Kiel Institute for World Economics
Duesternbrooker Weg 120
24105 Kiel (Germany)

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Investigating the Impact of an Appreciation of the Euro in a Small Macroeconometric Model of Germany and the Euro Area

by

Carsten-Patrick Meier

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Abstract:

Since the start of European monetary union, the macroeconomic situation in Germany can in many respects only be analyzed in combination with the situation in the rest of the euro area. To take this into account, a small macroeconometric model is constructed that models the euro area as consisting of two regions, Germany and the rest of the euro area. The rest of the world is treated as exogenous. Given problems with modelling the relevant relationships in a standard vector autoregression approach, the model is set up as a dynamic simultaneous equations model. The model is used to study the impact of monetary policy or of exchange rate changes on economic activity in Germany and the euro area.

Key words: Macroeconometric model for Germany, euro area, appreciation

JEL classification: E17, F47

Dr. Carsten-Patrick Meier
Institute for World Economics
24100 Kiel / Germany
Phone: +49 431 8814-267
Fax: +49 431 8814-525

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1. Introduction

Between early 2002 and early 2004, the euro appreciated in real effective terms by some 20 percent. Vis-à-vis the U.S. dollar, the appreciation was even sharper. Against this background, concern was raised that the developments on the foreign exchange markets may considerably dampen the upswing in Germany and in the euro area.

In the present paper, the effects of an appreciation of the euro on Germany and on the euro area will be analyzed using a small structural macroeconometric model of aggregate demand in the euro area. The motivation for using this type of model in place of the more conventional vector autoregressive (VAR) models stems from the fact, that we found it quite difficult to find a significant elasticity of GDP with respect to the real exchange rate in a VAR framework. In a standard macroeconomic export function, in contrast, the elasticities are typically stable and highly significant.

A special feature of the model is that the euro area is divided into Germany and the rest of the euro area. Since the start of European monetary union, the macroeconomic situation in Germany can in many respects only be analyzed in combination with the situation in the rest of the euro area. The two-region approach presented in this paper takes this into account. It allows to account for various feedback effects between Germany and the rest of the euro area. As a side effect, it generates consistent results for Germany and the Euro area.

2. The Model

2.1 Overview

The model used in the present paper can be interpreted as the "IS equation" of a larger macroeconomic model for the euro area. It is specified with the demand side of the national accounts statistics in mind, with individual behavioral equations for domestic demand, exports and imports, which are analyzed as a system of simultaneous dynamic equations. The euro area is divided into Germany and the rest of the euro area. Each region is modeled separately by four stochastic equations (exports, imports, domestic demand and industrial production). The regional results are aggregated via identities to give the results for the euro area as a whole.

The model accounts not only for the primary effects of an appreciation of the euro, but also for a number of important side- and feedback effects. In particular, the model considers that export and import data from the national accounts for the euro area comprise the trade among its member states. Exports of the rest of the euro area will thus be influenced by GDP in the euro area. A dampening effect on exports by an appreciation of the euro will, therefore, be followed by another dampening effect because of lower GDP growth. The model also accounts for the fact that imports are influenced by exports. That is, that the effect on GDP of a decline in exports due to appreciation will be lowered by the fall in imports that it causes. In addition, imports are affected by domestic demand and there is a positive terms-of-trade effect on domestic demand.

The model does not account for endogenous reactions of monetary policy. All simulated effects of an appreciation apply for given interest rates. Moreover, the model does not allow for feedback effects from inflation and wages. Since the main channel via which these entities could affect aggregate demand would be monetary policy, which we assumed to remain exogenous, we did not model the wage-price process.[1]

2.2 The Data

The two-region approach used in the present study requires the construction of a special national accounts data set for the euro area without Germany. We construct this data by subtracting the respective German series from the series for the euro area as a whole. Data for the latter come from Eurostat; for data points before 1991 we use the dataset that accompanies the ECB's area wide model (Fagan et al. (2001). National accounts data for Germany comes from the Federal Statistical Office. It refers to West Germany for the time before 1991; the break that occurs in the series due to unification has been eliminated using growth rates. The data is shown in Figure 1. Overall, there is a large amount of synchronization between the national accounts aggregates of Germany and those of the rest of the euro area. Significant deviations occur for all aggregates at the beginning of the 1990s and for domestic demand also from the middle of the 1990s onwards; the latter may partly reflect the weakness of construction investment in Germany after the unification induced boom.

