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THE REAL EXCHANGE RATES OF GERMANY

Jerome L. Stein
Karlhans Sauernheimer

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Center for Economic Studies
University of Munich
Schackstr. 4
80539 Munich
Germany
Telephone & Telefax:
++49-89-2180-3112

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Abstract

First: we explain, within the context of a theoretically consistent model, what are the fundamental external and internal determinants of the real effective exchange rate of Germany. Second: we explain how one should view the real effective exchange rate in evaluating the competitiveness of the German economy.

Jerome L. Stein
Brown University
Department of Economics
Providence, RI 02912
USA

Karlhans Sauernheimer
University of Munich
Seminar für Internationale
Wirtschaftsbeziehungen
Ludwigstrasse 28/II
80539 Munich
Germany

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Historical Background

For very open economies like the Federal Republic of Germany the real effective exchange rate is an economic variable of major importance, where a rise signifies an appreciation. The strength of these exchange rate effects is positvely related to the degree of openess of an economy. Germany is an extremely open economy. The ratio of exports to GDP (in 1990) was 32% compared to 17.5% in the OECD, 11.1% in Japan and 9.8% in the US. In 1991, the ratio of tradables to output (BIS, 1993, graph 19) was 45% compared to about 40% in France and the UK and about 32% in the US. Furthermore, Germany is deeply integrated into the international financial markets. The freedom of capital movements, lack of exchange restrictions and the important role of the DM as a reserve currency second in the world after the US dollar, imply that the securities markets are completely open. The strong dependence of the German economy on the international markets for goods and financial assets has always induced the economic policy in Germany to give a high priority to exchange rate issues.

From 1949 to 1973 Germany had fixed nominal exchange rates as a member country of the Bretton Woods agreement. Towards the end of that time the speculative capital inflows became larger and the speed at which they flowed into the German money and capital markets increased as a consequence of the persistent expectation of DM appreciations. These well known riskless one way speculations in fixed rate systems made monetary control impossible and induced the German government to adopt a floating exchange rate.

From 1973 to 1979 the German Mark floated jointly with some other European currencies, the famous snake. Participants in that agreement changed frequently, contributing more to instability than to stability. In 1979 Chancellor Schmidt and President Giscard d'Estaing initiated a new approach towards more nominal exchange rate stability and started the European Monetary System

(EMS). The eight currencies of the then nine member countries of the EMS were fixed to each other within narrow bands of ± 2.25 % floating vis-a-vis all other currencies. Numerous realignments, exactly 12 between 1979 and 1987, were needed in order to keep the real exchange rates in line with the requirements for internal and external equilibrium. From 1987 to 1992 nominal exchange rate changes were avoided giving the impression that the existing rates were equilibrium rates. This was an illusion. In 1992 the divergent inflation rates led to a collapse of the system and made a realignment necessary[1]. In 1993, speculative attacks tested the stability of the established nominal rates. The central banks were no longer able to defend the fixed parities and agreed to enlarge the bands to ± 15% which means that there is a system of de facto flexible nominal exchange rates within the EMS.

Stylized Facts

We pose the salient stylized facts that a satisfactory theory must explain. Our model is developed in such a way that it explains these stylized facts in a logically satisfactory way. Our model differs from many of the contemporary models which are not consistent with the stylized facts. Many of these facts concern the stationarity of series. A series is defined as weakly stationary if it has a finite mean and variance both of which are independent of time. Thus if the mean of a variable varies with time, it is not stationary. The stationarity results are based upon the Dickey-Fuller or adjusted Dickey-Fuller statistics reported in table 1. All of the data are from the IMF, International Financial Statistics, quarterly, 1973.1-1994.1 except for the starred elements which come from Masson et al and are based upon annual data 1950-1990. When we give the ADF statistic ADF(C,j), the presence of a constant is denoted by C and the number of lagged first difference terms is denoted by j. The significance level is based upon the MacKinnon 10% critical values.

The real exchange rate that we focus upon is the real effective exchange rate as reported in the International Monetary Fund's International Financial Statistics. It is the ratio of domestic to foreign normalized unit labor costs in a common

[1]From 1987 through 1992, the rate of inflation of the GDP deflator was 6.2% pa in the UK, 6.5% pa in Italy but only 3.0 % pa in France and 3.3% pa in Germany. Italy and the UK were forced to withdraw from the ERM in 1993.

currency. The weighting scheme used to construct the rates is based upon disaggregated data for trade among the seventeen industrial countries in manufactured goods for 1980. The weights reflect the relative importance of both a country's trading partners in its direct bilateral trade relations and competition in third markets. Normalized unit labor costs in manufacturing (w,w') are calculated by dividing an index of actual hourly compensation per worker (W,W') by a five-year moving average index of output per manhour (A,A'). We may express the real effective exchange rate R as equation (1). Foreign variables are denoted with a prime. The nominal effective exchange rate is denoted by N. A rise in N or R signifies an appreciation. The first term (NW/W') refers to nominal magnitudes and the second term (A'/A) refers to real magnitudes. An appreciation can occur either because relative nominal wages rise faster than the depreciation of the currency or because foreign productivity A' rises faster than domestic productivity A.

(1) $R = N\, w/w' = (NW/W')(A'/A)$ $\qquad w=W/A,\ w'=W'/A'$

First: the real effective exchange rate of Germany (GRREU) is not stationary. The mean of R is not independent of time. The same is true for the US-German CPI based exchange rate: The CPI based real exchange rate , measured as the nominal exchange rate N (dollars/DM) divided by the US to the German CPI, is not the same as the real effective exchange rate. However, neither real exchange rate is stationary. Second: the real effective (GRREU) and nominal effective (GRNEU) exchange rates move together(figure 1).

The first two facts mean that we cannot explain the rising nominal effective value of the DM on the basis of the purchasing power parity PPP theory. It is often claimed that the appreciation of the nominal value of the DM is primarily due to the German anti-inflationary monetary policies. This view would imply that the nominal DM/$US should be positively related to the ratio of money/real GNP in Germany (M/y) compared to that in the US (M/y)'. We compared[2] the nominal

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[2]All our data are from the IMF, International Financial Statistics.Germany is referred to with the prefix GR and the US by the prefix US. The numbers refer to the row in the IFS. The hypothesis is that : (1a) DM/$US = a + b(M/y)/(M/y)'. The German nominal price of the dollar DM/$ = GRae, the money per unit of output in Germany is (M/y) = (GR38nbc/ GR99ar) and in the US it is (M/y)' = (US59mbc/US99br). Hence the variable on the right hand side of (1a) is (GR38nbc/ GR99ar) / (US59mbc/US99br), and the

DM/$ with the ratio of M3 to German GNP in 1985 prices to M2 to GNP in 1985 prices in the US. We find that the nominal DM/$ is not cointegrated with German/ US money stocks per unit of output. The ADF(C,0)= -1.88 is not significant even at the 10% level. One cannot explain the movement of the nominal DM/$US by the movement of money/real GNP in Germany relative to the US. This is another example of the failure of monetary theories of the exchange rate.

Third: The terms of trade, the ratio of German export prices to import prices in unit values, are not stationary. The real effective exchange rate and the German terms of trade often exhibit similar trends, but these variables are not the same[3]. The Granger causality seems to run from the terms of trade to the real effective exchange rate, and not the reverse way[4]. Figure 2 plots[5] the normalized values of the real effective exchange rate (GRREU) and terms of trade (GRTOT).

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sample period is 1973.1 -1994.2. In this context, a rise in DM/$ implies a depreciation of the nominal DM.

[3]The real effective exchange rate GRREU=Nw/w', the ratio of unit labor costs in the tradable sectors at home relative to abroad. The terms of trade $T=p_x/p_m=q_x/q_m$, where p_x is the price of the German export good, p_m is the German price of the import good which may well be produced at home, and q_x and q_m are the corresponding prices abroad. T and GRREU are different concepts.

The relation between the terms of trade and a measure of the real exchange rate depends upon what measure of the real exchange rate used. If we used the CPI- US/German exchange rate, then there is a two way Granger causality between the German terms of trade and the CPI US/German exchange rate. This is not surprising. Supposed we considered the CP I deflated exchange rate $R= N (p_x)^a (p_m)^{(1-a)} / (q_x)^b (q_m)^{(1-b)}$. The German consumer prices of German exports are p_x,with weight a, the consumer prices of the German import competing goods are p_m, with weight (1-a), the consumer prices of the US goods which compete with German exports are q_x with weight b and those which compete with the German goods which are also imported are q_m with weight 1-b. The nominal exchange rate N=$US/DM. Then the CPI real exchange rate can be expressed as:

$R = (Np_m/ qm) T^{(a-b)}$, where Tis the terms of trade. The imported goods consisting of materials such as oil may follow the law of one price. If the "law of one price" for imported consumer goods were applied to these aggregates of traded goods, then $(Np_m/ qm) =1$ and $R=T^{(a-b)}$. That is, the CPI real exchange rate would be a closely related to the terms of trade. In general, the goods x are not the same in Germany and in the other countries but are substitutes.

[4]The Granger causality tests are sensitive to the lag strucure used, so they should be interpreted cautiously.

[5] Sometimes in our graphs, we use the normalized value of a variable X to facilitate comparisons. A normalized value of X is: (X - its mean)/standard deviation. Thereby, we avoid choosing an arbitrary base period and the graph shows the variation in X as a given number of standard deviations from its own mean.

Fourth: The ratio of German net foreign assets to GNP (GRNFA) is not stationary. German net foreign assets are external assets less external liabilities. Germany started as a debtor in 1950 and rose to a large creditor in 1989 before unification[6].

Fifth, the ratio of the current account/GNP from 1973.1-1989.4 is not stationary. The series is seasonal so we calculate a four quarter moving average of the current account/GNP, adjusted for the rate of capacity utilization. The series (described in figure 9 as GRCAGNP1) shows significant swings. Stylized fact four leads to the questions: what produced the movement of Germany from a debtor country to a major creditor? What produced the run of current account surpluses until German reunification, even though the real effective exchange rate was appreciating since 1985?

The so called "intertemporal budget constraint" (IBC) assumption made in many recent models seems inappropriate. This IBC assumption claims that the behavior of economic units is constrained to ensure that the initial and terminal values of the foreign debt or assets will be the same; and it excludes movements from creditor to debtor between initial and terminal points. Alternatively, the IBC assumes that the current account/GNP is stationary at zero. It is not clear what operational or empirical content the IBC assumption has for a sovereign country. However, stylized fact four questions the applicability of this assumption to Germany[7].

Sixth:since 1980, the German real long term rate of interest (GRINT) converges to the US real long term rate of interest (USRINT). See in figure 4. We measure the real long term rate of interest by the nominal yield on bonds less the rate of

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[6]The data for German net foreign assets/GNP are from Masson, Kremers and Horne (table 6, 1993). They are annual data.

1950	-0.04	1970	0.0661
1960	0.0350	1980	0.0345
		1989	0.201

[7]The IBC assumption is not applicable either to the US , which went from a large creditor to a large debtor in recent years, or to Japan which went from a large debtor in 1950 to a large creditor in 1990.

inflation of the CPI over the past four quarters[8]. The real long term rate of interest differential is stationary at an expected value of zero. For the period 1980.1-1992.3, the ADF(N,1)= -2.28 (MacKinnon 10%=-1.6). No constant (N) was used because the constant was not significant. The German real long term rate of interest is Granger caused by the US rate, and not the reverse.

