Discussion Papers

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Berlin, June 2002

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ISSN 1619-4535

German exports to the euro area*

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June 10, 2002

Abstract

The growth of the German economy intrinsically depends on the development of German exports to the euro area, which is by far the biggest market for German products. The paper estimates a structural equation for the export demand from the EMU member countries, which is suitable for both simulations and short-term forecasts. However, the equation systematically underestimates the export demand for data from 1999 onwards, indicating that German exports have greatly benefited from the introduction of the European Monetary Union–a special effect, that is not considered in the structural equation.

JEL Codes: C22, C52, F47

Keywords: Export Demand, Income and Price Elasticity, Intra-EMU Trade, Error Correction Model

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* The study's main results were presented at a workshop, jointly organized by Prof. Juergen Wolters (Free University of Berlin) and Dr. habil. Gustav-Adolf Horn (DIW Berlin) in June 2001. I would like to thank all the participants for fruitful discussions and helpful comments. I am particularly grateful to Prof. Juergen Wolters for his continuing support, which has enabled major improvements to be made.

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1 Motivation

Germany has a highly export-dependent economy. At the moment, the export rate[1] is about 33 percent and this trend is going to increase further. The euro area is by far the biggest market for German products (Figure A.1, Appendix): 44 percent of the total export of goods was exported to EMU member countries in 2001. In a nutshell: the growth of the German economy intrinsically depends on the development of the export of goods to the euro area. Therefore, it seems reasonable to investigate the driving forces behind the German exports to EMU member countries, in order to develop an export demand equation that can be used for short-term forecasts; the assessment of the future macroeconomic development in Germany ultimately depends on the reliable forecasting of export growth.

There is already a sizable amount of literature on export demand equations for Germany, but these studies always analyze the subject using a highly aggregated level–they focus either on the total export of goods (special trade) or on total exports (goods and services according to National Accounts Statistics).[2] One reason for this is that the data situation is still quite complicated on the European level. All the statistical offices for EMU member countries recently switched to a new methodology–the European System of National and Regional Accounts (ESA95). Shortly after the switch, only a few time series were available and they were too short to be used in estimation equations. Meanwhile, many statistical offices have provided backward calculations for the most important time series. Recent studies show, however, that it is often quite difficult to deal with these series, because many of them are plagued by structural breaks or varying seasonal patterns. Since the whole process is a long way from being completed, further revisions are to be expected.

[1] The export rate is calculated as total exports (at current prices) as a proportion of GDP (at current prices). The time series are taken from the National Accounts Statistics and contain figures for Germany (West) until 1990:4 and figures for a unified Germany afterwards.

[2] Export of goods: Döpke/Fischer (1994), Deutsche Bundesbank (1997 and 1998); total exports: Strauß (2002), Seifert (2000).

This paper presents a structural equation for the demand for German goods from the EMU member countries. The equation is part of the macroeconometric multi-country model of the German Institute for Economic Research (DIW Berlin). Therefore, it has to meet specific requirements. Since the multi-country model is designed to be used for both simulations and short-term forecasts, the equation has to be suitable for both purposes. This implies, however, that the choice of explanatory variables is limited–only those variables can be used that are explained endogenously in the model. If this were not the case, interactions between different economies could not take effect in the model as a whole.

The paper is presented as follows: Section 2 introduces the hypothesis on the export demand function and explains how the variables that catch the determining factors have been constructed. Since the estimation result intrinsically depends on how the variables are constructed, a detailed description of the data input and the different steps is given. Section 3 presents the estimated export demand function and analyzes its forecast performance. In Section 4, the main findings of the study are summarized and conclusions are drawn.

2 Determining factors for German exports

2.1 Hypothesis on the export demand function

Suppose that country A (the home country) is the exporting country and that country B (the foreign country) is the importing country. Country B's demand for goods depends on its preferences, commodity prices and income. The Marshallian demand function (D_i) reads as follows:

$$x_i = D_i(p_1, p_2, ..., p_n, Y) = D_i(\mathbf{p}, Y) \quad (i = 1, ..., n)$$

where $\mathbf{p} = (p_1, p_2, ..., p_n)$ is the vector of prices and Y denotes the money income.

To simplify matters, it is assumed that country B is only interested in two goods: the imported good (x_A) and a domestic commodity (x_B). The price of x_A (p_A) is fixed in currency of country A, whereas the price of x_B (p_B) is fixed in currency of country B. Furthermore, it is assumed that

- the import good (x_A) is a normal good, i.e. a rise in country B's aggregate income (Y_B) leads to a rise in its demand for x_A (positive income elasticity);
- country B's demand curve for the import good (x_A) has the normal negative slope; i.e. a rise in p_A leads to a fall in the demand for x_A (negative own-price elasticity);
- the import good (x_A) is a substitute for the domestic commodity (x_B): i.e. a rise in p_B leads to an increase in country B's demand for x_A (positive cross-price elasticity).

Given these assumptions, country B's demand for the import commodity (x_A) can be formulated in the following way:

$$x_A = x_A(\overset{(-)}{p_A/e}, \overset{(+)}{p_B}, \overset{(+)}{Y_B})$$

where e is the nominal exchange rate. The algebraic sign above the determining factors stands for the algebraic sign of the dependent variable's derivative with respect to this factor.

While empirical export demand functions usually depend on prices and income (Goldstein/Khan (1978), Möller/Jarchow (1990)), recent literature includes the growing international division of labor as another determining factor which has a positive influence on exports (Döpke/Fischer (1994), Strauß (2002)). Thus, the export demand function to be estimated reads as follows:

$$x_A = x_A\left(\overset{(-)}{\frac{p_A}{e \times p_B}}, \overset{(+)}{Y_B}, \overset{(+)}{div}\right)$$

where *div* stands for the growing international division of labor. Note, that the single prices have now been transformed into a relative price, which is in fact a real external value. This variable is a measure of the price competitiveness of country A's exporters.