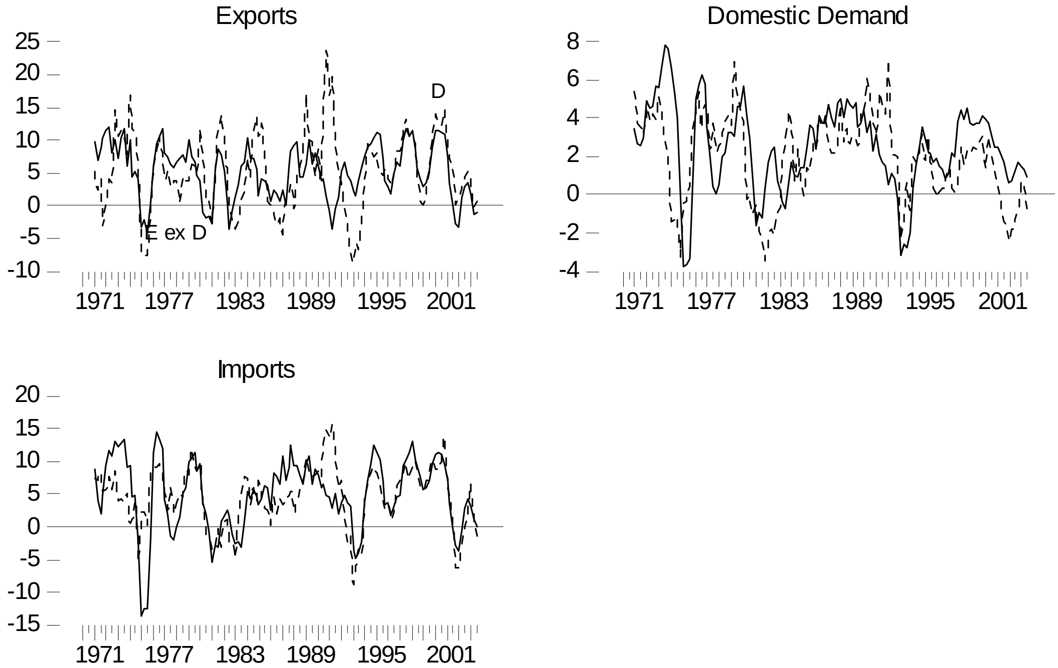
The two regions do not have equal weight. With 31.5 percent over the past four years, Germany is the smaller part. However, compared to all other countries of the euro area, Germany is by far the largest, so the two-region disaggregation makes most sense for Germany. Germany's share in total euro area exports is 0.30, its share in total imports is 0.28 and its share in total final demand is 0.32. These shares are used when aggregating the regional results to those for the euro area as a whole.

To model the effects of an appreciation of the euro on exports we follow standard practice and use effective exchange rate indexes. For Germany such an index is readily available from the Deutsche Bundesbank. The

[1] This implies that there is no feedback effect on price competitiveness. Given the stickiness of prices, the impact of this omission should be small in the adjustment period of 3 years that we analyze.

Figure 1:

National Accounts Aggregates for Germany and for the Rest of the Euro Area[a]



[a] Changes over previous year in percent. Broken lines refer to Germany, solid lines to the rest of the euro area.

Source: Eurostat, Destatis, Fagan et al. (2001); own calculations.

"indicator of international price competitiveness" covers Germany's real effective exchange rate against 49 trading partners, including those from the rest of the euro area. For the rest of the euro area, such an index has to be constructed. Note that we cannot simply take the ECB's real effective exchange rate index for the euro area as an approximation, since one important trading for the rest of the euro area is missing from this index: Germany.[2] Instead we use data on shares of the most important countries or currency areas — Germany, Japan, Switzerland, the Britain and the "dollar area" — in total trade of France, Italy, the

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[2] Since the start of EMU, real exchange rate changes between members of the euro area are no longer of great importance for their exports. The parameters of the export functions will, however, be estimated on a much longer sample, that reaches back into the time where real exchange rates could change quite sharply between today's members of the euro area.

Table 1:

Trade and Exchange Rate Weights [a]

	France[b]	Italy[b]	Nether-lands[b]	Belgium[b]	Spain[b]	Euro area ex Germ.[c]	Germany[d]
Germany	23.0	23.7	25.6	22.2	19.9	32.6	—
Japan	8.5	9.4	9.1	7.6	7.1	12.0	9.2
Switzerland	3.3	3.6	2.1	2.1	2.0	4.1	5.9
United Kingdom	10.0	8.7	11.2	10.7	9.1	13.9	9.7
Dollar area	17.5	17.6	16.2	14.6	13.5	23.3	22.9
United States	11.0	10.7	10.0	9.6	7.9	14.5	12.4
Singapore	1.5	1.3	1.3	0.9	1.0	1.8	1.3
South Korea	1.7	2.0	1.3	1.1	1.6	2.3	2.0
Hong Kong	1.3	1.5	1.6	1.0	1.0	1.9	1.1
Taiwan[b]	1.0	1.0	1.0	1.0	1.0	1.4	2.0
P. R. of China[b]	1.0	1.0	1.0	1.0	1.0	1.4	3.6
Total	62.3	80.5	80.4	71.8	65.1	100.0	47.1

[a] Percentages. [b]Share of the country/currency area in total trade of the country. [c]Share of the country/currency in the real effective exchange rate. [d]Share of respective country/currency in the Bundesbank's indicator of price competitiveness for Germany, normalized to the set of countries/currency areas analyzed here. That is, together with share of the rest of the euro area (52.9 %), they sum up to 100.0.

Source: Buldorini et al. (2002), p. 31 ; own calculations.