The significance of stylized fact six is that the Germans do not control their real long term interest, but that it converges to the externally determined US real long term rate of interest. Germany is "small" in the international financial markets, and there is no risk premium on long term assets.

Seventh: the short term capital flows involving banks are stationary, with an expected value of zero. The ADF(N,0)= -8.0 which is significant at the 1 % value

Eigth. The real effective exchange rate is generally viewed as an inverse measure of competitiveness. How can one explain the phenomena from 1985 to 1987 where there was a rapid appreciation of of the real effective exchange rate and a rise in the current account/GNP?

The rationale of the Natural Real Exchange Rate (NATREX) : an intuitive summary of the model and the significance of the approach

The real exchange rate is a crucial variable in affecting the allocation of resources in the very open German economy, and it profoundly affects the competitiveness of the economy. The NATREX is the real exchange rate, consistent with internal and external balance. External balance is the situation where the current account plus the nonspeculative capital inflow sum to zero, when there is internal balance such that actual output is equal to capacity output. NATREX corresponds to Nurkse's concept of the equilibrium exchange rate produced by the fundamentals. Speculative capital flows, for example based upon anticipations of nominal interest rate changes at home and abroad, and cyclical variations in the ratio of actual to capacity output are not included in what we consider to be the fundamentals, but produce deviations of the actual real exchange rate from the NATREX.

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[8]The results concerning convergence are not sensitive to alternative reasonable measures of inflation.

It is important to understand the fundamental determinants of the real exchange rate. For example domestic factors, such as rises in nominal unit labor cost relative to productivity, may or may not be induced by changes in the NATREX. If they are not reflecting changes in the NATREX, then the real effective exchange rate (equation 1) exceeds the NATREX. The initial rise in the real effective exchange rate is not sustainable . The German economy will lose competitiveness; and the ratio of the current account to GNP will decline. There will be downward pressure on the nominal value of the currency or in relative prices and the real effective exchange rate will converge to the NATREX. We consider a currency over or undervalued insofar as the real effective exchange rate exceeds or is less than the NATREX.

The fundamental determinants of the NATREX are productivity and social thrift at home and in the rest of the world. These are the exogenous variables subsumed under vector Z. Time preference and productivity govern the saving and investment decisions, derived from intertemporal optimization when the agents know that the future disturbances to Z are unknowable and that they do not have perfect quantitative knowledge of the economic structure. The analysis has four aspects: (i) the medium run and the longer run, and (ii) whether the productivity or thrift variables have changed. The NATREX is a moving equilibrium concept consistent with internal and external balance. It is not a normative concept, but is a concept of postive economics. NATREX is a benchmark which explains the longer run movements in the real exchange rate.

We believe that the NATREX model is a general model which is not sensitive to to the many current controversies concerning specific forms of the structural equations. For this reason, we present the intuition behind the model before we specify the structural equations.

Medium run effects

A rise in the productivity of capital or a decline in social(public plus private) thrift leads to a rise in investment less saving. We may view this gap in two ways. There is a rise in the excess demand for goods. Similarly, the excess of investment over saving means that some of the investment is financed abroad.

There is a nonspeculative capital inflow. The real exchange rate can appreciate in two ways. The capital inflow which finances investment less saving appreciates the nominal exchange rate. Alternatively, if the rise in excess demand is mainly for domestic goods, there will be a rise in the ratio of domestic to foreign trade weighted unit labor costs measured in a common currency (equation 1) . It makes no difference in the model whether the real exchange rate appreciates because the nominal exchange rate appreciates or if the appreciation occurs because domestic nominal unit labor costs rise relative to the foreign nominal unit labor costs.

Longer run effects

Whereas higher capital productivity and lower time preference have the same effects upon the real exchange rate in the medium run, the longer run effects are different. In the longer run, the NATREX approach includes two stock adjustment processes. These stock adjustments come about because when the goods market clears in the medium run, there may be net investment and current account deficits or surpluses. The net investment changes the capital stock and the current account deficits or surpluses change the foreign debt. Either one of these changes wealth. There is then a feedback from the changes in the capital stock, foreign debt and wealth to investment, saving and the current account. This will then change the real exchange rate which equilibrates the goods market.

In a dynamically stable system, the capital and debt intensities converge to steady state levels. In the process, the real exchange rate converges to a steady state level. The trajectories to the steady state as well as the steady state will depend upon whether the initial disturbance was to the productivity of capital or the social saving ratio. If the disturbance lowered the social saving ratio, for example because government expenditures increased or tax rates decreased relative to GDP, the initial appreciation will change to a depreciation. The reason is that the current account deficits increase the foreign debt, which results in higher interest payments to foreigners. This tends to decrease the current account. A country could change from a creditor to a debtor, as a result of a rise in its time preference. Since the debt stabilizes in a dynamically stable system, the real exchange rate will depreciate to produce a trade surplus which will

finance the interest payments to foreigners. The new steady state real exchange rate is below its initial value.

A different trajectory occurs when the initial disturbance raises the productivity of capital and the rate of investment. The initial current account deficits finance capital formation and the capital intensity rises to a higher level. The higher capital raises real GDP and the rise in real GDP raises saving. Eventually, the induced rise in saving exceeds the rate of investment. As the capital stock converges to its new steady state value, and there will tend to be current account surpluses. The foreign debt will decline below its initial level, and the country can convert from a debtor to a creditor. The rise in interest income from abroad, or the decline in interest payments to foreigners, tends to appreciate the exchange rate. However, the rise in wealth tends to raise the value of imports relative to exports and tends to reduce the trade balance. The development of the real exchange rate is ambiguous in that case.

The NATREX model states that the real effective exchange rate observed at any time R(t) is the sum of two elements.The first is the NATREX which is a function of capital k(t), foreign debt F(t) and the real fundamentals Z(t), denoted R[k(t),F(t);Z(t)]. The second term is the deviation of the real effective exchange rate from the NATREX. The deviation e(t)=[R(t) - R(k(t),F(t);Z(t))] can be produced in several ways. (i) It may result from short term speculative capital flows, produced by anticipations, for example of nominal interest rate changes at home and abroad. (ii) It may result from cyclical factors measured by the rate of capacity utilization. (iii) It may result from labor market pressures which raise nominal unit labor costs, in a way not related to our fundamentals. We show that the deviation is stationary with an expectation of the deviation is zero, but will be serially correlated. Figure 3 shows how the real effective exchange rate (GRREU) converges to the NATREX.

$$(2)\ R(t)= N(t)w(t)/w'(t) = R[k(t),F(t);Z(t)] + [\ R(t) - R(k(t),F(t);Z(t))\ ]$$
$$= R[k(t),F(t);Z(t)] + e(t)$$

The variance of the disturbance e(t) is high so that there are large fluctuations in the real effective exchange rate in the short run. However, these variations average out to zero. The real effective exchange rate converges to the

NATREX, because deviations of the real effective exchange rate from the NATREX affect the competitiveness of the economy and produce current account changes. However, the NATREX is a moving equilibrium R[k(t),F(t);Z(t)] because capital, debt and the fundamentals are not stationary.

The relation of NATREX to PPP

The NATREX model states that the real exchange rate which produces internal and external balance is a function of the endogenous capital and debt and exogenous vector Z, of productivity and thrift at home and abroad. We indicated how the different elements of Z exert different effects upon the equilibrium real exchange rate. If the disturbances are such that the NATREX has a constant mean, then the real effective exchange rate will also have a constant mean. This is the purchasing power parity theory (PPP). If the disturbances are such that the NATREX does not have a constant mean, then the real effective exchange rate will not be stationary. Thus the PPP theory is a special case of NATREX which has has a constant mean. We observe in table 1 that the real effective exchange rate is not stationary. This is not surprising because the fundamentals: the terms of trade, German/US productivity , German and G7 social time preference are not stationary. Figure 3 graphs the real effective exchange rate (GRREU) and the estimated NATREX. Since the fundamentals do not have means that are independent of time, the natural real effective exchange rate is not independent of time.

The Competitveness of the German Economy

The Bundesbank has been concerned with indicators of the competitiveness of the German economy. Changes in our fundamentals: the terms of trade, productivity and thrift at home and abroad, which affect the gap between saving and investment at capacity output, simultaneously affect both the current account and the real effective exchange rate. There are two aspects of competitiveness. First, is the endogenous response of the current account to the fundamentals and the real exchange rate. This is the transfer mechanism which finances investment less saving. Second, is the response of the current account to a change in the real effective exchange rate which does not correspond to changes in the NATREX. This may arise from labor market pressure upon unit

labor costs, not justified by the fundamentals. When the real effective exchange rate exceeds the NATREX, the competitive position is adversely affected. We are able to explain movements in the current account in terms of these two factors: the transfer and the competitiveness . Just looking at the real effective exchange rate as a measure of competitiveness is misleading.

The NATREX model

Our optimization and structural equations are more general than the standard approach. Our optimization is based upon the view that the agents know that they do not and cannot know the evolution of the fundamentals and do not have perfect knowledge of the structural equations of the system. The real exchange rate and the underlying fundamentals vector Z are not stationary. Nobody can predict the values of Z(t) in the future. Therefore the NATREX model uses Dynamic Programming, sub-optimal feedback control optimization, and rejects the perfect foresight or Muth Rational Expectations Approach[9]. The dynamic programming approach:sub-optimal feedback control optimization, unlike the Maximum Principle approach, guarantees that the economy will converge to the unknown and changing optimal steady state.

Sovereign countries do not have the intertemporal budget constraint, which requires that the initial and terminal debts be the same. We allow countries to change from debtor to creditor, and vice-versa. Germany moved from a debtor to a creditor status from 1950 to 1990. We know that the US moved from a creditor to a debtor. The foreign debt is an endogenous variable determined by the exogenous fundamentals. Our intertemporal budget constraint is that the foreign debt stabilize, and not explode. Then, the current account will be zero: the trade balance pays the interest.

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[9]The Muth Rational Expectations hypothesis is that the economic agents know the distributions of the exogenous variables and know the model and its parameters perfectly. The MRE hypothesis makes the ad hoc assumption that excludes speculative bubbles, even though the solution of the MRE model implies that there is a positive eigenvalue. This assumption is not part of the model and has no theoretical justification within the MRE framework. Second, there is no theory to explain the speed at which the economy arrives at MRE. See Stein (1992a)(1992b).

Equations (3)-(7) describe the NATREX model that we are using[10].There are five basic endogenous variables and five basic equations. The endogenous variables are: the real effective exchange rate (NATREX) , the real long term interest rate, the capital intensity, the debt intensity and the current account. The model assumes that actual output converges to capacity output, but we do not discuss the mechanism whereby output converges to capacity output[11] . Equation (3) states that the NATREX is the real exchange rate which produces basic balance of payments equilibrium at capacity output, where the current account plus the nonspeculative long term capital inflow sum to zero. The NATREX corresponds to Nurkse's definition of "the equilibrium" exchange rate. We associate the nonspeculative long term capital inflow with investment less saving , or absorption plus the trade balance less capacity output, in the following way.

