effective, second half 2000	-9%
Maeso-Fernandez et al. (2001)	BEER/ PEER	– Productivity (direct and indirect) – Interest rate differential – Government spending – Oil prices	effective, 2000 Q4	-3% to -20% depends on the specification
Alberola et al. (1999)	PEER	– Productivity (indirect) – Net foreign assets	USD, end-1998 effective, end 1998	USD/€ 1.26 effective: -4.5%
Hansen, Roeger (2000)	PEER	– Productivity (indirect) – Net foreign assets	effective, 1999 Q3	Around -15%
Stein (2001)	NATREX	– Time preference (consumption to GDP) – Productivity (direct) – Rate of return on investment	USD, 2001 Q1	USD/€ 1.17
Duval (2001)	NATREX	– Interest rate differential – Productivity (direct) – Savings rate	USD, 2000 Q3	USD/€ 1.15

Study	Methodology	Fundamentals	Reference currency and period	"Equilibrium" rate or under(-)/over(+) valuation
	Structural approaches			
Wren-Lewis and Driver (1998)	FEER	Internal and External balance	USD, 2000	USD/€ 1.19 - 1.45
Borowski and Couharde (2000)	FEER		USD, effective first half of 1999	USD/€ 1.23 - 1.31 effective: -10%
IMF (2000)	Saving-investment approach		USD, summer 2000	USD/€: -30% or more
			effective, summer 2000	-10 to -20%
Detken et al. (2000)	Various models		effective, end 1999	-3.5 to -30%
Detken and Marin-Martinez (2001)	NATREX (structural)		effective, end-1999	Around -25%

Alberola, E., S. G. 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. Borowski, D. and C. Couharde (2000) "Euro, dollar, yen; pour une approche multilatérale des taux des change d'équilibre" in Revue Economique, 51, 3, 671-680. Chinn, M. and R. Alquist (2000) "Tracking the Euro's Progress", in International Finance, 3, 3, 357-373. Clostermann, J. and B. Schnatz (2000) "The determinants of the euro-dollar exchange rate: synthetic fundamentals and a non-existing currency", in Konjunkturpolitik/Applied Economics Quarterly, 46, 3, 274-302. Detken, C., A. Dieppe, J. Henry, C. Marin and F. Smets (2000) "Determinants of the effective real exchange rate of the synthetic euro: alternative methodological approaches", mimeo, ECB, Frankfurt am Main. Detken, C. and C. Marin-Martinez (2001), "The effective euro equilibrium exchange rate since the 70's: a structural Natrex estimation, mimeo, ECB, Frankfurt. Duval, R. (2000), "Estimation du taux de change reel d'equilibre de long term euro/dollar par une approche dynamique synthetique", mimeo, Universite Paris-I Pantheon. Gern, K.-J., C. Kamps, C. P. Meier, and J. Scheide (2000) "Euroland: peak of the upswing – little evidence of a new economy, Kiel Discussion Papers 369, Kiel. Hansen J. and W. Roeger (2000) "Estimation of real equilibrium exchange rates", European Commission Economic Papers, 144. International Monetary Fund (2000) "Staff Report on the Monetary and Exchange Rate Policies of the Euro Area"; Staff Country Report No. 00/146, Washington D. C. Koen, V., L. Boone, A. de Serres, N. Fuchs (2001) "Tracking the euro", OECD Economics Department Working Paper No. 24/2001. Lorenzen, H. P. and N. Thygesen (2000) "The relation between the euro and the dollar", paper presented at the EPRU Conference, Copenhangen. Maeso-Fernandez, F., C. Osbat, and B. Schnatz (2001) "Determinants of the euro real effective exchange rate," ECB Working Paper No. 85, Frankfurt am Main. Stein, J. (2001) "The equilibrium value of the euro/$US exchange rate: an evaluation of research", CESifo Working Paper No. 525, Munich. Teiletche, J. (2000) "La parité/dollar durant les décennies 80 et 90: peut-on trouver une spécification raisonable et à quel horizon?", mimeo. van Aarle, B., M. Boss, and J. Hlouskova (2000) "Forecasting the euro exchange rate using vector error correction models", in Weltwirtschaftliches Archiv/Review of World Economics, 136, 2, 232-258. Wren-Lewis, S. and R. Driver (1998) "Real exchange rates for the year 2000", Institute for International Economics, Policy Analyses in International Economics.