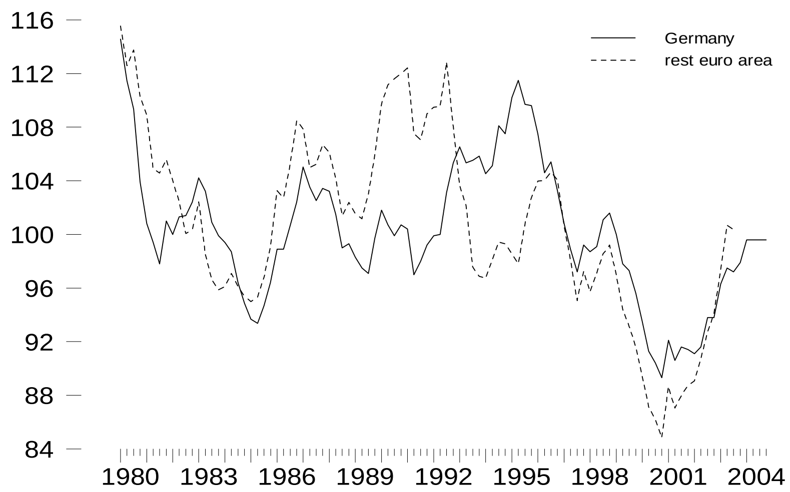
Netherlands, Belgium and Spain to construct a new index. Here, the "dollar area" is the United States plus a number of east Asian countries whose currencies have in the past been relatively closely tied to the U.S. dollar (Singapore, South Korea, Hong Kong, Taiwan and China). The same data has been used by the ECB in the construction of its real effective exchange rate indexes for the euro area (Buldorini et al. 2002).[3]

The weights of the five countries/currency areas in the newly constructed index are shown in Table 1, together with the weights for the individual countries. With a share of 32.6 percent, Germany is by far the most important trading partner for the rest of the euro area, followed by

[3] Taiwan and China are not covered in Buldorini et al. (2002). We assume a share of 1 percent for both countries.

Figure 2:

Real Effective Exchange Rates for Germany and the Rest of the Euro Area[a]



[a]A rise of the indicator implies a real appreciation and thus a loss of competitiveness.

Source: Deutsche Bundesbank; own calculations.

the dollar area (23.3 percent). It is interesting to note that the weight of the dollar area is nearly the same for the rest of the euro area and for Germany, as constructed from the weights used in the Bundesbank's indicator of international price competitiveness.[4]

Figure 2 shows the development of the two indices of real effective exchange rates since 1980. In the early 1980s the two series move closely together. In the second half of the 1980s, however, the rest of the euro area was losing price competitiveness, which eventually lead to the EMS crisis in 1992 and a sharp devaluation of some EMS currencies vis-à-vis the D-Mark, that implied a gain in competitiveness in the rest of the euro area and loss of competitiveness for Germany. It was only with the start of the run-up to EMU in 1996 that the indicators started to

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4 The weights of an indicator that comprises 38 countries can be found in Deutsche Bundesbank (1998).

move more or less in line, again. Unsurprisingly, since then the differences have been minor.

Another important data series for modeling exports is an index of economic activity abroad. Such an index is constructed for Germany and for the rest of the euro area on the basis of industrial production and trade weights. Again, it has to be recognized that the rest of the euro area is the most important trading partner for Germany and vice versa.

2.3 Model Equations

With one exception, the model equations follow standard macroeconometric specifications. The equations are modeled in error-correction form, with a long-run relationship specified by economic theory and short-run dynamics determined by sample-based times series criteria. All equations were specified such that there is cointegration between the variables, that the residuals of the equations do not show any sign of autocorrelation and that parameters are structurally stable and parsimoniously used.[5] Various tests were employed to make sure that the requirements are fulfilled. Moreover, a systematic search for poorly

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[5] Brüggemann and Lütkepohl (2001) show that a model selection strategy based on sequential elimination based on the lowest t-ratios is equivalent to sequentially eliminating coefficients based on a model selection criterion such as AIC or BIC, given that at each step of the elimination process a suitable threshold t-value is used. Using this result, we select the dynamic structure of the equations by first choosing some maximal lag order, estimating the model with all lags included and sequentially eliminate the coefficient with the lowest t-ratio and record the BIC for each of the models that appeared in the reduction process. In principle, the model with the minimum parameterization is our preferred model. However, we find that the BIC at times selects models that are parameterized too parsimoniously to capture the full dynamics of the underlying process, as can be seen from the serial correlation of the estimated residuals. Since the bootstrap procedure we use for constructing confidence intervals requires serially uncorrelated residuals and, moreover, since serial correlation may cause parameter estimation bias and thus poor forecast performance, we augment our criterion-based model selection with a test for autocorrelation. That is, we select the specification that minimizes the BIC among all specifications that passed tests for non-autocorrelated residuals up to the first, the fourth and the eighth order.

modeled observations (“outliers”) was run, to reduce the risk of parameter biases.[6]

Aggregate demand is modeled in a highly aggregative way in the present model. We only distinguish between domestic demand and net exports.[7] Net exports are however, not modeled as a single variable. Instead, standard export and import functions have been specified separately.