2.2 Data

This paper examines the development of German exports to the euro area. The corresponding time series has been calculated by summing up German exports to the other EMU member countries (in current prices) and using the export price index (1995=100) to convert them into real terms.[3]

Empirical studies usually use foreign GDP to model the aggregate income of the foreign country.[4] In the case of Germany, however, this procedure has the disadvantage that it uses a sluggish time series (foreign GDP) to explain a series that develops very dynamically (German exports). Therefore, recent studies instead use a variable–like the index of industrial production[5]–that better catches the *dynamics* of economic activity in the foreign country. This study uses the same method, though the variable that approximates the economic activity in the euro area is selected with regard to the structure of German exports. There are five export goods categories–automobiles, electrical goods, machinery, iron and steel products, chemical products–which account for almost two-thirds of total German exports to the euro zone and which mainly belong to the investment goods category. For this reason, an index series that reflects the investment activity in the euro area is used as a proxy for the economic activity in this area. The index series is calculated as follows: first, raw data for gross fixed capital formation (GFCF) (at constant prices of 1995) in France, Italy, Spain, the Netherlands, Belgium, Austria and Finland is converted into euro using the corresponding fixed conversion rates. Then, these series are cumulated to obtain the EMU-aggregate.[6] Fi-

[3]Detailed information on the data base is provided in the Appendix.

[4]Cf. Sawyer/Sprinkle (1999)

[5]Cf. Döpke/Fischer (1994), Strauß (2002)

[6]The time series for GFCF (calculated according to ESA95) provided by Ireland, Portugal and Luxembourg are too short. Therefore, these countries are not included in the

nally, the index series is calculated using 1995 as its base year.

Compiling euro zone data is a tricky task. It is inappropriate to simply aggregate the data across individual countries, although this is a much practiced approach; exchange rate fluctuations distort the aggregated series. However, using fixed conversion rates for transforming national figures into a common currency avoids this problem and makes sure that the aggregate correctly reflects the development of the individual series. In order to illustrate the importance of the aggregation problem, Figure 1 displays the impact of both procedures on the development of the index series that reflects the investment activity in the euro zone[7]: The EMU-aggregate consisting of national GFCF-series, which have been transformed using the fixed euro conversion rates, shows an overall positive trend that was only interrupted at the beginning of the nineties, when Europe went through a phase of economic stagnation that was followed by a recession. The other EMU-aggregate consisting of national GFCF-series, which have been converted using the corresponding Deutsche Mark exchange rates, shows three phases of economic stagnation in the mid-eighties, at the beginning of the nineties and in the mid-nineties and a massive slump in the recession years 1992/1993. This slump was so strong that the index series falls below the level that it had already achieved in the mid-eighties. The reason behind the different development of the two index series is that when the Deutsche Mark conversion rate is used, fluctuations in its exchange rate with the European currencies distort the EMU-aggregate: the appreciation of the Deutsche Mark during the eighties and between 1992 and 1995 caused positive trends in European investment activity to be underestimated and negative trends to be overestimated. Such a time series

EMU-aggregate. Nevertheless, leaving out these smaller countries does not cause any problems, because 96% of all German exports to the euro zone go to the above-mentioned EU7-countries.

[7]The index series that reflects the investment activity in the euro zone has been seasonally adjusted, so that the impact of exchange rate changes on the development of the aggregated series is clearly visible and is not overlapped by a seasonal pattern.

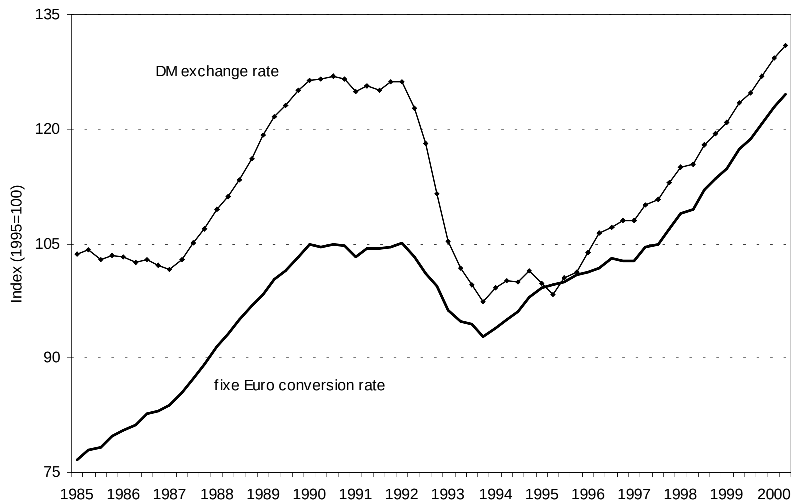

Figure 1: **Impact of different exchange rates on the development of the investment activity in the euro area**

does not correctly reflect the demand from the euro area.[8]

In this study, the real external value of the Deutsche Mark in relation to the currencies of the EMU member countries is used to measure the price competitiveness of German exporters. It is calculated as follows: first, the bilateral real external values of the Deutsche Mark based on relative consumer prices (CPI) are calculated. Then the real external value of the Deutsche Mark in relation to a basket of the European currencies is compiled by weighting