the approaches reviewed here have important drawbacks, partly reflecting the inherent difficulty of modelling exchange rate behaviour. Apart from the lack of consensus on the appropriate concept of the "equilibrium exchange rate", even models belonging to the same category often send conflicting signals, not only with respect to the magnitude, but also with regard to the direction of the perceived divergence from equilibrium.

However, in the few periods when the vast majority of different models indicate a deviation from "equilibrium" in the same direction, they may support, at least qualitatively, the judgement that the exchange rate was not in line with economic fundamentals. As early as the second half of 1999, the vast majority of these empirical applications recorded some negative deviation of the actual exchange rate of the euro from its measured "equilibrium exchange rate" derived from fundamentals-based models. This assessment was consolidated during 2000, and in autumn 2000 virtually all the models surveyed indicated that exchange rates had moved out of line with

fundamentals. Accordingly, all the models taken together encompass useful information, so that any assessment of, and statement on, the level of exchange rates should initially build to some extent on such a broad-based multi-approach analysis. However, the range of the available estimates – not to mention the additional statistical uncertainty surrounding the estimates in the econometric approaches and the sensitivity of the results to changes in the underlying assumptions in the more structural approaches – precludes any quantitative derivation of the precise extent of the suggested "undervaluation" at that time. No studies have been published that assess these recent developments in terms of exchange rate "equilibria" for 2001.

Another drawback to these approaches is that the models are based on time-series analysis, and thus identify empirical relationships between fundamentals and the exchange rate based on past experience. If factors which were irrelevant in the past have affected recent exchange rate trends, they could be recognised in such a framework only with a significant delay. Correspondingly, regime shifts or structural breaks in the relationships can also be detected empirically only after some time has passed. In the literature, several other factors relating to more institutional changes brought about by the advent of EMU have been claimed to have an influence on the euro exchange rate. For instance, autonomous sources of portfolio shifts not directly related to macroeconomic data, such as the deepening of the European bond market and the relaxation of regulatory constraints on the asset allocation of institutional investors, could be relevant in this connection. While it cannot be excluded that all these changes in the institutional environment have had an effect on recent exchange rate developments, their magnitude is impossible to quantify at this juncture.

4 Conclusions

In the light of the most relevant theoretical approaches, this article has discussed the potential effects on exchange rates of differentials in inflation performance, (real) interest rates and productivity, as well as the impact of fiscal variables, terms-of-trade shocks, the current account balance and the net foreign asset position. Since explanations for exchange rate developments built on single variables only are not likely to be successful, a number of studies identify an association between trends in exchange rates and several economic fundamentals. However, using these approaches, it is difficult to give a precise figure to what could be considered the "appropriate" level of an exchange rate. In spite of this, the approaches discussed in the article are of interest for the policy maker, as they may support an explanation of exchange rate trends and – in exceptional cases – a qualitative judgement on the position of the exchange rate with regard to developments in economic fundamentals.

Given the wide range of available estimates and the statistical uncertainty surrounding them, the issue of the magnitude of exchange rate overvaluation and undervaluation remains to a large extent a matter of judgement. In addition, it cannot be ruled out that actual exchange rate trends have been driven by factors which are not included in fundamentals-based models, or that recent developments are subject to a structural break or regime changes in the institutional environment. If such changes were believed to be under way, this would point to an even greater degree of uncertainty surrounding estimates of a "fair value" for the euro, as their quantitative impact on the exchange rate as well as the extent to which they are of a permanent or transitory nature is highly uncertain. Assuming the absence of major structural breaks in the underlying relationships, virtually all the models surveyed suggested an undervaluation of the euro in autumn 2000, thereby supporting the qualitative judgement that exchange rates had moved out of line with fundamentals.