Exports

Exports depend on industrial activity abroad and on the real effective exchange rate. A time trend is used to account for the fact that international trade increases faster than production. For Germany, the coefficient of this trend is allowed to break in 1991; it is higher afterwards. The break was not found to be significant in the rest of the euro area, for which the sample, however, starts later.

Denoting the log of exports as *x*, the log of industrial production abroad as *i*, the real effective exchange rate as *q*, time as *t*, the change of a variable over the previous period with Δ and letting uppercase letters *D* and *E* indicate whether the variable refers to Germany or to the rest of the euro area, respectively, the equation for German exports reads[8]

$$\Delta x_t^D = \underset{(6.339)}{1.356} - \underset{(10.161)}{0.467}\, x_{t-1}^D + \underset{(9.584)}{0.535}\, i_{t-1}^D - \underset{(9.804)}{0.410}\, q_{t-1}^D + \underset{(5.484)}{0.0013}t \qquad (1)$$

$$+ \underset{(9.749)}{0.00008}t^{91} + \underset{(7.467)}{0.6745}\,\Delta i_t^D - \underset{(4.390)}{0.255}\,\Delta q_t^D$$

T: 1973:3–2003:3; R^2: 0.628; DW: 1.936; Outliers: 1988:1, 1990:1, 1974:1, 1980:1, 1984:2

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6 On the importance of outlier elimination see Franses and Lucas (1998) and Krasker et al. (1983). Our approach here follows that proposed by Chen and Lui (1993) for autoregressive models.

7 Rae and Turner (2001) present a similar specification.

8 As some experimentation showed significant outliers at the start of the 1990s, we excluded the observations 1990:3-1991:1 from the sample that is used for estimating the export functions, assuming that the unification boom and especially the introduction of the D-Mark in eastern Germany in mid 1990 is responsible for this unusual behaviour.

The respective equation for the exports of the rest of the euro area is

$$\Delta x_t^E = \underset{(4.543)}{-0.154}\, x_{t-1}^E + \underset{(4.623)}{0.238}\, i_{t-1}^E - \underset{(3.377)}{0.063}\, q_{t-1}^E + \underset{(1.451)}{0.0004}t \qquad (2)$$

$$+ \underset{(9.406)}{1.195}\, \Delta i_t^E - \underset{(3.127)}{0.1634}\, \Delta q_t^E$$

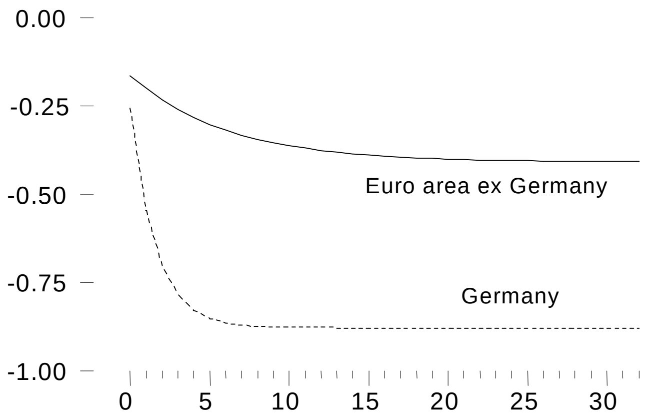
T: 1980:2–2003:3; R^2: 0.441; DW: 2.062; Outliers: 1981:2, 1987:3, 1989:2, 1991:2

Note that the series for industrial production abroad i_t^D comprises data from the rest of the euro area as well as data from the rest of the world. In the simulations, the rest of the euro area enters with a weight of 0.4. The i_t^E series comprises industrial production from the rest of the world (weight: 0.4), from Germany (0.2) and from the rest of the euro area itself (0.4). The latter data is necessary because of the construction of the Eurostat euro area export data, which does not represent true extra-EWU-trade but is simply the sum of the national accounts exports of the individual member states. By construction, this characteristic carries over to the rest of the euro area data used here. This data also has an intra-EWU-trade component and, therefore, depends not only on economic activity abroad (including Germany) but also on activity in the rest of the euro area itself. This specification of the export functions as dependent partly on industrial production in Germany and in the rest of the euro area implies in turn that industrial production in Germany and in the rest of the euro area endogenous. We therefore appended simple bridge equations for both regions, that relate industrial production to GDP.

According to the estimates in equation (1) and (2), Germany is much more vulnerable to exchange rate changes than the rest of the euro area. The long run elasticity of exports with respect to exchange rate changes is in Germany with 0.88 more than double the value of the elasticity in the rest of the euro area (0.41). Moreover, adjustment to a change in the exchange rate is in the euro area considerably slower than in Germany (Figure 3).