[8]Beyer, Doornik and Hendry (2000) dealt with the problem of constructing historical euro zone data. They proposed calculating the within-country growth rates of each variable, aggregating them to a weighted-sum euro zone growth rate and use this growth rate together with a starting value for the EMU-aggregate to calculate aggregate levels. The variable weights of the different countries are still influenced by exchange rate changes, but due to the fact that only growth rates and not levels are multiplied with these weights, exchange rate changes do not have any negative effects on the aggregate. A similar result can be achieved if national time series are transformed into a common currency using fixed conversion rates. Since this approach is far less complicated, it is used in this study.

the bilateral external values with the respective country's share in German exports.[9] Using consumer prices to calculate real external values is often criticized for theoretical reasons, because this index includes non-traded goods as well as traded goods.[10] Therefore, two alternative external values have been tested that better meet the theoretical requirements: one is based on the relation of the export price to the European price level[11], the other is based on relative unit labor costs in Germany and in the euro zone. The comparative estimations reveal that these variables do not outperform the real external value based on relative consumer prices[12]; their calculation, however, is far more time-consuming. There is also another argument for using the relative consumer prices: the export demand function is part of the macroeconometric model for Germany, which is used for both simulations and short-term forecasts. Since the DIW Berlin regularly prepares forecasts for the price level trend in the EMU member countries, forecasts for the real external value based on relative consumer prices are always available and can be directly included in the model for Germany. Using these figures increases the consistency of the DIW forecast and it considerably reduces the time that has to be spent updating the model's data base.

Even if economic activity in the euro area and the price competitiveness of the German exporters remain unchanged, German exports to the euro zone would continue to increase, because of the growing international division of labor. Due to the integration of the European market, companies have the opportunity to reduce production costs by moving parts of their production to neighboring European countries. This strategy leads to a reduced manufacturing penetration in the home country and it implies that the products can be exported and re-imported up to several times in the course of the production process. The export growth caused by the growing international

[9]In order to avoid problems, which could occur due to simultaneity, the share of the preceding period is always taken. This procedure does not influence the estimation results.

[10]Cf. Deutsche Bundesbank (1998a), Lapp/Scheide/Solveen (1995)

[11]The European price level is approximated by the final demand deflator of the EU7-countries.

[12]Similar results are reported by Deutsche Bundesbank (1998a) and Strauß (2001).

division of labor is modeled in this study using a linear trend.

Section (2.1) explained from a theoretical point of view how export demand is influenced by its determining factors. Consequently, there are 'prejudices' associated with the signs of the coefficients to be estimated. A positive relationship between investment activity in the euro area and German exports is expected. The impact of the real external value on exports, however, is expected to be negative, because both of the developments, which can hide behind a rise in external value, worsen the price competitiveness of German exporters: first, the price level in the home country (Germany) rises faster than that in EMU member countries. Second, the nominal external value rises; in other words the Deutsche Mark appreciates.[13] Finally, the growing international division of labor is expected to have a positive effect on German exports.

Figure 2 displays time series for German exports, for investment activity in the euro area and for the real external value of the Deutsche Mark. These series are not seasonally adjusted. Therefore, centered seasonal dummies are used in the estimation equations to model the seasonal pattern. Since the time series are transformed into logarithms, the estimated coefficients can be interpreted as elasticities.

[13]Since 1.1.1999, the nominal external value of the Deutsche Mark in relation to the currencies of EMU member countries has been fixed. This means that from 1999 onwards changes in the real external value can only occur due to a different development of prices in the home and in the foreign country.

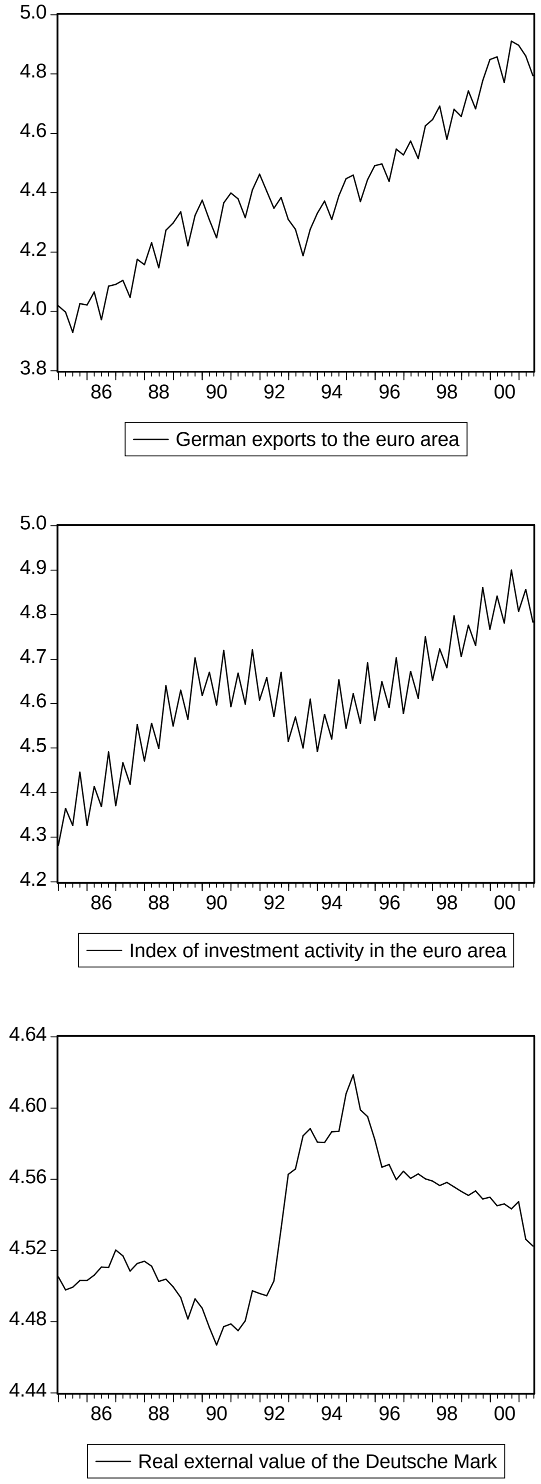

Figure 2: **Original time series, logs**

3 Econometric analysis

3.1 Unit root and cointegration tests

The export demand equation is a component of a structural model and should therefore reflect a theoretically-founded long-run steady state relationship; from an econometric point of view, this is equivalent to the requirement that the time series forming export demand should be cointegrated. Since cointegration tests require specific time series properties, all the time series are first subjected to unit root tests.[14]