Desired investment less saving I -S, equal to absorption plus the trade balance less capacity output A+B - y, is the excess flow supply of tradable long term securities plus nontradable long term securities plus short term securities plus domestic money. Our medium run equilibrium conditions assume that: the domestic long term nontradable plus short term capital flows are zero and the excess supply of money is zero. We know from stylized fact seven that the short term capital flows reflected on bank balance sheets are stationary with an expected value of zero. We are justified in excluding them from an equilibrium concept of the real exchange rate.Under these conditions I - S corresponds to the nonspeculative long term capital inflow, denoted LTK. Equation (3) states that in the medium run, (a) the basic balance of payments is zero: the current account plus the nonspeculative long term capital inflow sum to zero. CA + LTK=0, or (b) absorption plus the trade balance is equal to capacity output A+B-y=0. The current account CA=B - rF is the trade balance B less interest payments to foreigners rF, where r is the real long term interest rate and F is the foreign debt (+) or net foreign assets (-).

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[10] The NATREX model is the subject of Stein, Allen et al, (1995,), Stein (1994b) (1994c). The reader is advised to see Polly Reynolds Allen, "The Economic and Policy Implications of the NATREX Model" for a lucid ,self contained, nontechnical exposition of the model .

[11]For the US economy, the dynamics of unemployment and inflation are analyzed in Stein (1994a) Can the Central Bank Achieve Price Stability, Federal Reserve bank of St Louis, Review, March/April..

The real exchange rate NATREX is the relative price that produces balance of payments equilibrium evaluated at capacity output. This is R in equation (3). Variations in the real effective exchange rate affect the competitiveness of the German economy[12] and thereby produce the equilibrium in equation (3). We now explain the trade balance and how we determine the competitiveness of the German economy. The trade balance B depends positively upon the profitability of the tradable sectors Π and negatively upon the level of GNP= y - rF which affects import demand. Thus B = B(Π, GNP) is the trade balance equation. The competitveness of the tradable sector depends upon the profits generated. Therefore, the determinants of the profits in the tradable sector are the indicators of competitiveness.

An indicator of competitiveness would tell us when the trade balance will increase or decrease. The profit function in the tradable sector is equation (4a). The profit function is a function of output and input prices and the level of technology. Let output of tradables be $y_t = y(x, x'; A)$, p= the price of tradables in domestic currency, w=W/A=the unit labor cost, x= input of labor, w'/N =the price of imported materials in domestic currency and x' =the quantity of the imported materials.

(4a) $\Pi(p, w, w'/N) = \max [p\, y_t(x,x') - wx - (w'/N)\, x']$

The profit function has three characteristics.(i) It is nondecreasing in output price p and nonincreasing in input prices w, w'/N. (ii) It is homogeneous of degree one in all of the prices.(iii) It is convex in p and w, w'/N. We may therefore write the profit function as (4b). Profits increase when there is an increase in Np/w', and decrease when Nw/w' rises.

(4b) $\Pi(p, w, w'/N) = (w'/N)\, \Pi(Np/w', Nw/w')$

We now associate the measurable concepts of the model with the elements of the profit function. The terms of trade are the ratio of export prices to import prices. Materials are a major component of imports. The terms of trade T would correspond to Np/w'.

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[12]The relation between the real effective exchange rate (REU) and those based upon broad based price deflators, as well as the issue of competitiveness, are discussed below.

The real effective exchange rate R=Nw/w' is the ratio of German to foreign unit labor costs. The German unit labor costs are Nw measured in foreign currency; and w' represents foreign unit labor costs proportional to foreign prices[13]. Therefore Nw / w' in the profit function is measured by the real effective exchange rate. An appreciation of the real effective exchange rate reduces profits and hence competitiveness. A rise in productivity A lowers, and a rise in the nominal wage W raises, unit labor costs w=W/A.

(4c) $\Pi = \Pi(R, T)$

With these correspondences, the trade balance depends upon the profit function $\Pi(R, T)$ in tradables. From (4c) the trade balance B is a positive function of: the terms of trade and is negatively related to the real effective exchange rate. We also know that imports depend upon GNP which is y - rF. Therefore the current account is equation (4).

(4) $CA = B[\Pi(R, T), y(k;u) - rF] - rF = B(y(k;u), R; Z) - rF,$

where R is the endogenous real effective exchange rate and the exogenous terms of trade is an argument in Z.

Equation (3) states that the NATREX real exchange rate is the value of R such that there is external equilibrium: the capital outflow S-I is equal to the current account, evaluated at capacity output. The curve IX in figure 5 is the set of real exchange rates and real long term rates of interest which satisfies equation (3). It is negatively sloped because a rise in the real rate of interest lowers absorption relative to capacity output. A depreciation of the real exchange rate will increase the competitiveness of the economy and increase the trade balance, to offset the interest rate effect.

The real exchange rate will be driven to the NATREX, which is the value of R along the IX curve, i.e., which satisfies equation (3). The the mechanism of adjustment of the real exchange rateto the IX curve is equation

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[13]We use w' as an index of foreign prices, in general.

(3a) $dR/dt = H [A(k,F,r;z) + B(y(k;u), R, F; Z) - y(k;u)], \quad H'>0; B_R<0$

If $CA + (I - S) = CA + LTK = A+B-y$ is positive, then : (i) there is an excess demand for the German currency relative to foreign currency. (ii) There is an excess demand for German goods at capacity output. Then either (i) the nominal DM will appreciate.or (ii) domestic unit labor costs will rise relative to their foreign counterparts. If the nominal exchange rate were fixed, reserves would rise and this would lead to a rise in money per unit of output. The nominal wage would rise. In either case, the real effective value of the DM will appreciate. Since the trade balance is negatively related to the real value of the currency, the real exchange rate will converge[14] to the NATREX.

Equation (5) states that German and US long term assets are close substitutes and there is no risk premium. Investors have long horizons and contemplate both direct and portfolio investment.The dominant long rate of interest in the G7 is the US rate. The expected real return on domestic long term assets is the real long term rate of interest r plus the expected long term appreciation of the DM which is the average annual E(DR) over a long horizon. The expected return in the G7 is the real long term US interest rate r'. Using all available information, the investors know (table 1) that the real effective German exchange rate R(t) is integrated of order 1 such that the first differences are stationary with E(DR)=0. Therefore, in making their long term investment decision, they just contemplate the real long term interest rate differential (r-r'). Figure 4 compares the German (GRRINT) and US real long term interest rates (USRINT). As is clear from figure 4, table 1 and stylized fact six, the differential (r-r') is stationary and its expected value is zero.

The portfolio balance equation (5) is that German real long term rates move towards the US level. The PB curve in figure 5 describes portfolio balance, when the German real long term rate has converged to the US rate.

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[14] In (3a), $\delta(dR/dt)/\delta R = H' B_R < 0$.

The NATREX Model

(3) $A(k,F,r;z) + B(\ y(k;u),\ R,\ F;\ Z) - y(k;u) = CA\ - (S - I\ ) = 0$

(4) $CA = B(\Pi(R,T),\ y - rF) - rF = B(\ y(k;u),\ R;\ Z) - rF$

(5) $d\ (r-r')/dt = -a(r - r')$

(6) $dk/dt = J(q) = J(k;Z) \qquad J_k<0$

(7) $dF/dt = J(k;Z) - S(k,F;Z) = L(k,F;Z) \quad L_k=J_k-S_k<0;\ L_F=-S_F<0$

Endogenous variables: R=NATREX=equilibrium real effective exchange rate , k=capital intensity; F=foreign debt intensity, positive for debtor, negative for creditor, r=real domestic long term interest rate; CA=current account. Exogenous variables, the fundamentals Z=(T) terms of trade, (r') real long term G7 rate of interest, (k') G7 capital intensity, productivity of capital (u), index of time preference (g). .

Equation (6) is the investment equation. In the standard optimal growth models, the Maximum Principle is used to derive the optimal rate of investment. This is an open loop control where we must have perfect knowledge. We must know with certainty the steady state capital intensity, denoted k*, and the production function. Then the optimal growth path is a saddle point path. The slightest error in our knowledge, the slightest deviation from the path, will send the economy off on an errant trajectory; and the economy will never reach the steady state. The use of the Maximum Principle is not feasible in economics because we do not have perfect knowledge and the unknown steady state is changing with the production function. That is, one cannot be forward looking with perfect knowledge; and if there is not perfect knowledge, the economy will travel along an errant trajectory and never reach the optimal steady state.

For this reason, Infante and Stein (RES, 1973) developed a closed loop suboptimal feedback control (SOFC) based upon dynamic programming. We proved that if the rate of investment is a nonlinear function of the difference between the current marginal product of capital y'(k(t) ;u(t)) and the social discount rate then the trajectory of the rate of investment will be very close to the unknowable optimal trajectory . Our SOFC is guaranteed to home in on the unknowable optimal steady state capital intensity, and will be extremely close to the unknown optimum path. Disturbances will occur all of the time to the production function, which will change the currently measurable marginal product of capital and the unknown steady state. Our rate of investment will be

adjusted, and will home in on the unknowable optimal trajectory. We have synthesized the optimal control for the realistic situation that there is not perfect knowledge and that the basic parameters are changing in an unknowable way. All that we require are observable measurements of the marginal product of capital.

Infante and Stein analyzed the situation for an economy where the saving and investment decisions are identical. When saving and investment decisions are made independently, and when the capital good is not the same as the output, then Stein (1994)(1995, ch.2,3) made two changes in the SOFC. The optimal rate of investment is a nonlinear function of the Keynes-Tobin q-ratio based upon current measurements of variables, $dk/dt=J(q)$ in equation (6). The q-ratio based upon current measurements is (6a) below. The output is assumed to be primarily[15] in the export good whose current price is p_X. The capital good is a composite of the export good (x) and the import good (m). The price of the capital good is $p_K=p_X^{a}\, p_m^{(1-a)}$, where a and 1-a represents the weights of the export and import good.

$$(6a)\quad q = \int_t^s (p_X/p_K)\, y'(k(t);u(t))\, e^{-rv}\, dv = T(t)^{1-a}\; y'(k(t);u(t)) / r.$$

where v goes from t to s, and s goes to infinity.

The q-ratio used is based upon current measurements of the marginal physical product of capital $y'(k(t);u(t))$, and the price of the export good. Making the substitution for the price of the capital good, the relevant q-ratio is positively related to the current terms of trade T(t), the current marginal physical product of capital $y'(k(t);u(t))$, and negatively to the current real rate of interest r.

The rate of investment dk/dt will be positively related to the q-ratio so defined. When $q>1$ then the rate of change of the capital intensity will be positive and when $q<1$, the rate of change of the capital intensity will be negative. In the steady state, the capital intensity $k=k^*$ such that $q=1$ or $T^{1-a}\; y'(k^*;u) = r$. We

[15]The output and capital goods could be weighted averages of export, import and nontraded goods, without changing the basic argument.

include the terms of trade T in our vector Z of fundamentals and obtain investment equation (6) .

Equation (6) is described by the J=0 curve in figure 6. At $k=k^*$, the q-ratio is unity and the capital intensity is not changing. When k is less (greater) than k^*, then q is greater (less) than unity, and the capital intensity rises (declines). The horizontal vectors describe this movement.