Figure 3:

Dynamic Reaction of Exports to a Permanent Real Effective Appreciation by 10 Percent



Source: Own calculations

Imports

Imports are modeled as dependent on the (log of the) sum of domestic demand and exports, denoted *dx*. This way, we account for the fact that imports of intermediate inputs that are induced by production for export represent a large and rising share of total imports. For Germany, the preferred specification is

$$\Delta m_t^D = \underset{(3.902)}{-4.197} - \underset{(3.981)}{0.413}\, m_{t-1}^D + \underset{(3.937)}{0.969}\, dx_{t-1}^D + \underset{(9.289)}{2.139}\, \Delta dx_t^D \qquad (3)$$

T: 1991:2–2003:3; R^2: 0.649; DW: 2.128; Outliers: –

For the rest of the euro area we find

$$\Delta m_t^E = \underset{(6.898)}{-2.829} - \underset{(7.166)}{0.381}\, m_{t-1}^E + \underset{(7.012)}{0.700}\, dx_{t-1}^E + \underset{(34.146)}{2.156}\, \Delta dx_t^E \qquad (4)$$
$$+ \underset{(6.456)}{0.403} \left(\Delta dx_{t-1}^E + \Delta dx_{t-3}^E\right)$$

T: 1992:1–2003:3; R^2: 0.962; DW 2.039; Outliers: —

Note that the specifications do not contain a real exchange rate. A dependence of imports on the real exchange rate was tested for but not found significant.[9]

Domestic demand

As regards domestic demand, we deviate somewhat from standard practice, in an attempt to capture an important effect of exchange rate changes on the economy. A real appreciation of the euro can be interpreted as a positive supply shock for the euro area, comparable to an increase in productivity growth or to a fall in oil prices: either less must be exported to finance a given amount of imports or more can be imported for a given amount of exports (Kohli 2004). In contrast to a productivity shock, however, the positive real income effect of an appreciation or of an oil price fall is not accounted for by real GDP. In fact, real GDP falls as a result of a fall in import prices since the latter enter the GDP deflator with a negative sign. Kohli (2004) shows that changes in the terms of trade account for a large share of the changes in real income of a number of industrialized countries.[10]

To account for this terms of trade effect, the indicator of price competitiveness q is introduced as a second argument, in addition to GDP y, in the stochastic equation for domestic demand d. The equation for domestic demand in Germany reads:

$$\Delta d_t^D = \underset{(3.564)}{-0.171} - \underset{(6.186)}{0.269}\, d_{t-1}^D + \underset{(6.260)}{0.257}\, y_{t-1}^D + \underset{(5.807)}{0.052}\, q_{t-1}^D + \underset{(16.639)}{0.9951}\, \Delta y_t^D \quad (5)$$

T: 1971:2–2003:3; R^2: 0.487; DW: 1.942; Outliers: 1974:1, 1990:2, 1991:1, 1991:2, 1991:4

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9 This is in line with previous findings for Germany. Strauß (2003), for instance, finds only a small exchange rate elasticity that is only marginally significant.

10 Fox et al. (2002) analyse the terms of trade-effect for single country in a time series study.

For the rest of the euro area the preferred equation is

$$\Delta d_t^E = \underset{(2.989)}{-0.171} + \underset{(3.869)}{0.1764}\, d_{t-1}^E + \underset{(3.885)}{0.186}\, y_{t-1}^E + \underset{(2.847)}{0.023}\, q_{t-1}^E + \underset{(17.938)}{1.111}\, \Delta y_t^E + \underset{(3.848)}{0.063}\, \Delta q_t^E \qquad (6)$$

T: 1975:2–2003:3; R^2: 0.763; DW: 1.750; Outliers: –

Both in the equation for Germany and in the equation for the rest of the euro area, the coefficient of the indicator of price competitiveness is significantly positive. Accounting for this variable also increases the stability of the estimation results and the fit of the equation. There is, thus, indeed evidence for a terms-of-trade effect on domestic demand. The long run elasticity of domestic demand with respect to the indicator of price competitiveness is estimated to be 0.2 for Germany and 0.13 for the rest of the euro area.

In addition to the stochastic equations, the model contains a number of identities for adding up the individual components of demand. As a result of the logarithmic formulation of the equations for the components, these identities are formulated in growth rates, with the share of the respective component in the total giving the weight. The weights in these equations have been calculated using the average over the past four years.

3. Empirical Results

The full model will now be used to analyze the effects of an effective appreciation of the euro by 10 percent. Recent studies by international organizations with large macroeconometric models, which, however, focus on the effects of an effective depreciation of the U.S. dollar, can be used as a benchmark. For instance, the OECD (2003) finds in an analysis based on its econometric world model that a 10 percent real effective depreciation of the dollar would slow down economic growth in the euro area by 0.2 percentage points in the first year.[11] Simulations of the six German research institutes (Arbeitsgemeinschaft 2003) with the macroeconometric multi-country model of Oxford Economic Forecasting found that a 10 percent real appreciation of the euro against the dollar would dampen GDP growth in the euro area by 0.1 percentage points, both in the first and in the second year. However, the simulations implied strong endogenous reactions from monetary policy. Euro area interest rates would decline by 0.9 percentage points in the first year and by 0.3 percentage points in the second. Without these reactions, the output effect would have been stronger.