The unit root tests show that German exports, investment activity in the euro area and the real external value of the Deutsche Mark are integrated of order one; they are I(1).[15] In order to identify those combinations of variables that form a cointegration relationship, the Engle-Granger approach (Engle-Granger (1987)) is used. This approach is based on the definition of cointegration, which states that two (or more) I(1)-variables are cointegrated, if there is a stationary linear combination. The Engle-Granger test is a two-step approach: first, one runs a regression between the respective variables in levels and then tests whether the residuals from this regression are stationary. The Engle-Granger test identifies a cointegration relationship between exports, investment activity in the euro area, the real external value of the Deutsche Mark and the growing international division of labor. This result is significant at the 1% significance level (Table 4, Appendix). Using a cointegration test, which is based on a single-equation approach is often criticized.[16] The reason for this is, that these tests can only test for the existence of *one* cointegration relationship. As long as there are only two variables ($n = 2$) to be tested in the model, this is not a problem, because only one cointegration vector could exist at most. However, if there are $n > 2$

[14]The exact specification of the unit root tests and the results are reported in Table 3, Appendix. Eviews 3.1 was used for the econometric analysis.

[15]Integrated of order one means, that the time series has to be differenced once, in order to obtain a stationary time series. Therefore, I(1)-variables are also called difference-stationary.

[16]Cf. Harris (1995)

variables in the model, up to $n-1$ linear independent cointegration vectors could exist and tests that are based on a single-equation approach can not identify them. Erroneously assuming that there is only one cointegration relationship when in fact more exist, has severe consequences for the reliability of the estimated coefficients: they cannot be interpreted, because they are a linear combination of the existing cointegration vectors.

Therefore, the result was checked again, using the Johansen cointegration test, which is based on a multivariate VAR (vector autoregression) approach. The Johansen test delivers two important results (Table 5, Appendix): first, the cointegration relationship which has been identified using the Engle-Granger approach is proved at the 1% significance level. Second, the Johansen test proves, that there is in fact only *one* cointegration vector. This result is essential for the estimation approach for the export demand function, as it implies that in principle a single-equation error correction model can be used. The single-equation approach is usually less efficient–compared to a system of equations–because it neglects available information. But when the explanatory variables for exports are weakly exogenous, this disadvantage disappears. Therefore, it is examined, if the demand for investment goods from the euro area and the real external value of the Deutsche Mark are weakly exogenous in relation to exports.

Weak exogeneity can easily be tested using a vector error correction model (VECM). This is a system of error correction equations that can be derived by transforming a vector autoregression (VAR). An error correction equation consists of two components–the error correction mechanism and the short-run dynamic model. The error correction mechanism consists of the cointegration relationship, which reflects the long-run steady state relation, and the long-run coefficient. The error correction mechanism makes sure that deviations from the long-run steady state, which are also called "errors", are partly corrected in the next period. The long-run coefficient states how fast this adjustment is performed. An insignificant long-run coefficient implies that the error correction mechanism does not work in the corresponding equation. Consequently, this equation does not contribute to the adjustment process of the whole system. Suppose, that the long-run coefficients in the error correction equations for the investment activity in the euro area and for the real external value of the Deutsche Mark are insignificant. Then, the adjustment is exclusively carried out by the error correction mechanism in the export equation and the VECM can therefore be reduced to a single-equation approach. There is evidence that both explanatory variables are weakly exogenous.[17] Thus, the export demand can be efficiently estimated using a single-equation error correction model.

3.2 Estimating the export demand function

The estimation is based on unadjusted quarterly figures covering the period 1985:3-2001:3. The specification of the estimation equation was derived applying the 'general to specific' approach. This means that the estimation procedure started with a generous lag-specification for all variables and that the insignificant ones were excluded one by one. In order to clearly present the estimation results, the following notation is used: EX denotes German exports, $GFCF$ stands for investment activity in the euro area and $REXVAL$ denotes the real external value of the Deutsche Mark. $Trend$ is a linear time trend, which takes the value 1 in the third quarter 1985 and the values 2, 3, etc. in the following quarters–it is a proxy for the growing international division of labor. sd_1, sd_2 and sd_3 denote centered seasonal dummies. The equation is estimated using nonlinear least squares (NLS). Thus, the t-values of the coefficients can be directly interpreted. The export demand function reads as follows (t-values in parentheses):

[17]The t-values for the long-run coefficients are -1.55 (GFCF-equation) and -2.37 (REXVAL-equation), i.e. the latter t-value is slightly above the critical value. However, varying the lag structure of the VECM always leads to the result, that the long-run coefficient of the REXVAL-equation is insignificant.