We may work with almost any saving function which satisfies our intertemporal budget constraint. A very general saving function that will do that is $S=S(k,F;Z)$ that saving is positively related to the foreign debt $\delta S/\delta F > 0$. Saving is GNP less public plus private consumption. GNP is GDP less interest payments to foreigners ($GNP=y(k;u) - rF$) and social consumption must be a function of wealth $C=C(k,F;Z)$ which involves capital less debt. The saving will be positively related to the foreign debt if $\delta S/\delta F > 0$, a rise in the debt reduces consumption (via a reduction in wealth) by more than it reduces GNP. A rise in capital increases wealth and GDP and we expect that to raise saving, $\delta S/\delta k > 0$. All of the decisions are based upon current measurements of variables and are guaranteed to drive the system to the steady state, regardless of the disturbances.

We must allow the terms of trade to affect saving, if the model is to be able to explain the evidence discussed below that an improvement in the terms of trade raises the current account. Recall that the current account is equal to saving less investment. Therefore, a rise in the terms of trade must raise saving less investment if the current account is to rise. We explain $S_T > 0$ in the following way. Saving is GDP less consumption. Let the main component of GDP be the export good, whose price is p_x, and the main component of consumption is the import good, whose price is p_m. Then saving is equation (7a). Insofar as we measure the real variables in terms of the export good, real saving is (7b). Real saving is then positively related to the terms of trade T, an element of Z.

(7a) $S = p_x\, y(k;u) - p_m C$

(7b) $S/p_x = y(k;u) - C(k,F;Z) \,/\, T = S(k,F;Z)$

A crucial exogenous parameter of the social consumption function is an index of time preference g=(private plus government consumption) /GNP, where g is an element of Z. A rise in the cyclically adjusted government budget deficit, not offset by a decrease in private consumption, is a rise in g. Or, a change in the demographic composition of the population towards groups whose consumption to income ratio is high (very young, old) will also raise the index of time preference. We shall see that the private time preference, reflected by the consumption/GNP ratio, is stationary. However the government time preference, reflected by the ratio of government consumption/GNP, is not stationary. Insofar as we do not make a distinction in the model between private and public consumption, we work with the sum of the two: the time preference measured by the ratio of public plus private consumption/GNP, corrected for cyclical variations in the ratio of actual to capacity output.

The rate of change of the foreign debt dF/dt is equation (7), equal to investment less saving equal to the current account deficit. We most definitely do not have the standard intertemporal budget constraint that the initial and terminal values of the foreign debt are equal.The foreign debt is an endogenous variable, and countries may and do change from debtor to creditor and vice-versa. Our intertemporal budget constraint is that the value of the foreign debt converges to a steady state (denoted by an asterisk) value F*, and that the system is dynamically stable: that is, the debt does not explode. In the steady state, where the debt is constant, investment less saving equal to the current account deficit is equal to zero. Then, the trade balance B* must equal the interest payments rF* on the foreign debt.

The curve dF/dt=(J-S)=L=0 in figure 6 is the relation between debt and capital such that investment less saving (J-S)=L=0. Since we have goods market clearing along the IX curve, function (J-S) is equal to the current account. Along the L=0 curve, the current account is zero, and the foreign debt is not changing. It is negatively sloped for the following reason. A rise in capital raises saving less investment, which produces a capital outlflow and reduces the debt. Hence the slope is negative.

Given capital, the debt converges to the L=0 curve. A rise in the foreign debt above the L=0 curve, reduces wealth which reduces consumption and raises

saving. The rise in saving less investment produces a capital outlow which reduces the foreign debt back to the L=0 curve. The element of stability $\delta(dF/dt)/\delta F < 0$ produces our intertemporal budget constraint, whereby the debt stabilizes at value $F^*(Z)$.

This completes the exposition of the model. There are five crucial variables: the real effective exchange rate, the real long term rate of interest, the capital intensity, the debt intensity and the curent account. The exogenous variables are: productivity and thrift (index of time preference), the world real rate of interest, the terms of trade, foreign capital and foreign demand. Our optimization is more general, realistic and operational than is the standard approach. We use a feedback control guaranteed to drive the economy to the steady state in a manner which does not require perfect knowledge and is robust to perturbations.

Solution of the Model

The real exchange rate which produces external balance at capacity output, when there is also portfolio equilibrium, is described by equation (8). It is the simultaneous solution of equation (3) and the portfolio balance equation, the equilibrium solution of equation (5). Equation (3) is graphed as the IX curve, and the portfolio balance is graphed as the PB curve, in figure 5. The dynamics of adjustment are equations (3a) and (5).

(8) $R(t) = R [k(t), F(t); Z(t)]$

When there is both goods market and portfolio balance, the q-ratio need not be equal to unity nor need investment less saving, equal to the capital inflow, be equal to zero.In that case, the capital and foreign debt will vary according to equations (6)(7). These variations, as well as variations in the fundamentals, produce movements in the IX curve. Hence the NATREX in equation (8) is not stationary, and neither will be the observed real effective exchange rate.
Figure 6 describes equations (6) and (7), the endogenous movements in capital and debt. The curve $dk/dt=J=0$ indicates the capital intensity k^* where the q-ratio is unity. Then the marginal product of capital is equal to the world real rate of interest, equation (9). The capital stock converges monotonically to k^*, in the direction of the horizontal vectors.

(9) $T^{1-a}\, y'(k^*;u) = r'$,

When the debt converges to its steady state level F* on the L=0 curve, investment less saving equal to the current account is zero. This means that the trade balance is equal to the interest payments, equation (10), where the asterisk denotes a steady state value.

(10) $B(\, y(k^*;u),\, R^*,\, F^*;Z) = r'\, F^*$

Equation (8) and figure 5 describe the NATREX at any time, as a function of capital, debt and the fundamentals. Equations (6)(7) and figure 6 describe the trajectories of capital and debt. Equations (9)(10) describe the steady state values of capital and debt, which then affect the steady state value of the NATREX in equation (11).

(11) $R^* = R[Z(t)]$

The exogenous fundamentals Z=(Z',Z'') involve foreign and domestic variables. The NATREX is an equilibrium rate. Cyclical and speculative factors are not considered in the set of fundamentals, but affect the deviation of the real effective exchange rate from the NATREX, term e in equation (2). We first examine the data and then show how the NATREX model explains the empirical phenomena.

Data

We use the data that correspond as closely as possible to the variables in the theoretical analysis. The source and measurement of the data are explicitly cited in the notes to table 3. A general discussion of the data, their strengths and limitations, is the subject of this section.

The real exchange rate in the model is the relative price that produces external balance CA + (I-S)=0, where the current account CA is the trade balance less interest payments to foreigners. We have elected to use the real effective

exchange rate (REU in the International Financial Statistics) based upon the analysis in connection with equation (4) above.

The measure we use of time preference is the ratio of social consumption to GNP, denoted DISRAT for "discount rate", adjusted for variations in the rate of capacity utilization. For Germany we use the sum of goverment consumption and private consumption to GNP as our measure of time preference. The NATREX model abstracts from variations in the rate of capacity utilization, hence we adjust our fundamentals for cyclical factors. This is done by regressing DISRAT on the rate of capacity utilization and taking the residual GRDIS1 as our index of time preference for Germany. For the G7, the time preference index is G7DISRAT=G7 governrnent expenditures plus private consumption / G7 GNP, since we do not have data on how much of G7 government expenditures is consumption. Moreover, we do not need to adjust the G7 variable for their rate of capacity utilization since that is external to Germany.

We have excluded the G7 (US) real long term rate of interest from our vector of exogenous variables Z in the econometrics because the real G7 long term rate of interest must be determined by productivity and thrift in the G7 which are already included in Z.

Figures 7a-7c describe the evolution[16] of DISRAT. We plot the ratios of private (GRC1 fig. 7a) consumption/GNP and government (GRGC1 fig. 7b) consumption/GNP , both adjusted for the rate of capacity utilization. Both ratios of private and government consumption/GNP have trended downwards. However, the private adjusted consumption ratio GRC1 is stationary, whereas the govenment adjusted ratio GRC1 is not stationary. Therefore, the reason that total German time preference GRDIS1 in figure 7c has trended downwards is that German government consumption/GNP has trended downwards. We use the total GRDIS1 because we want to avoid two problems. First: the social consumption ratio could rise because of variations in tax rates. That would affect the private consumption ratio. Second, we avoid the controversy concerning Ricardian equivalence, which is irrelevant to our analysis.

[16]The effect of the policies followed by Schmidt and Kohl upon DISRAT are discussed below.

The most difficult variable to measure is the parameter of productivity u in the production function y(k;u) in Germany and abroad. In terms of the econometrics, we would like a variable which relects the'productivity parameter u and is also integrated or order one, I(1). Since it is impossible to measure u, we use the productivity of labor in the tradable sectors in Germany, which is primarily industrial production. GRPROD1 reflects y(k;u) in Germany . We adjust productivity for the rate of capacity utilization. GRPROD1 is the residual of a regression of industrial production/worker on the rate of capacity utilization. For productivity in the G7 we use the US industrial production/nonagricultural employment (USPROD) . The fundamental variable GRUSPROD1= (GRPROD1) / (USPROD) is used to reflect the productivity in Germany relative to the G7..

Econometric Methodology and Results

The theory and econometrics can be related as follows. The evolution of the real exchange ratecan be seen from identity (12); a sum of three terms.

(12) $R(t) = [R(t) - R(k(t),F(t);Z(t))] + [R(k(t),F(t);Z(t)) - R^*(Z(t)] + R^*(Z(t)]$

The first term is portrayed in the vertical vectors in figure 5 concerning how the real exchange rate converges to the NATREX which is R(k(t),F(t);Z(t)). At any time, speculative and cyclical elements plus wage/price rigidities produce deviations between the real effective exchange rate and the NATREX. However, the model claims that these deviations average out to zero. The second term describes the evolution of NATREX as capital and foreign debt evolve over time,based upon equations (6)(7) and phase diagram figure 6. The last term is the steady state NATREX equation (11) when capital and debt are no longer changing.

The econometrics of cointegration[17] attempt to disentangle the longer run equilbrium of a relationship from the movements towards the equilibrium. Let X be an endogenous variable, such as the real exchange rate R or foreign debt F; and Z represents a vector of exogenous variables. A dynamic process, equation (13a) is specified. Equation (13b) states that exogenous vector Z is not

[17]See Campbell and Perron (1991), Lim and Martin (1992) for a discussion of cointegration.

stationary but is integrated of order one I(1). This is exactly what we want, because our exogenous variables of productivity and thrift and the terms of trade are I(1). This means that it is likely that the real exchange rate will end up being integrated of order one.