3.1 The Setup

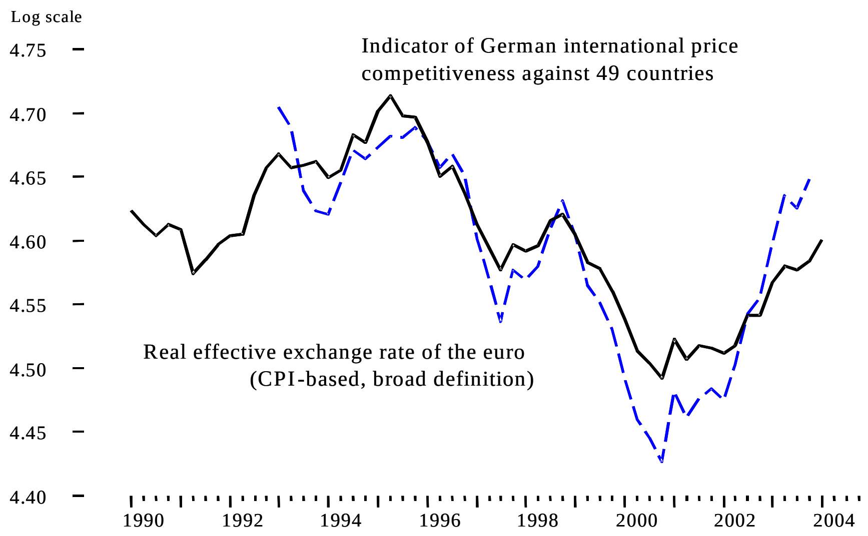
In the simulations it is assumed that the exchange rate reaches its new level immediately and remains there over the period analyzed. Since endogenous price adjustments are not modeled, the nominal appreciation is equal to the real appreciation over the whole simulation period. For the short-run effects which are the focus of the analysis here, this simplification may be justified. In future work, we intend to append a supply-side block to the model, to be able to investigate price adjustments.

A conceptual problem arises from the fact, that we are interested in the impact of an appreciation of the effective exchange rate of the euro. In the model, however, exports and domestic demand in the two regions depend on region-specific exchange rate indices. We therefore need some formula that translates a 10 percent change in the index of the real effective exchange rate of the euro into changes of the two regional indices. We can obtain such a relationships by simply regressing each of the regional indices on the euro area index over the period from 1996 up to now. The sample is determined by the fact that since 1996 nominal exchange rates between EMU-members have been de facto fixed.

[11] The results in OECD (2003) refer to the change in the output gap against the baseline solution. With potential output growth unaffected by exchange rate changes, the documented change in the output gap by 0.2 percentage points implies a change in real GDP of the same magnitude.

Figure3:

Real Effective Exchange Rates for Germany and the Rest of the Euro Area[a]



[a] Natural logarithms.

Source: Deutsche Bundesbank; own calculations.

Therefore, the exchange rate indices should have since than been moving more or less in line.

We find that Bundesbank's indicator of international price competitiveness moves by half a percentage point for every 1 percentage point change in the real effective exchange rate of the euro. Such a relationship is also indicated by visual inspection of Figure 3. The newly constructed real effective exchange rate index for the rest of the euro area is somewhat more closely tied to the aggregate euro area index; the coefficient is 0.72. Thus, a 10 percent appreciation of the euro increases the indicator of international price competitiveness of the German economy by 5 percent and the real effective exchange rate index of the rest of the euro area by 7.2 percent. The higher responsiveness to changes in the exchange rate of the euro in the rest of the euro area partly compensates for the lower exchange rate elasticity of exports.

The dynamic multipliers of an exchange rate change will be given together with 95 percent-confidence bands. This way, the uncertainty of the estimate can be assessed. The confidence intervals are estimated via stochastic simulation. We use a non-parametric bootstrap with 1,000 replications to approximate the distribution of the multipliers.[12]

2.3 Simulation Results

The impact of a effective revaluation of the euro by 10 percent is summarized in Figure 5. In the quarter of the appreciation, exports fall against the baseline solution, both in Germany and in the rest of the euro area. This fall continues over the next quarters, albeit with declining speed. In the first year, annual average export growth in Germany falls by 3.5 percent points behind the baseline solution (Table 2), for the rest of the euro area, the respective figure is 2.3 percentage points and exports of the euro area as a whole will be dampened by 2.6 percentage points. In the second year, the effect is smaller, amounting to –0.8 percentage points for the euro area as a whole. Even for the third year, a significant negative effect on euro area exports is documented (–0.5 percentage points). In the long run, German exports fall by 5 percent against the baseline solution. This results conforms with our previous studies (e.g. Benner et al. 2002) if one takes into account that changes in the real effective exchange rate of the euro translate into the German indicator of price competitiveness that enters our export equation with a factor of 0.5.[13]

Imports react in a similar way, albeit somewhat less pronounced than exports. The estimated multiplier is, however, subject to considerably higher estimation uncertainty. The annual average of import growth falls behind the baseline solution by 2.8 percentage points in the first year in Germany and by 1.2 percentage points in rest of the euro area. The fall in imports, thus, compensates much of the fall in exports.