$$
\begin{array}{l}
\Delta lnEX_t = \underset{(\textit{-6.4})}{-0.76}\,[lnEX_{t-1} - \underset{(\textit{-3.7})}{6.14} - \underset{(\textit{-10.3})}{0.01}trend - \underset{(\textit{-4.0})}{0.51}lnGFCF_{t-1} + \underset{(\textit{-4.0})}{1.04}lnREXVAL_{t-1}] \\
\qquad \underset{(\textit{0.6})}{+0.05sd_1} \quad \underset{(\textit{2.7})}{+\,0.08sd_2} \quad \underset{(\textit{-0.8})}{-\,0.06sd_3} \\
\qquad \underset{(\textit{2.0})}{+0.22\Delta lnEX_{t-2}} \quad \underset{(\textit{2.0})}{+\,0.23\Delta lnEX_{t-3}} \quad \underset{(\textit{1.4})}{+\,0.15\Delta lnEX_{t-4}} \\
\qquad \underset{(\textit{3.8})}{+0.89\Delta lnGFCF_t} \quad \underset{(\textit{2.8})}{+\,0.69\Delta lnGFCF_{t-1}}
\end{array}
$$

Let's first have a look at the cointegration relationship [in parenthesis]: according to Banerjee et al. (1998), the t-value for the negative long-run coefficient of an error correction model can be used to find out whether a cointegration relationship exists. For the selected specification of the cointegration vector (two stochastic regressors, constant and trend) the critical value at the 1 % significance level is -4.51. The t-value for the estimated long-run coefficient (-6.4) is significantly smaller than the critical value. Thus, the null hypothesis stating that no cointegration relation exists, can definitely be rejected. The estimated long-run coefficient is -0.76; i.e. deviations from a steady state are to a large extent corrected in the following period. All the determining factors for German exports have the expected signs. In the long run, a 1 % increase in the investment activity in the euro area per quarter leads to an increase in German exports of about half percent per quarter, whereas a 1 % increase in the real external value of the Deutsche Mark per quarter leads to a decline in German exports of about the same amount. The very high price elasticity reflects the high competitive pressure that German exporters face in the European market. In the long run, the price competitiveness of German exporters is far more important for the growth of German exports than the investment activity in the euro area is. The latter, however, plays an important role in the short-run adjustment of the model: changes in the level of investment activity in the euro area in the current and preceding period greatly influence the growth of exports. Since this study is based on quarterly figures, this implies that an up-swing in the euro area leads to a significant increase in German exports within the next three to six months. Furthermore, the short-run adjustment is carried out by the lagged endogenous variables.

The diagnostic tests reported in Table 1 show that the model fits the data quite well ($\bar{R}^2$=0.88). The model specification was checked using both White's Heteroscedasticity Test and Ramsey's Reset Test. White's Heteroscedasticity Test is a general test for misspecification, since the null hypothesis underlying the test assumes that the error terms are both homoscedastic and

Diagnostics	
Adjusted R-squared ($\bar{R}^2$)	0.88
Residual Tests	**Probability**
Normality Test (Jarque-Bera)	[0.31]
Serial Correlation LM Test (lag 1)	[0.45]
Serial Correlation LM Test (lag 4)	[0.84]
Serial Correlation LM Test (lag 8)	[0.52]
White's Heteroscedasticity Test	[0.60]
Reset Test (lag 1)	[0.98]
ARCH LM Test (lag 1)	[0.15]
ARCH LM Test (lag 4)	[0.66]
Stability Tests	
CUSUM Test[a]	0
CUSUM^2 Test[a]	0

[a] Number of quarters where the cumulative sum goes outside the area between the 5 % critical lines.

Table 1: **Diagnostic tests**

independent of the regressors, and that the linear specification of the model is correct. Failure of any one of these conditions could lead to a significant test statistic. Since the test statistic is insignificant, the null hypothesis–assuming that the model is correctly specified–can not be rejected. Ramsey's Reset Test is a general test investigating whether one of the following kinds of misspecification exists: omitted variables, incorrect functional form and correlation between error term and regressors. Since the test statistic is also insignificant there is no reason to believe that the model is misspecified. Moreover, there is no evidence for autocorrelation in the residuals. Finally, the CUSUM tests state parameter stability (Figure 3).

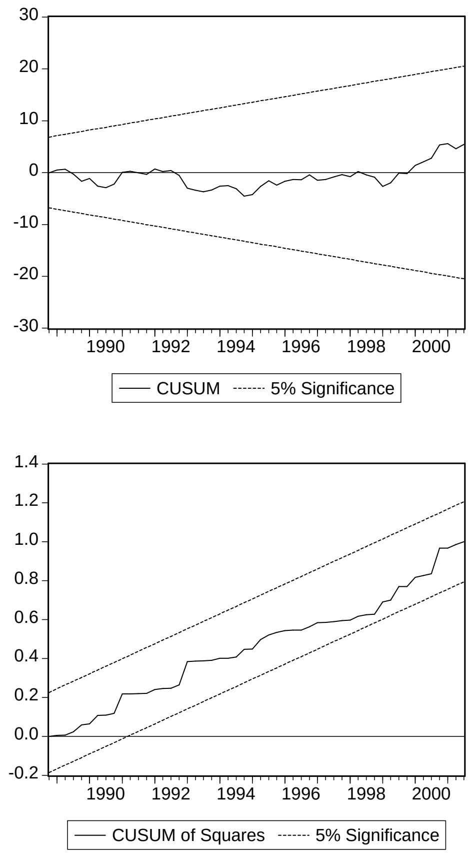

Figure 3: **Results of the CUSUM tests**

3.3 Forecast evaluation

Since the estimation equation for German exports to the EMU member countries is used for forecasting purposes, its forecasting quality has to be examined in detail. Therefore, two different kinds of simulations are carried out: an *ex post* in-sample and an *ex post* out-of sample forecast. Since both methods refer to a forecast period for which actual data for all variables are available, the forecasting quality of the equation can be evaluated comparing actual values for the endogenous variable with those simulated by the equation.