Equation (13c) is the expected steady state that occurs when Z(t) is constant . Using (12)-(13), the dynamic system to be estimated is equation (14). Let $E(e_i)=0$

(13a) $X(t) = a\, X(t-1) + b_1\, Z(t) + b_2\, Z(t-1) + e_1(t)$
(13b) $Z(t) - Z(t-1) = e_2(t)$
(13c) $X^*(t) = [(b_1+b_2)/(1-a)]Z(t) = BZ(t)$
(14) $X(t) = BZ(t) + c_1[X(t-1) - BZ(t-1)] + c_2\, DZ(t) + e(t)$

There are several established methods of estimating vector coefficient B in equation (14). We have chosen to use the two step Engle-Granger method[18]. First, we use the Johansen framework to determine how many cointegrating vectors there are among the variables (X, Z), where X is the real effective exchange rate (GRREU) and Z is the vector of the exogenous variables =[GRTOT, GRDIS1, G7DISRAT,GRUSPROD]. We find that there is only one cointegrating vector, as reported in table 2. This means that we need all of the four variables in Z to explain the real exchange rate.

Second, knowing that there is only one cointegrating vector, we estimate equation (15); and the estimate of vector B is B'. Equation (15) is our cointegrating equation, reported in table 3, the essense of the analysis. We associate the estimate B'Z(t) of the real exchange rate from table 3 (equation 15) with the theoretical NATREX.

(15) $X(t) = B'Z(t) + h(t)$ = NATREX + residual X=GRREU

[18]The Nonlinear lest squares (NLS) method (Phillips-Loretan) estimates (14) where B is constrained to be the same in the first and second terms. In Stein (1994) NLS in an equation like (14) and OLS on an equation like (12a) were used, with very similar results. Here, we obtained good results using the Engle-Granger method, but only the terms of trade were significant when we used NLS.

Third, we then report estimates of equation (16a) as (16b), where h(t-1)=X(t-1)-B'Z(t-1) is the error correction.

(16a) $X(t) = a(NATREX)(t) + c_1\, h(t-1) + c_2\, DZ(t) + e(t)$

(16b) GRREU = 0.999 NATREX + 0.6 (GRREU(-1) - NATREX(-1))
(standard. error) (0.003) (0.09)

The NATREX is R(k(t),F(t);Z(t)); and the debt F(t) is an endogenous variable. That is the reason why, in table 3 the endogenous real effective exchange rate is regressed exclusively upon exogenous variables Z. Each of the variables in the cointegrating equation reported in table 3 is significant at the 1 per cent level. The German terms of trade(GRTOT), the German rate of time preference(GRDIS1) and the German/US productivity ratio (GRUSPROD) appreciate,and the G7 time preference (G7DISRAT)depreciates , the real value of the DM (GRREU). Figure 3 graphs the real effective exchange rate (GRREU) and the NATREX=B'Z(t) derived from table 3. It is seen that the NATREX does explain the longer run movements in the real value of the DM. Deviation [R(t)-NATREX(t)] in equation (11) average out to zero.

The results in table 3 are to be interpreted as they relate to the theory This is the difficult part of the analysis: just how should the econometrics be interpreted?

Interpretation of the Results

Table 4, rows a-b, summarizes the theoretical arguments of the effects of changes in the fundamentals Z upon the real effective exchange rate (GRREU). This was done in an intuitive way the beginning of the paper. Here we do it in terms of the NATREX . Row a refers to the medium run, described in figure 5, row b refers to the trajectory to the steady state point E1 in figure 6, and row c refers to the econometric results in the cointegrating equation in table 3.

The signs of the coefficients underlying the NATREX in table 4 are reflecting the movements in figure 5 which we call the medium run. That is, the coefficients in row c of table 4 conform perfectly to parts 1a, 2a, 3a and 4a in table. 4 They do not conform to the steady state mentioned in row (b) in table 4.

The NATREX explains the movement of the real effective exchange rate very well in figure 3. There are two types of fundamentals in Z: external and exogenous domestic in the model . We ask: to what extent is the NATREX affected by the domestic component and to what extent by the foreign component? Figure 8 is designed to answer this question.

The domestic component contains as exogenous variables, the German rate of time preference GRDIS1 and German[19] productivity GRPROD1. The external components are: the terms of trade (GRTOT), G7 time preference (G7DISRAT) and US productivity. We formed a variable called HOME, the domestic component, as follows, where the C(i) refer to the coefficients in table 3. Define as HOME=C(1)/2 + C(3)*GRUSPROD + C(4)*GRDIS1 . This is graphed along with the NATREX in figure 8. The foreign component (fig. 8a) is just the difference between the NATREX and the domestic component (fig. 8b).

The real exchange rate at any time is affected by all of the fundamentals which are constantly changing. However, figure 8 shows that the HOME variables dominate from 1975-79, 1987-93 and the external variables dominate the 1979-87 period.

External Fundamentals

1. The terms of trade

The terms of trade are primarily affected by rising or falling imports prices, which are exogenous to Germany. There were two periods where the terms of trade were important in affecting the real effective exchange rate, as shown in figure 2. The first was 1979-81, the second oil price shock. The second was 1985-87, when commodity prices were falling. The NATREX scenario is in table 4.1. Let us consider a rise in the terms of trade (1985-87). Start with the medium run in figure 5. Initially, the IX curve is IX-1, the portfolio balance curve is PB and the real exchange rate is at point H. A rise in the terms of trade raises the

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[19]We allocated the productivity ratio (GRUSPROD) entirely to the domestic (HOME) component, because only the German productivity was significant .

current account and stimulates investment. The excess demand for goods rises, or the basic balance of payments increases at the real exchange rate H. The IX curve shifts to IX-2. The real effective exchange rate appreciates to H3 to equilibrate the balance of payments. The appreciation of the real exchange rate offsets the rise in the terms of trade. At point H3, the current account and investment have increased, and the rise in saving less investment equals the higher current account.

The economy is at point E4 in phase diagram figure 6. At E4, there is a positive current account and the q-ratio has risen, the result of the rise in the terms of trade. The economy follows trajectory E4-E1 to the new steady state. There is capital accumulation raising the capital intensity to k*. The current account surpluses lead to a decline in the debt. The lower debt lowers saving and the endogenous debt stabilizes at a lower level.

The decline in the debt raises the IX curve further above IX-2 in figure 5. The rise in capital would partially offset this rise. The final result is that the real effective exchange rate appreciates above H3. This is the 1985-87 scenario. Figure 2 shows how the real exchange rate and terms of trade were rising. Figure 9 shows how (GRCAGNP1) the cyclically adjusted, four quarter moving average of the current account/GNP was rising during that period.

When the terms of trade decline (1979-81), the argument is in reverse. The IX curve (fig. 5) shifts downwards say from IX-2 to IX-1 and the real effective exchange rate depreciates from H3 to H. The economy is initially at point E5 in figure 6. The trajecectory is E5-E1, where the debt rises due to current account deficits and stabilizes at a higher level. Figure 2 shows how the real effective exchange rate was declining with the terms of trade. Figure 9 shows how the current account (GRCAGNP1) was declining[20].

[20]This is why we need the condition $\delta S/\delta T > 0$ in the saving function (7b).

2. Rise in G7 Time Preference

The major external disturbance from 1980-85 was the rise in the G7 time preference, described by G7DISRAT in figure 7d. This rise raised US real long term interest rates (USRINT) in figure 4.

Table 4.2 describes this situation. Let the initial situation be described by thecurves IX-1, PB1 in figure 5. The rise in the G7 time preference has two effects. First, it raises the US real long term rate of interest from r1 to r2, the PB curve shifts from PB1 to PB2. This per se lead to a demand for US assets and the portfolio adjustment raises real long term German interest rates. The interest rate effect tends to depreciate the real value of the DM. However, the rise in the G7 time preference increases the German current account and shifts the IX curve to IX-2. The net effect is that the real effective value of the DM depreciates from H to H2. At H2, there is a higher current account matched by a rise in saving less the lower rate of investment.

The economy is at point E2 in figure 6. The q-ratio has declined due to the higher real rate of interest. There is a current account surplus due to the rise in the G7 time preference. The trajectory is E2-E1, where the foreign debt declines as does the capital intensity. The rise in the current account from 1980-87 is seen in figure 9.

The excess demand for goods resulting from the declines in the debt and capital intensity shift the IX curve in figure 5 further to the right, and the real effective exchange rate appreciates above H2.

Domestic disturbances

1. German time preference, from Schmidt to Kohl

Figures 7a, 7b and 7c describe the cyclically adjusted German time preference. From 1975-82, both private (GRC1) consumption/GNP and public (GRGC1) consumption /GNP were rising. From 1984-91 private time preference, and from 1988-93 governent time preference was declining. The social (total) cyclically adjusted time preference (GRDIS1) is figure 7c. It rose from 1975-80 and

declined from 1984-93. These periods coincide exactly with two governmental legislative periods. There was a social liberal government under Schmidt from 1974-82 and a conservative liberal government under Kohl from 1982 to the present. It was part of Kohl's government program to slow down public consumption and public deficits which had grown massively under Schmidt. The consolidation of the public budgets enforced higher taxes and lower transfers. Both of them reduced private consumption. The NATREX analysis of this effect is in table 4.3.

Start with the Schmidt period.The Schmidt policy of a rise in time preference was initially justified at the Bonn summit in 1978 when Schmidt agreed to a locomotive role for the German economy. There is a rise in investment less saving, so the rise in time preference shifts the IX curve from IX1 to IX2. This excess is financed by a capital inflow and the real effective exchange rate appreciates from H to H3, which restores the equality of aggregate demand to capacity output or the current account plus investment less saving, evaluated at capacity output, to zero.

At H3 there is a current account deficit. This means that the economy is at point E7 in figure 6. The trajectory is E7-E1 to the steady state, with a higher debt. The higher debt lowers the aggregate demand or current account, and shifts the IX curve downwards below IX-1. The initial appreciation of the real exchange rate to H3> R(0) is more than offset. The real exchange rate along trajectory E7-E1 ends up below R(0). The Schmidt policy first appreciated the real exchange rate H3> R(0), as it raised aggregate demand. It then led to a depreciation below its initial level $R^* < R(0)$, as a result of the decline in the current account (fig. 9).

The developments under Kohl seen in figure 7c for GRDIS1 from 1984-93 are the reverse of the Schmidt policies . If we start at H3 with curve IX-2, then the Kohl policy of a decline in time preference lowers the aggregate demand to IX-1. The rise in saving less investment leads to an initial depreciation of the real effective exchange rate from H3 to H, and a rise in the current account.

The economy is at point E6 in figure 6. The current account surpluses decrease the debt. The decline in the debt raises aggregate demand and the current

account. The IX curve shifts upwards above the initial level IX-2 and the real effective exchange rate appreciates above its initial level. The major force explaining the trend rise in the NATREX during the Kohl period is the decline in social time preference, reflected in the curve HOME in figure 8.

2. A rise in the productivity of capital

The German unification presented a laboratory situation to study the consequences of a rise in the productivity of capital. The treaty of economic and currency unification from 1 July 1990 integrated both parts of Germany economically. Because the capital intensity in East Germany was very low compared to West Germany, the aggregate German capital intensity declined substantially after unification. The marginal product of capital increased. Table 4.4 describes this situation[21].

Initially, the economy was at point H (fig. 5). The rise in the q-ratio raises investment less saving and shifts the IX curve from IX-1 to IX-2. The real exchange rate appreciates to point H3, where the current account declines to offset the rise in investment less saving. The Deutsche Bundesbank restrained the rate of inflation, so the real exchange rate appreciated as a result of an appreciation in the nominal rate from 1990-92 (figure 1).