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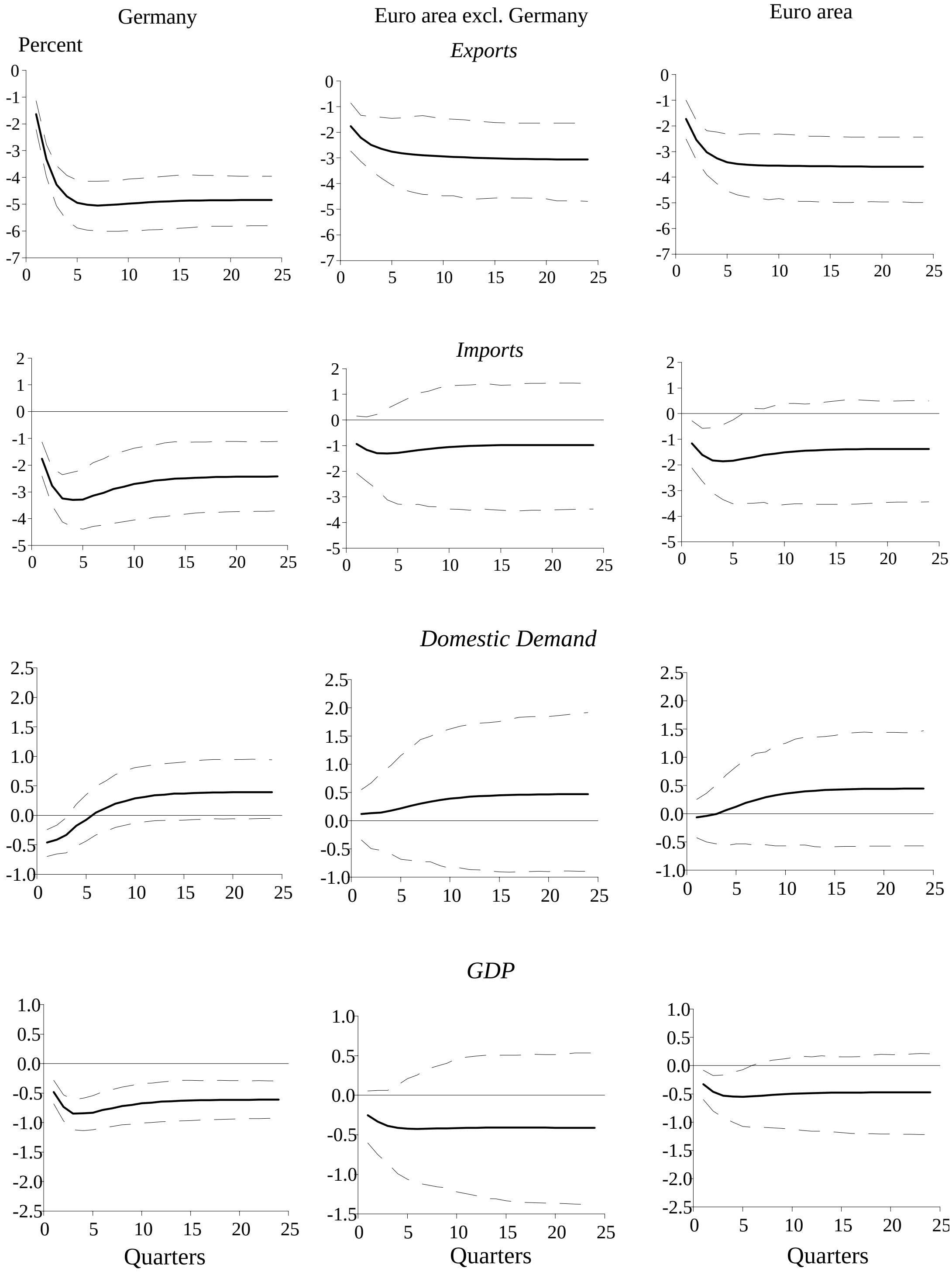
[12] See Berkowitz and Kilian (2000), Horrowitz (2001), and Clements and Taylor (2001) for recent surveys on bootstrap methods to obtain confidence intervals. A non-technical introduction to the bootstrap is given by Brownstone and Valetta (2001).

[13] In the present model, exports are additionally dampened by lower economic activity in the rest of the euro area. However, this effect is counteracted by the fact that the long run elasticity of German exports with respect to the indicator of price competitiveness is estimated somewhat lower here (0.9) than in Benner et al. (2002) (1.1).

Figure 5:

Effects of a 10 Percent Real Effective Appreciation of the Euro on Main Aggregates in Germany and in the Rest of the Euro Area[a]



[a]Deviation from the baseline solution in percent. The change in the exchange rate occurs in period 1. Broken lines indicate the 95 percent confidence interval of the respective multiplies. Confidence intervals are estimated via stochastic simulation (non-parametric bootstrapping with 1,000 replications).