3.3.1 In-sample forecast

The in-sample forecasting quality of the export demand function is tested by a *dynamic* forecasting procedure. This method uses the coefficients estimated in the export demand function (estimation sample: 1985:3-2001:3) together with actual values for the exogenous variables in order to predict the endogenous variable.[18] The dynamic forecasting approach is a strict test for the validity of the equation, because the endogenous variable is exclusively determined by the simulation solution. This implies that prediction errors do not loose importance in the course of time but instead continually influence the development of the predicted series. On the other hand, an equation's strength for dynamic forecasting gives strong evidence for its validity. In the following, the development in the *level* of German exports is simulated; i.e. raw data for real exports of goods (Deutsche Mark bn) are predicted. The simulation starts in 1985 : 3 and runs until 2001:3. The statistics displayed in Table 2 characterize the forecasting quality of the equation.

The root mean squared error and the mean absolute percent error measure the average and the average percent deviation of the predicted time series from its actual time path. The small values reflect the good forecasting ability of the model. Theil's inequality coefficient measures the fit of the model.

[18] At the beginning of the simulation period actual values for the German exports are supplied for the lagged endogenous variable.

Forecast evaluation	
Root Mean Squared Error	2.26
Mean Absolute Percent Error	1.79
Theil Inequality Coefficient	0.01
Bias Proportion	0.00
Variance Proportion	0.05
Covariance Proportion	0.95

Table 2: **Statistical results evaluating the forecast**

It always lies between zero and one; zero indicates a perfect fit. For the simulation under consideration, Theil's inequality coefficient is 0.01 indicating that the estimation equation fits well. Theil's inequality coefficient can be decomposed into three different measures that indicate the source of the forecast error: the bias proportion states how far the mean of the forecast is from the mean of the actual series. This measure reflects the proportion of the systematic forecast error in relation to the overall forecast error. The bias proportion should be close to zero, because a significant value indicates that there is a systematic error in the forecast, which would require a revision of the fitted model. The variance proportion reflects the ability of the model to catch the variability of the variable under consideration. A significant variance proportion indicates that the actual series fluctuates considerably, whereas the forecasted series only fluctuates slightly or vice versa. The covariance proportion measures the unsystematic forecast error. Ideally, the bias and variance proportion of the forecast error should be zero and the forecast error should in fact be completely due to the unsystematic forecast error. Table 2 shows that the export demand equation meets these requirements to a very high extent.

In order to visualize the forecast quality of the export demand function, actual values (dotted line) and forecasted values (solid line) for German exports are plotted in Figure 4 together with the forecast error. The latter is expressed as a percentage of the actual value–a negative (positive) sign indicates an underestimation (overestimation). The development of the actual and the predicted values for German exports proves that the forecasted series tracks the development of the actual figures quite closely over the whole forecasting period. Nevertheless, the graph of prediction error clearly reveals that the equation underestimates the growth of the exports for the year 1999 onwards. This means there is an additional positive trend in the development of exports that is not captured by the equation. Since this phenomenon coincides with the start of the European Monetary Union, it would be reasonable to assume a connection.

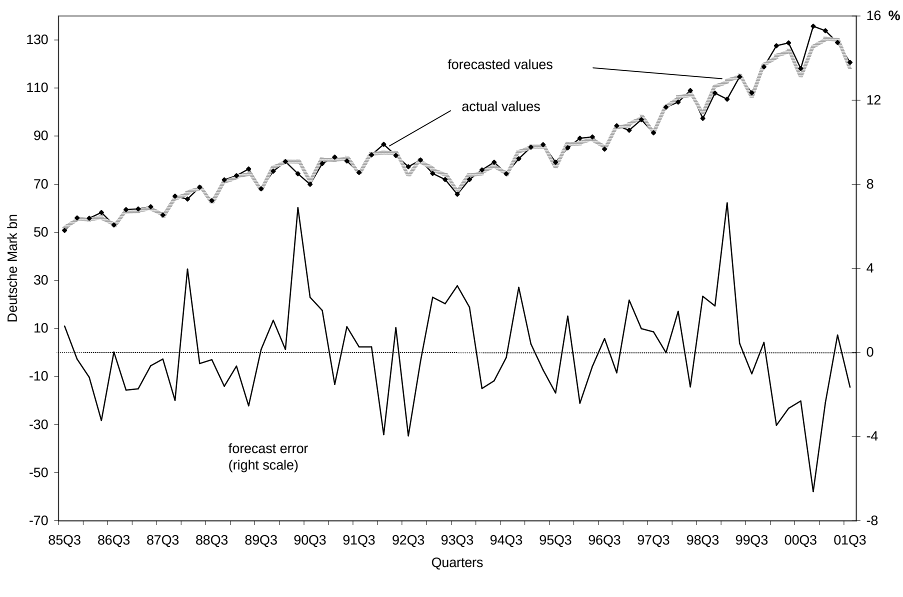

Figure 4: **In-sample forecast for German exports**

German exporters have benefited from the introduction of the common European currency due to its effects on price competitiveness. In the past, German exporters faced considerable exchange rate fluctuations due to overshooting. Periods of significant appreciation of the Deutsche Mark in relation to the currencies of Germany's most important European trading partners were followed by periods where these appreciations were partly reversed. Because of the high level of competitive pressure in the European market, German exporters had no scope for passing the price increases[19] caused by the appreciation of the Deutsche Mark on to customers. They instead had to hold their supply price (in foreign currency) relatively constant in order to defend their market share. Such a pricing-to-market strategy however implies that periods in which the Deutsche Mark appreciated (depreciated) coincided with declining (increasing) export prices in DM and consequently with a decline (increase) in the profits of the German exporters. So German exporters did not just taking production costs into account when setting their prices but also added a small premium to cover the exchange rate risk. This mark-up created extra profits when the Deutsche Mark depreciated and built up a stock of financial resources that could be used to offset losses in profits when an appreciation in the Deutsche Mark occurred.