The unification placed the economy at point E3 in figure 6. The trajectory of the economy was E3-N. There was a rise in the capital intensity because the q-ratio rose. There was significant growth in German productivity, cyclically adjusted GRPROD1, relative to the G7, figure 7e . There were current account deficits to finance investment less saving. Figure 9 shows the decline in the German current account (GRCAGNP1), as the real effective exchange rate appreciated.

The rise in capital and debt then lower the current account ,or investment less saving. Hence along E3-N the IX curve in figure 5 is shifting down, thereby offsetting the initial appreciation. As capital rises with the reconstruction of Eastern Germany, GDP will rise. Saving increases relative to investment along

[21]To be sure there were large transfers fronm West to East which tended to raise consumption. However, the basic trend of German time preference GRDIS1 in figure 7c was downwards. Hence we view the post unification period as one where the major disturbance was the rise in the productivity of capital.

trajectory N-E1 The current account deficits turns into current account surpluses, and the debt declines.

The rise in capital and decline in the debt have offsetting effects upon the IX curve. The decline in the debt raises investment less saving or the current account, and shifts the IX curve upwards. The debt effect along N-E1 appreciates the real effective exchange rate. The rise in capital raises GDP and saving less investment and tends to shift the IX curve downwrds. It is a force of depreciation. The net effect is ambiguous. The cointegrating equation in table 3 is picking up the appreciation effect H to H3.

The competitiveness of the German economy

The Deutsche Bundesbank has been looking for indicators of the competitiveness of the German economy[22]. There are different movements of different measures of the real exchange rate. The real exchange rate based upon deflators of total expenditure or of unit costs in the enterprise sector as a whole are relatively stationary, whereas REU rose by about 40 percent from 1985-93. The Bundesbank did not find that the real effective exchange rate (REU) as defined in equation (1) above was a good indicator of competitiveness.

We address ourselves to several questions. First, what is the relation between the real effective exchange rate (REU) and one based upon broad deflators? Second, what is a theoretically relevant indicator of competitiveness? Third, how does the NATREX model explain the competitiveness of the German economy?

1. Relation between measures of the real exchange rate

The real exchange rate based upon broad deflators (R1) is equation (17.1). The nominal exchange rate is N (rise is an appreciation), $p =(p_T)^{1-a} (p_n)^a$ is the German and $P=(P_T)^{1-b}(P_n)^b$ is the foreign broad based deflator. Subscript T refers to the tradable, and n to the nontradable sector.

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[22]Deutsche Bundesbank, Monthly Report, Real Exchange Rates as an Indicator of International Competitiveness, 46, no. 5, May, 1994.

(17.1) $R1 = N\,(p_T)^{1-a}\,(p_n)^a\,/(P_T)^{1-b}(P_n)^b$

This can be written as (17.2). The first term is the relative prices of tradables. The second term is the relative price of nontradables to tradables in Germany relative to abroad.

(17.2) $R1 = (Np_T/P_T)\,[(p_n/p_T)^a\,/\,(P_n/P_T)^b]$

The first term (Np_T/P_T) corresponds to REU the real effective exchange rate in tradables. The ratio of relative prices p_n/p_T or P_n/P_T corresponds to the productivity in tradables relative to tradables[23],denoted h in Germany or H abroad . Equation (17.3) is obtained., which relates the two measures of the real exchange rate

(17.3) $R1= (REU)\,[h^a/H^b\,]$

The real effective exchange rate REU has been appreciating since 1978 (figure 1). However, the productivity in tradables to nontradables in Germany relative to abroad (h/H) has been falling from 1970-91.The Bank for International Settlements (BIS 1993, table 17) calculated that the index h of productivity tradable/nontradable in Germany rose from 100 in 1970 to 104 in 1991. The corresponding ratio H in the major countries rose from 100 to 149. Foreign relative productivity in tradables to nontradables has risen, whereas it has remained the same in Germany. Thus $[h^a/H^b\,]$ has declined drastically. Since R1 is the product of REU and a function of h/H, the rise in REU and decline in h/H has led to a relative constancy in the real exchange rate R1 based upon broad deflators.

---

[23]The price is the nominal wage/productivity. With wage equality in the tradable and nontradable sectors, relative prices in nontradable/tradable equal relative productivities in tradable/nontradable. Thus pn/pT = h and Pn/PT=H.

2. The profit function indicates competitiveness

The competitiveness of the tradable sector affects movements of the current account. An indicator of competitiveness would tell us when the current account will increase or decrease. The competitveness of the tradable sector depends upon the profits generated. Therefore, the determinants of the profits in the tradable sector are the indicators of competitiveness. The profit function in the tradable sector is equation (4c) . The profit function was predicated upon a world of price takers. Insofar as Germany is not exclusively a price taker, we augment the concept . by also including the growth of foreign demand: the real growth of GDP in the G7, as an argument in the current account.

The profit function (4c) is $\Pi(R,T)$ where R is REU the real effective exchange rate in tradables and T is the terms of trade. The rise in the terms of trade picks up the ratio of the selling price to the price of imported materials. The rise in the real effective exchange rate picks up domestic costs relative to foreign costs. The profit function picks up the effect of input prices, certainly of imported materials, upon profits and competitiveness.

With these correspondences, the current account is a positive function of: the terms of trade, productivity and the growth rate of the G7, and is negatively related to the real effective exchange rate (R=REU). The productivity variable (GRPROD1) is the industrial production per worker, adjusted for variations in the rate of capacity utilization[24].

Our measure of the current account to GNP is as follows[25]. Since it is seasonal, we take a 4 quarter moving average. Since it is also affected by the ratio of capacity utilization in manufacturing, we regress a 4 quarter moving average on the ratio of capacity utilization in manufacturing and GRCAGNP1 is the residual.

(18) GRCAGNP1 = F(GRTOT, GRPROD1, G7GROWTH, GRREU)

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[24]See the description in the notes to table 4.

[25]The data for the current account refer to the quarter and the GNP data are annualized. The current account/GNP is GR77ad / GR99ac in the IMF, International Financial Statistics.

Table 5 is the regression equation, which corresponds nicely with equation (18). The terms of trade[26], German productivity and G7 growth increase the current account and the real effective exchange rate decreases it.
Thus the indicator of competitiveness is equation (18) or table 5, not the real effective exchange rate per se. Figure 9 compares the actual current account GRCAGNP1 with the forecast[27] from the regression FCAGNP. It is clear that we have a fairly good indicator of competitiveness. This measure of competitiveness is based upon the fundamentals, and reflects the transfer process when investment differs from saving.

There is a second way to look at the competitveness of the German economy in terms of the NATREX model. The NATREX is the real exchange rate associated with external balance, when the cyclical and speculative factors are eliminated. When the real exchange rate exceeds (is below) the NATREX there is a loss (gain) of competitiveness, and the current account declines (rises). In terms of figure 5, when the real exchange rate is above the IX curve, the sum of the current account and nonspeculative capital inflow would tend to be negative, and the ratio of domestic to foreign prices, in a common currency would tend to fall. With free exchange rates, it would be the nominal value of the currency which tends to depreciate. With fixed exchange rates, it would be the ratio of German to foreign prices which tends to fall.

Therefore we can describe competitiveness by equation (20). There is a lagged adjustment of the current account, but it is adversely affected by the deviation of the real effective exchangeGRREU rate from the NATREX. Call [GRREU - NATREX] the error. We regresssed the current account upon a constant, its lagged value and two lagged values of the error. The period is 1976.1-1993.3.

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[26]The terms of trade embody several effects.The major external force is the price of imported materials. From 1978-81 the decline in the terms of trade (fig. 2) was due to rising world market prices of imported materials. From 1985-87, the rise in the terms of trade was primarily due to the appreciation of the DM relative to the $US, since commodity prices are $US prices. Hence the bilateral $US/DM rate is involved in the terns of trade.

[27] The coefficient estimates must be viewed cautiously, because the current account regression exhibits serial correlation of residuals. Figure 9 is sufficient for our purposes to show how the regression based upon fundamentals exhibits the same pattern as does the cyclically and seasonally adjusted current account/GNP..

(19) GRCAGNP1= C + a_1 GRCAGNP1(-1) + b_1 (GRREU - NATREX) + b_2(GRREU - NATREX)(-1)

The coefficient b_1 of the error is negative and significant at the 1 per cent level. The current account is adversely affected when the real effective exchange rate exceeds the NATREX. This is the competitiveness effect.

Our main contributions are as follows. First we explained, within the context of a theoretically consistent model, what are the fundamental external and domestic determinants of the real effective exchange rate of Germany[28]. Second, we explained how one should view the real effective exchange rate in evaluating the competitveness of the German economy. The current account is affected by the transfer process and by the competitveness. We believe that the appropriate measure of competitiveness is the deviation of the real effective exchange rate from the NATREX. This deviation would reflect developments in the labor market and speculative factors. The analysis of the current account based upon the fundamentals, equation (18) explains the evolution of the debtor-creditor position of Germany.

[28]We have examined the real effective exchange rate of Germany. The bilateral German/French real exchange rate has been examined by Crouhy-Veyrac and Saint Marc (1995) within the framework of the NATREX model. There are many important questions not addressed in this study. The reader should see Sinn and Sinn, Friedmann and Hermann, Clausen and Willms .

Tables

Figures

Table 1

Stationarity Tests, Germany, 1973.1 -1994.2

Non-stationary I(1)

1.Real effective exchange rate ADF(C,0)=-0.2

2.Terms of trade ADF(C,1)=-1.58; (a)Terms of trade Granger cause the real effective exchange rate, not the reverse;(b) Terms of trade and real effective exchange rate are not cointegrated

3. German Social time preference index: (private plus public consumption)/ GNP, adjusted for capacity utilization rate, ADF(C,2)=0.08.

4. G7 Social time preference index: ADF(C,1)= -2.2

5. German/US labor productivity: ADF (C,1)= -0.795

6. current account/GNP (1973.1-1989.4): ADF(C,1)= -1.3

7*. German net foreign assets/GNP: ADF(C,1)= -0.334

8*. German government debt/GNP: ADF(C,1)= -0.455

Stationary I(0)

1. Real German less real US long term interest rate; (a) The interest rate differential has an expectation of zero ADF(N,1)=-2.6

2. Short term capital flows: deposit money banks (GR77gbd), expected value equals flows: deposit money banks, expected value equals zero ADF(N,0)=-8.0

3. German growth rate of real GDP ADF(C,0)=-3.37

Table 2

Johansen Cointegration Test:

Variables: GRREU, GRTOT, GRUSPROD, GRDIS1, G7DISRAT

hypothesized # CEs	liklihood ratio	5% critical	1% critical
none*	75.55	68.52	76.07
≤1	44.86	47.21	54.46
≤2	20.1	29.68	35.65
≤3	8.04	15.41	20.04
≤4	1.68	3.76	6.65

LR test indicates that there is just 1 cointegrating equation, * =significant at 5%, reject the null hypothesis; lag interval 1 to 2 . Each Variable is integrated I(1).