Table 2:

Effects of a 10 Percent Real Effective Appreciation of the Euro on Main Aggregates in Germany and in the Euro Area[a]

	Exports	Imports	Domestic demand	GDP
		Germany		
1st year	–3.5 (–4.2; –2.8)	–2.8 (–3.6; –2.0)	–0.3 (–0.6; –0.1)	–0.8 (–1.0; –0.5)
2nd year	–1.5 (–1.7; –1.3)	–0.3 (0.7; 0.1)	0.4 (0.3; 0.6)	–0.0 (–0.1; 0.0)
3rd year	–0.7 (–0.9; –0.5)	0.2 (–0.1; 0.5)	0.4 (0.3; 0.5)	0.1 (0.0; 0.0)
		Euro area excluding Germany		
1st year	–2.3 (–3.3; –1.3)	–1.2 (–2.6; 0.2)	0.1 (–0.5; 0.8)	–0.4 (–0.8; 0.1)
2nd year	–0.6 (–1.0; –0.2)	0.0 (–0.7; 0.7)	0.1 (–0.2; 0.6)	–0.1 (–0.3; 0.2)
3rd year	–0.3 (–0.7; 0.0)	0.2 (–0.5; 0.7)	0.1 (–0.2; 0.5)	–0.0 (–0.2; 0.2)
		Euro area		
1st year	–2.6 (–3.5; –1.8)	–1.6 (–2.8; –0.5)	0.0 (–0.5; 0.5)	–0.5 (–0.8; –0.1)
2nd year	–0.8 (–1.2; –0.5)	–0.1 (–0.7; 0.5)	0.2 (0.0; 0.5)	–0.1 (–0.3; 0.2)
3rd year	–0.5 (–0.8; –0.2)	0.1 (–0.4; 0.6)	–0.2 (0.0; 0.5)	0.0 (–0.2; 0.2)

[a]Effect on the rates of change against the average of the previous year. Figures in parentheses give upper and lower bounds of the 95 percent confidence intervals. The latter are estimated via stochastic simulation (non-parametric bootstrapping with 1,000 replications).

As regards domestic demand, it is interesting to note that in Germany the stimulating effect of improved terms of trade is at first overcompensated by lower GDP growth. Still, after some six quarters, the terms of trade-effect starts to dominate, but the estimate is too imprecise to reject the hypothesis that domestic demand remains unaffected by exchange rate changes in the long run. For the rest of the euro area, there is an immediate positive impact, but this is not significantly different from zero. Real GDP is affected by the appreciation mainly in the first year. In Germany, it falls behind the baseline solution by 0.8 percentage points. In the rest of the euro area the dampening effects are smaller due to the small impact effect on exports; real GDP grows 0.4 percentage points less than in the baseline

Table 3:

Effects of a 10 Percent Real Appreciation of the Euro Against the U.S. Dollar on Main Aggregates in the Euro Area[a]

	Exports	Imports	Domestic demand	GDP
1st year	–0.9 (–1.3; –0.5)	–0.6 (–1.0; 0.0)	0.0 (–0.2; 0.2)	–0.2 (–0.3; –0.0)
2nd year	–0.3 (–0.4; –0.2)	–0.0 (–0.3; 0.1)	0.1 (0.0; 0.2)	0.0 (–0.1; 0.0)

[a]Effect on the rates of change against the average of the previous year. Figures in parentheses give upper and lower bounds of the 95 percent confidence intervals. The latter are estimated via stochastic simulation (non-parametric bootstrapping with 1,000 replications).

solution. The euro area as a whole loses 0.5 percentage points. In the following years, the effects are not significantly different from zero.

Note that the dynamic multipliers estimated here are similar those of the OECD (2003). To make the present study approximately comparable to that of the OECD, which focuses on a 10 percent real effective dollar depreciation, Table 3 shows the effects of a real appreciation of the euro only against the dollar in our model. Accordingly, real GDP in the euro area falls behind the baseline solution by 0.2 percentage points in the first year, with no further significant effects in the following years. The OECD study finds that the output gap in the euro area is by 0.2 percentage points smaller than in the baseline solution in both the first and the second year and by 0.3 percentage points in the third year. The small further opening of the output gap in the third year apart, these results are in line with those of the present study. Moreover, they are close to what we assumed in our previous forecasts for Germany and the euro area.

4. Perspectives

We have analyzed the effects of an appreciation of the euro on Germany and the euro area in a small structural econometric model. A characteristic feature of the model is the regional disaggregation of the euro area in Germany on the one hand and the rest of the euro area on the other. This setup allows to take feedback effects between the regions into account, which is especially interesting when the focus is not on the euro area as a whole but on a single country like Germany.

The environment we have used is well suited to address other quantitative macroeconomic questions. In particular, with a somewhat different specification of the domestic demand function, or maybe some disaggregation of domestic demand, the effects of interest rate changes could be investigated. This would, of course, be interesting for the ECB's monetary policy decisions. Another theme would be the analysis of international business cycle transmissions. Finally, the model can be used for forecasting.

As it stands, the model is partial in nature. As indicated above, a necessary augmentation is a supply side, with a wage and price setting process. Further details could, of course, be introduced, such as a modeling fiscal policy. Moreover, the model now relies on backward looking expectations, introducing rational expectations could make the model more realistic. These problems can hopefully be addressed in future research.

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