Such considerations are supported by empirical evidence: the movement of export prices (in DM) and nominal external value of the Deutsche Mark during the eighties and the first half of the nineties developed in opposite directions. In the second half of the nineties, the European convergence process began and national economic and monetary policy were harmonized step by step. This process was supported and supervised by the national central banks and exchange rate fluctuations were therefore reduced. Nevertheless, there was still uncertainty as to whether the EMU could begin as planned. Only after the common European currency was introduced in 1999 the situation did change for German exporters. On the one hand, the exchange rate

[19] It is still assumed that the export price reflecting the production costs is fixed in DM and that the supply price on the export market (in foreign currency) is given by export price (in DM) / nominal exchange rate (see subsection 2.1).

risk was eradicated and the risk premium on the export price was now unnecessary. Therefore, German exporters could set a supply price that reflected their price competitiveness. On the other hand, the introduction of the euro drastically increased the transparency surrounding goods and services: prices for goods and services can now be easily compared across Europe.[20] Therefore, the lower German export prices should be noted and rewarded.

These reflections are in line with the simulation result. It has raised the interesting question of whether this special effect caused by the introduction of the euro will disappear after a period of adjustment or whether it will permanently affect German export growth. Since this phenomenon occurs at the very end of the sample, the question can not be answered at present. However, the forecasted figures for 2001 provide evidence that the systematic underestimation has come to an end. This could indicate that the special effect is loosing importance.

3.3.2 Out-of-sample forecast

Finally, the stability of the estimated coefficients is examined using an ex post out-of-sample forecast. Therefore, the overall sample (1985:3-2001:3) was divided into an estimation sample (1985:3-1996:3) and a forecast sample (1996:4-2001:3) and the export demand equation was re-estimated for the shortened estimation sample. Then a dynamic forecast was performed for the period (1996:4-2001:3). Figure 5 shows that the forecast quality of the export demand function is quite good up until 1999. After that date, the equation systematically underestimates the dynamics of the export growth and performs even worse than the equation based on the estimation sample (1985:3-2001:3). This is not a surprising result, because the estimation sample has been cut off long before the additional dynamics start to push German export growth. Altogether, the result of the out-of-sample forecast

[20] The euro soon began to play an important role in Intra-EMU trade. The German Federal Statistical Office states that only half a year after the introduction of the euro nearly 40 % of German exports and 22 % of German imports have been priced in euro. Cf. Krockow (1999:873).

demonstrates the equation's quality. Although, there are problems in 1999 and 2000, but–when considering Figure 5–they seem to become less severe after these dates.

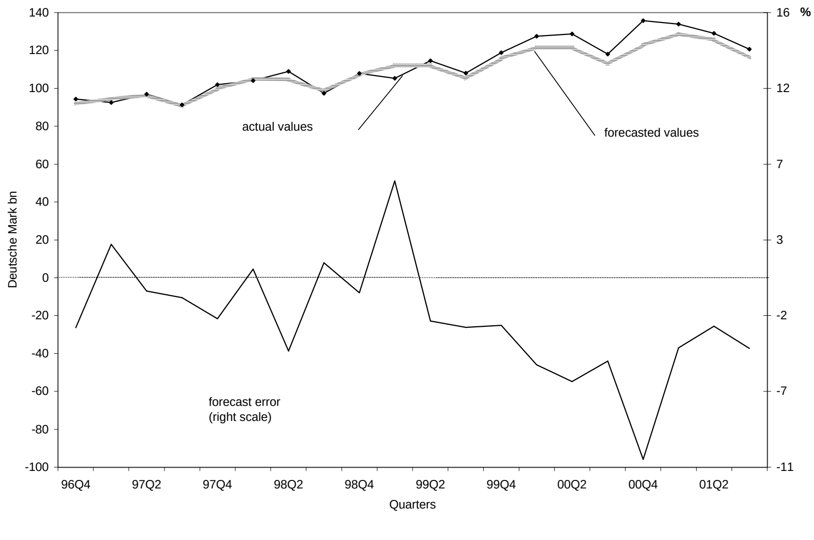

Figure 5: **Out-of-sample forecast for German exports**

4 Conclusion

The estimation equation for the German export of goods to EMU member countries presented in this paper combines reliable and innovative elements. The reliable aspects include the explanation of exports using the demand from abroad, the price competitiveness of German exporters and the growing international division of labor. The long-run relationship between these variables is remarkably stable. The innovative aspect of this study is that the variable reflecting the demand from abroad (index of investment activity in the EMU member countries) is constructed in such a way that the aggregated time series is not distorted by exchange rate fluctuations. Figure 1 illustrates that the development of the aggregated time series completely changes if exchange rate fluctuations are eliminated from the aggregate. It is therefore expected that the careful separation of exchange rate and demand effects strongly influences the estimated price and income elasticities. This study has shown that the estimated price elasticity of the exports increases und that the income elasticity decreases if exchange rate distortions are eliminated from the aggregated series. This means that in the long run, the price competitiveness of German exporters is more important than the demand for investment goods from abroad. The latter, however, plays an important role in short-run adjustment. An exciting discovery was that Germany has greatly benefited from the introduction of the euro. The introduction of the European currency has improved the sales opportunities for German exports, because–following the elimination of uncertainty surrounding exchange rate fluctuations and the corresponding risk premium–German exporters can reduce their supply prices. The euro also increases the transparency surrounding goods and services. Therefore, it is to be expected that the lower German export prices are recognized and rewarded. The special effect caused by introducing the euro is not considered in the structural equation; this leads to significant underestimations for German export growth in 1999 and 2000. The interesting question is whether the *dynamics* in the development of exports that accompanied the introduction of the euro will last–a question, that can only be answered by time.