Table 3

German Real Effective Exchange Rate (GRREU), 1975.1-1993.3, No. obs. 75

Variable	Coefficient	Std. error	2-tail sig.
C(1) CONSTANT	193.18	32.49	0.00
C(2) GRTOT	83.5	6.6	0.00
C(3) GRUSPROD	87.6	6.15	0.00
C(4) GRDIS1	132.5	39.5	0.00
C(5) G7DISRAT	-237.9	40.8	0.00

Adj R-Sq=0.87; Prob (F-stat)=0.00.

Source, symbols:The data are from the Internatiional Monetary Fund, International Financial Statistics.The prefix GR refers to Germany, US refers to US and G7 refers to the G7. The alphanumerics after the country prefix refer to the rows in the IFS.; GRREU=real effective exchange rate GRTOT=GR74/GR75=unit value German exports/German imports; GRDISRAT=(GR91fc+GR96fc) / GR99ac = government consumption plus private consumption divided by GNP. The adjustment for the rate of capacity utilization GRDIS1 is done as follows. Regress GRDISRAT=C1+C2*German rate of capacity utilization in manufacturing + residual . The residual is GRDIS1. The G7DISRAT=G7 government expenditures plus private consumption/G7 GNP. GRUSPROD=German industrial production per worker . GRPROD=GR66c/GR67), adjusted for rate of capacity utilization/US industrial production divided by nonagricultural employment (USPROD=US66c/US67c). The adjustment for the rate of capacity utilization is as follows. Regress German productivity in industrial production, GRPROD=C1 + C2*German rate of capacity utilization in manufacturing + GRPROD1. The residual is German productivity adjusted for cyclical variations. Hence GRUSPROD=GRPROD1/USPROD is relative productivity.

Table 4

Summary of the effects of foreign and domestic disturbances to productivity and thrift upon the NATREX. Medium run, figure 5; trajectory, figure 6

1. Rise in German terms of trade (GRTOT)
a. medium run H-H3, exchange rate appreciates R(1)>R(0)
b. trajectory , E4-E1, current account rises, debt declines, capital rises, appreciation R*>R(0)
c. cointegrating equation: rise in terms of trade appreciates real value of DM

2. Rise in G7 time preference (G7DISRAT)
a. medium run , H-H2, rise in G7 real interest rate, depreciation of German real exchange rate R(1)<R(0)
b. trajectory E2-E1. Current account increases, debt declines, decrease capital, appreciation of real exchange rate R*>R(1)
c. cointegrating equation: rise in G7 time preference depreciates the real value of the DM

3. Rise in German time preference (GRDIS1)
a. medium run H-H3 appreciation R(1)>R(0)
b. trajectory E5-E1, decrease in current account, rise in debt, depreciation R*<R(0)
c. cointegrating equation: rise in GRDIS1 appreciates real value of DM

4. Rise in German/G7 productivity (GRUSPROD1)
a. medium run H-H3 appreciation
b. trajectory (figure 4) E3-N, decrease in current account, rise in debt, depreciation; N-E1, increase in current account, decrease debt, appreciation; increase in capital, depreciation. Net effect is ambiguous
c. cointegrating equation: rise in German/US productivity appreciates real value of DM

Symbols

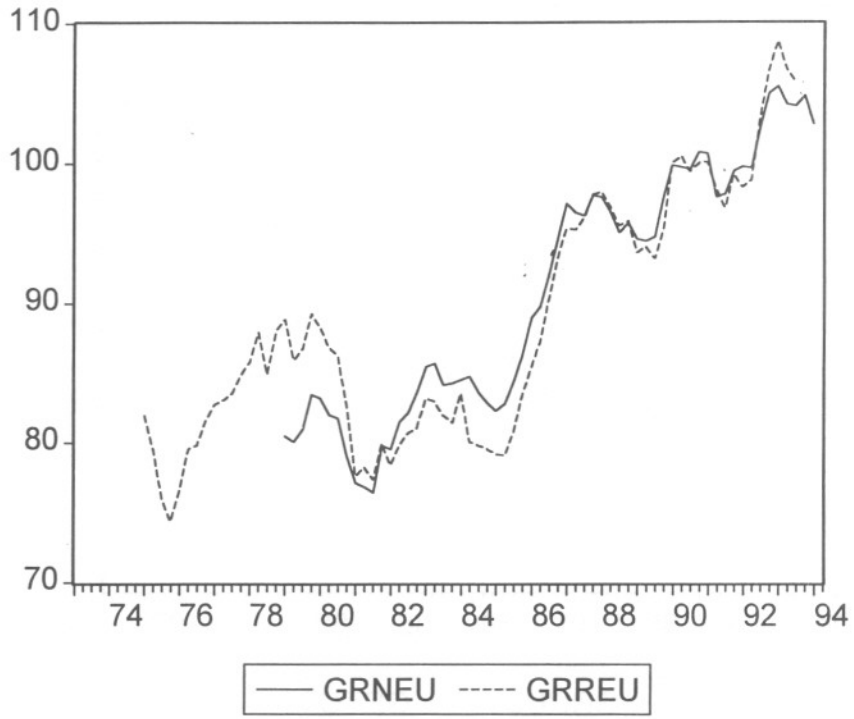
R(0) initial real exchange rate; R(1) medium run real exchange rate, R* steady state real exchange rate. The dependent variable is GRREU the real effective value of the DM

Table 5

The current account/GNP, 4 quarter moving average adjusted for the rate of capacity utilization, (GRCAGNP1), 1975.4 - 1993.3, obs. 72

variable	coefficient	std. error	t-stat	2-tail sig.
GRTOT	0.0268	0.0053	4.97	0.00
GRPROD1	0.0195	0.0043	4.51	0.00
G7GROWTH	6.5E-05	1.19E-05	5.44	0.00
GRREU	-3.0E-04	5.7E-05	-5.29	0.00

Adj. R-square=0.47, prob(F-stat)=0.00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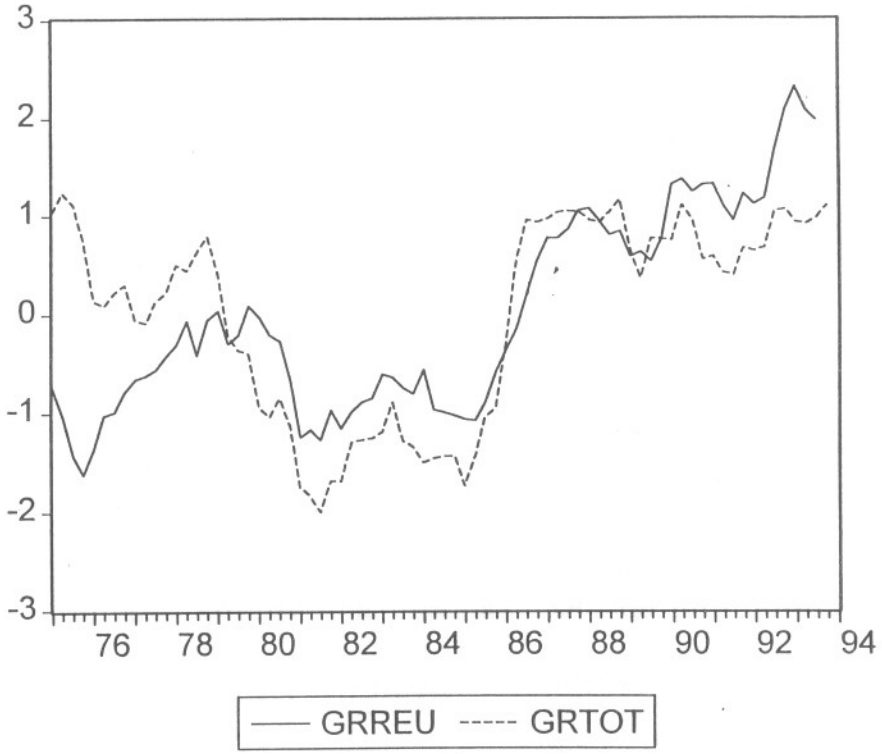
GRNEU
GRREU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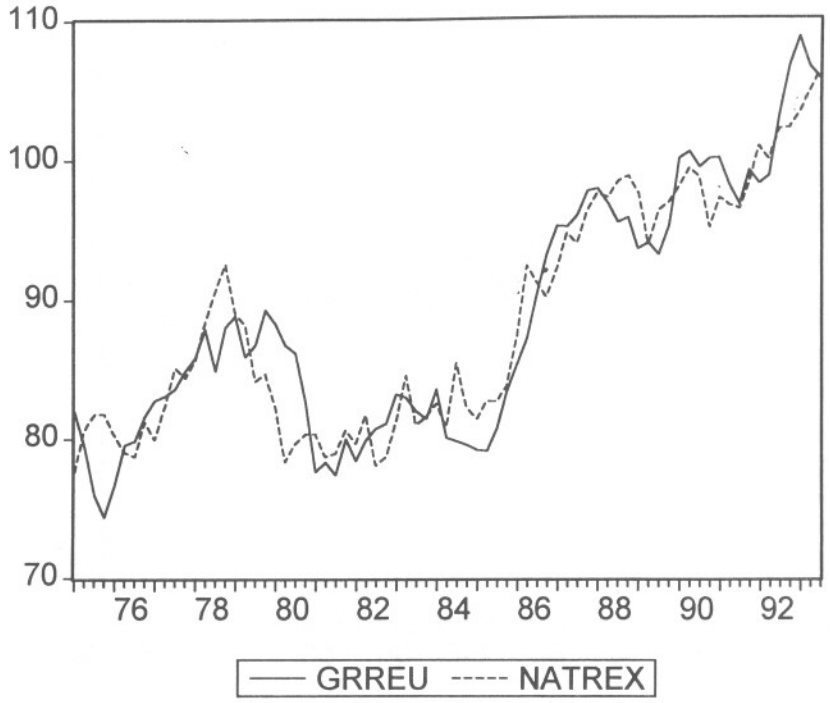
GRREU
GRTOT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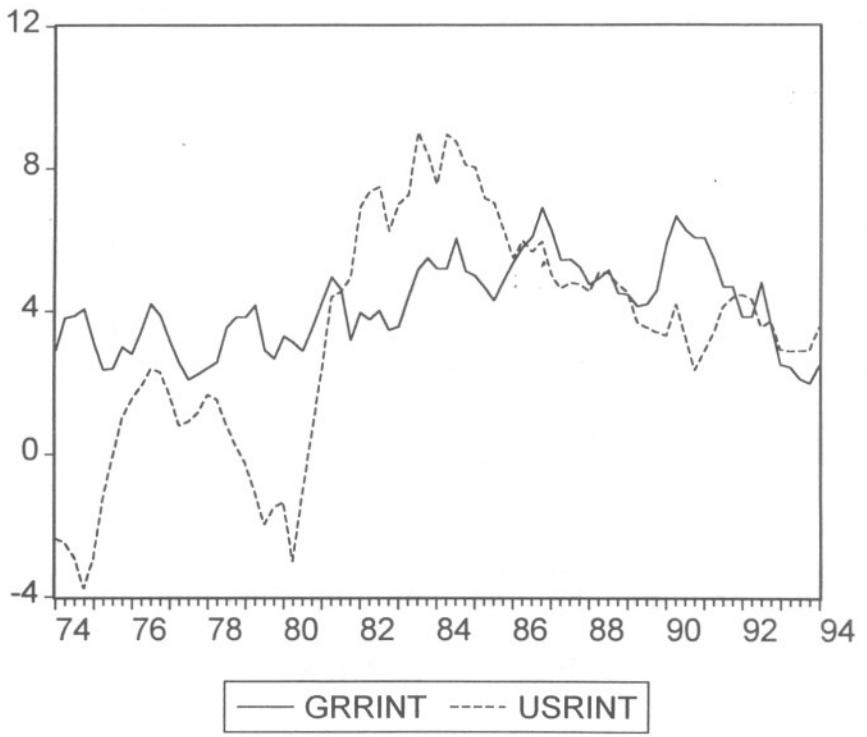
GRREU
NATREX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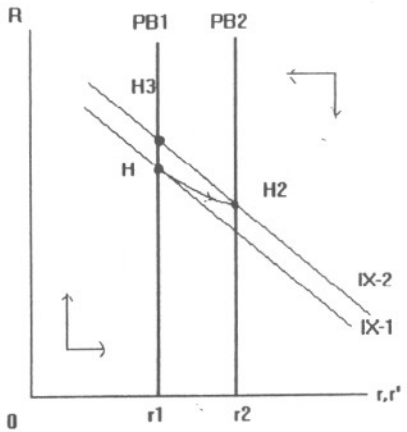


Figure 5

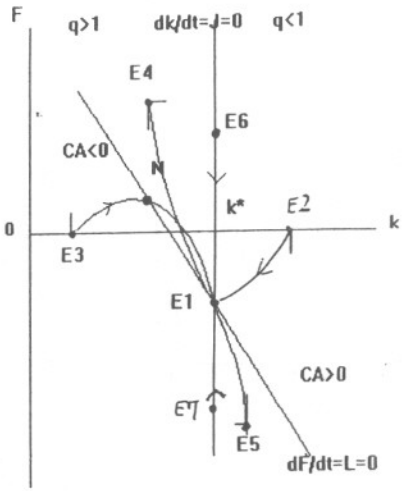
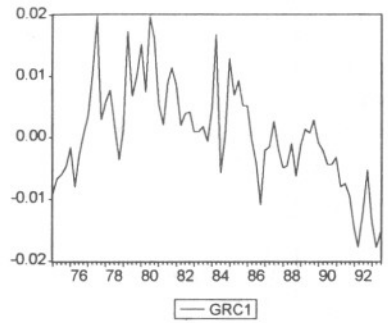


Figure 6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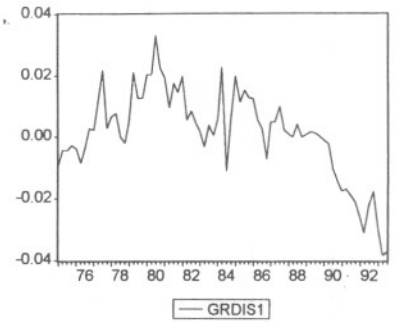
GRC1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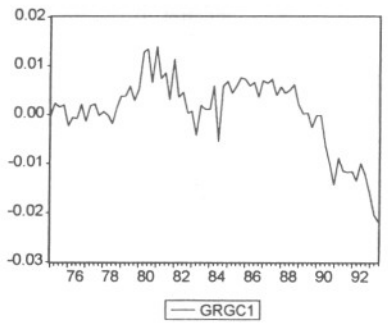
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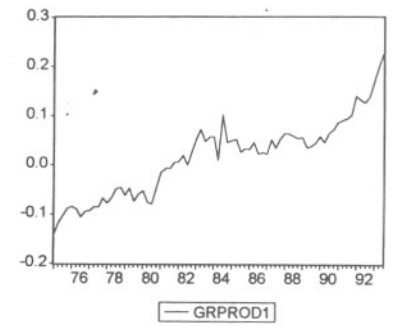
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-0.2
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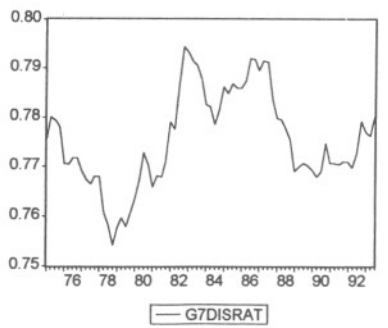
GRPROD1


0.80
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0.77
0.76
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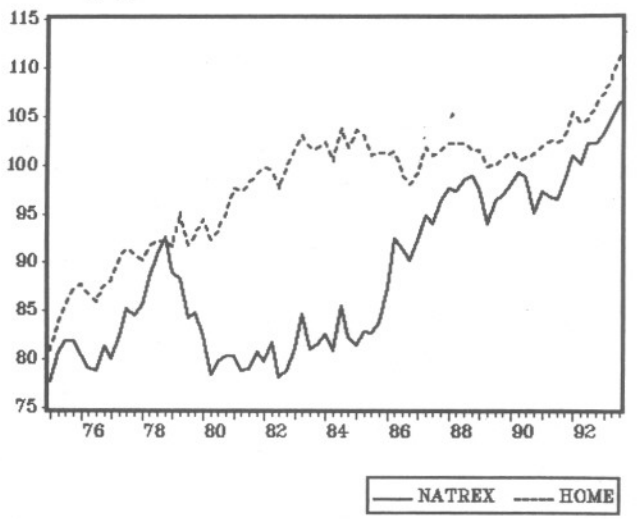
76 78 80 82 84 86 88 90 92
G7DISRAT

NATREX, DOMESTIC COMPONENT HOME=C(1)/2 + C(3)*GRUSPROD
+ C(4)*GRDIS1



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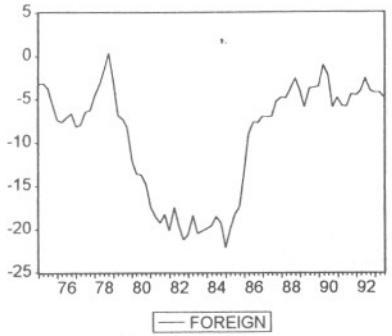
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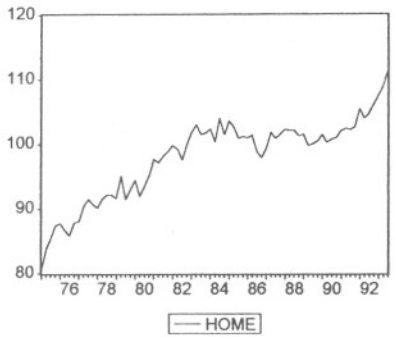
a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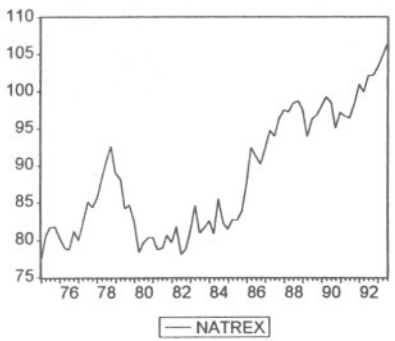
HOME

b


110
105
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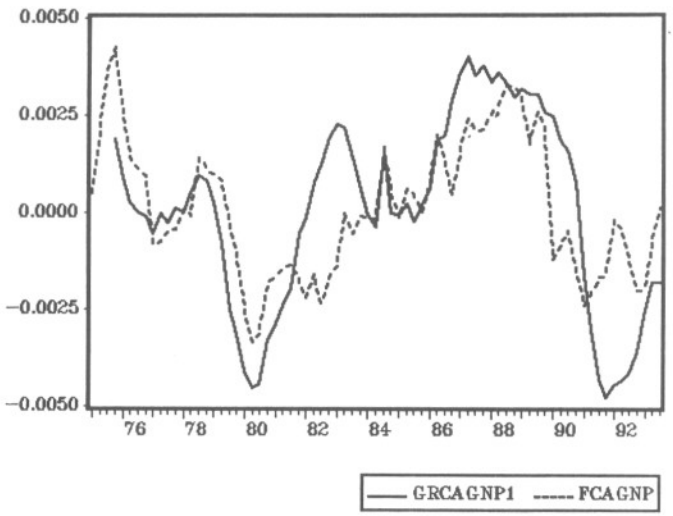
76 78 80 82 84 86 88 90 92
NATREX

c

GERMAN CURRENT ACCOUNT/GNP, CYCL. ADJ.; FORECAST FROM EQUATION
CAGNP1=F(GRTOT, GRPROD1, G7GROWTH, GRREU)



REFERENCES

Allen, Polly Reynolds (1995) The Economic and Policy Implications of the NATREX Approach, in Stein, Allen and associates, op. cit., ch.1

Bank for International Settlements (1993), Philip Turner and Jozef Van't dack, Measuring International Price and Cost Competitiveness, BIS Economic Papers, 39, Basle.

Campbell, John and Pierre Perron (1991), Pitfalls and Opportunities: What Economists Should Know about Unit Roots, NBER Macroeconomics Annual, MIT Press, 1991

Clausen, V. and Manfred Willms (1994) Lessons from German Monetary Union for European Monetary Union, Journal of international and Comparative economics, 3, 3, 195-228

Crouhy-Veyrac, Liliane and Miche`le Saint Marc (1995), The French Franc and the Deutsche Mark, 1971-1990 in Stein, Allen and associates , op. cit., ch.4

Deutsche Bundesbank (1994), Real Exchange Rates as Indicators of International Competitiveness, Monthly Report, 46, 5, May

Friedmann, W. and H. Hermann(1994), A Review of Gerlinde and Hans-Werner Sinn: Jumpstart, Journal of international and Comparative economics, 3

Infante, E.F. and Jerome L Stein (1973) Optimal Growth with Robust Feedback Control, Review of Economic Studies, XL (1), 47-60

Lim, G. C. and Vance L. Martin (1992) Efficient Estimation of Long Run Relationships: A Comparison of Alternative Cointegration Estimators with an Application. University of Melbourne, Research Paper #343

Masson, Paul R. Jeroen Kremers and Jocelyn Horne (1993), Net Foreign Assetsand International Adjustment, International Monetary Fund, Working paper 93/33

Nurkse, Ragnar (1945) Conditions of International Monetary Equilibrium, Essays in International Finance, International Finance Section, Princeton University

Sinn, Gerlinde and Hans-Werner (1992) Jumpstart: The Economic Unification of Germany, MIT Press

Stein, Jerome L., Polly Reynolds Allen et al (1995) Fundamental Determinants of Exchange Rates, Oxford University Press (in press)

Stein, Jerome L. (1994b) The Natural Real Exchange Rate of the United States Dollar and Determinants of Capital Flows, in John Williamson (ed) Equilibrium Exchange rates, Institute for International Economics, Washington, DC

----------(1994c) The Fundamental Determinants of the Real Exchange Rate of the US Dollar Relative to the G7, International Monetary Fund Working Paper, IMF, Washington, DC

----------(1994a) Can the Central Bank Achieve Price Stability? Federal Reserve Bank of St Louis, Review, 76, 2, March/April 1994

----------(1992a) Cobwebs, Rational Expectations and Futures Markets, Review of Economics and Statistics, LXXIV, 1

----------(1992b) Price Discovery Processes, Economic Record, Special Issue on Futures Markets

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