Appendix

A.1

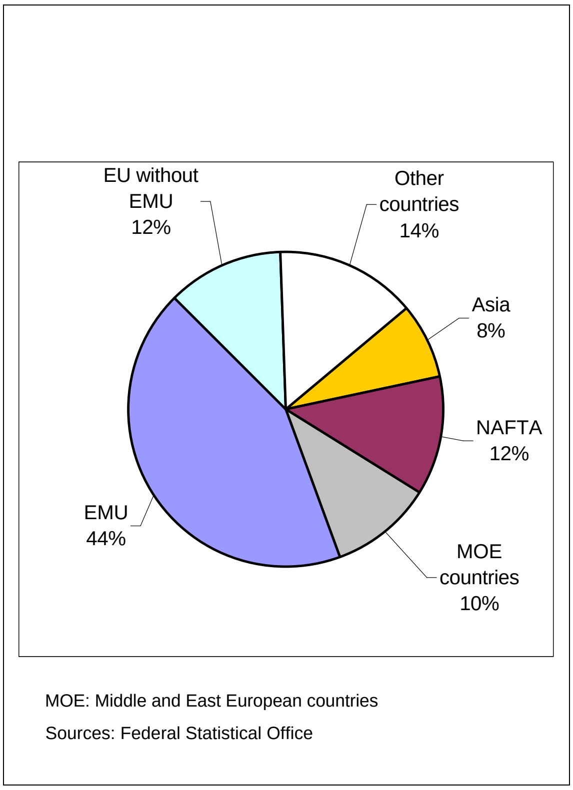

Figure A.1: German exports 2001 by regions

A.3

The time series for German exports could have a structural break due to German reunification. Therefore, the Perron-test (Perron (1989))–which is a unit root test that allows for a structural break in a time series–was performed first. Since this test did not find any evidence for the existence of a structural break, all time series could be subjected to the usual Augmented Dickey-Fuller test.

Augmented Dickey-Fuller Test						
Sample: 1985:1-2000:2						
Variable	**Specification**	**Lags**	**t-value**	**Critical value**		**Order of integration**
				5%	1%	
export of goods (EX)	C, trend, centr. seasonal dummies	2, 5	-1.22	-3.47	-4.01	I(1)
gross fixed capital formation (GFCF)	C, trend, centr. seasonal dummies	2, 3, 4	-2.76	-3.49	-4.12	I(1)
real external value of the Deutsche Mark (REXVAL)	C	1, 3	-2.04	-2.90	-3.52	I(1)
D(EX)	C, centr. seasonal dummies	4	-8.86***	-2.90	-3.52	I(0)
D(GFCF)	C, centr. seasonal dummies	1, 3, 4	-3.08**	-2.91	-3.55	I(0)
D(REXVAL)		3, 4	-6.06***	-1.94	-2.59	I(0)
*** (**) denotes significance at a 1%-level (5%-level)						

Table 3: **Unit root tests**

Engle-Granger Approach					
Sample: 1985:1-2000:2					
Specification	**ADF-test on residuals**		**Critical values**[1]		
	Lags	**t-value**	10%	5%	1%
EX, GFCF, REXVAL, C, Trend, centered seasonal dummies	2-4	-4.88***	-3.83	-4.12	-4.67

[1] critical values by MacKinnon (1991)

*** denotes significance at a 1%-level.

EX: German export of goods, GFCF: investment activity in the euro area,

REXVAL: real external value of the Deutsche Mark

Table 4: **Engle-Granger cointegration test**

Johansen Approach

Test assumption: linear deterministic trend in the data
Series: EX, GFCF, REXVAL
Exogenous series: centered seasonal dummies
Lags: 1 to 4

Eigenvalue	**Likelihood Ratio**	**5% Critical value**	**1% Critical value**	H_0**: number of cointegration equations**
0.47	53.3	42.4	48.5	none**
0.17	16.7	25.3	30.5	at most 1
0.10	6.1	12.3	16.3	at most 2

(**) denotes rejection of the hypothesis at a 1% significance level.

Likelihood ratio test indicates 1 cointegration equation at a 1% significance level.

EX: German export of goods, GFCF: investment activity in the euro area,

REXVAL: real external value of the Deutsche Mark

Table 5: **Johansen cointegration test**

Data base

Time Series	**Source**	**Annotations**
Germany		
export of goods (special trade (fob))	Federal Statistical Office Germany	Special trade according to official export statistics, including supplements to goods trade and minus freight and insurance costs. Segment 4016 Germany (West): 1980:1-1989:4 unified Germany: 1990:1-2000:4 raw data
export price index (Index der Durchschnittswerte Ausfuhr)	Federal Statistical Office Germany	chained index (1995=100) raw data
CPI	OECD: Main Economic Indicators	index (1995=100)

EMU member countries		
gross fixed capital formation	Eurostat: Quarterly National Accounts	at constant prices (1995=100), ESA95, raw data
exchange rates	Deutsche Bundesbank	
CPI	OECD: Main Economic Indicators	index (1995=100)

Abbreviations

CPI	Consumer Price Index
DM	Deutsche Mark
DIW Berlin	German Institute for Economic Research
EMU	denotes in this paper the member countries of the European Monetary Union *excluding* Germany
ESA	European System of National and Regional Accounts
EU7	France, Italy, Spain, the Netherlands, Belgium, Austria and Finland
EX	German export of goods
fob	free on board
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
NLS	Nonlinear Least Squares
REXVAL	Real external value of the Deutsche Mark
VAR	Vector autoregression
VECM	Vector error correction model

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