Institut für Makroökonomie
und Konjunkturforschung
Macroeconomic Policy Institute

Working Paper

6/2005

Sabine Stephan, IMK

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Hans-Böckler-Straße 39
D-40476 Düsseldorf
Germany
Phone: +49-211-7778-331
IMK@boeckler.de
http://www.imk-boeckler.de

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German Exports to the Euro Area – A Cointegration Approach*

Sabine Stephan
Macroeconomic Policy Institute (IMK)†

September 12, 2005

Abstract

This paper analyzes the determinants of German exports to the euro area, which is by far the biggest market for German products. Four conditional error correction models based on regionally disaggregated data are developed. One specification includes EMU industrial production and a real external value based on consumer prices, the other three use different EMU investment aggregates, the corresponding real external values and a proxy for European market integration to explain exports. The models perform equally well in a number of diagnostic tests. For short-term forecasts, however, the model using industrial production seems to be the best, since it outperforms the other models in terms of one-step ahead out-of-sample forecasts. Furthermore, the explanatory variables of this equation (industrial production and consumer prices) are easier to forecast than investment aggregates and the corresponding prices.

Keywords: Export Function, Income and Price Elasticity of Exports, Intra-EMU Trade, Error Correction Model, Forecasting

JEL Codes: C22, C52, F47

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* An earlier version of this paper was presented at the annual 2002 congress of the Verein für Socialpolitik. I thank Gustav-Adolf Horn, Hubert Strauss and Juergen Wolters for their helpful comments, as well as Florian Zinsmeister and Serhiy Yahnych for providing me with Eviews programs that facilitate the forecasting exercise.

† Hans-Böckler-Straße 39, 40476 Düsseldorf; email: sabine-stephan@boeckler.de

1 Motivation

Germany is traditionally one of the most successful export nations in the world and has further improved its export performance in recent years. Since 2003 Germany's total exports of goods have exceeded even those of the United States, although the German GDP is only one fourth of the U.S. GDP. The German export-to-GDP ratio is about 36 percent, which is remarkably high – not only compared to big economies like the United States or Japan, which have export ratios of about 7 to 12 percent, respectively, but also compared to medium-sized European economies like France, Italy and Spain, which have export ratios of about 27 percent.[1] It follows that Germany is a relatively open economy despite its rather large size and economic might. The biggest market for German products is the euro area – its share is about 43 percent. Since exports are crucial for Germany's macroeconomic performance, it is of great interest to analyze the determinants of German exports to the euro area and to derive an export function that can be used for short-term forecasts.

There is a sizable body of literature on Germany's aggregate exports (see Table 1). But this study is – to my knowledge – the first dealing with German exports to the European Monetary Union (EMU). Since we use a set of variables that accounts for both the specific structure of German trade with EMU member countries and the fact that since 1999 exports to these countries have no longer been influenced by exchange rate changes, we expect to obtain more reliable estimations of income and price elasticities from our approach based on regionally disaggregated data.

[1]The export ratio is calculated as total exports (at current prices) as a proportion of GDP (at current prices). All figures refer to the year 2004. Figures for the United States and Japan are taken from the International Financial Statistics (IMF) and the World Development Indicators database (World Bank). The figures for the European countries are taken from the Quarterly National Accounts provided by Eurostat.

author	estimation sample	method	dependent variable	Y	$P_X/P^*\cdot E$	deterministic regressors in EC term		
						$s9101$	$s9301$	trend
Clostermann (1996)	1975:1-1995:4	SEECM	goods	world trade volume 0.97	$P_X/PPI^*\cdot E$ -0.84	-0.07	-0.08	
Clostermann (1998)	1975:1-1995:4	SEECM	goods	world trade volume 0.80	$P_X/P^*_{gdp}\cdot E$ -0.74	-0.09	-0.07	
Bundesbank (1998a)	1975:1-1997:2	SEECM	goods	world trade volume 0.88	REEV18 -0.70	-0.07	-0.06	
Strauß (2000)	1974:2-1999:4	SEECM	goods + services	$IPRO^*$ 1.55	REEV38 -0.58			linear 0.002
Strauß (2000)	1974:2-1999:4	SEECM	goods + services	GDP^* 1.34	REEV38 -0.39			linear 0.003
Seifert (2000)	1979:1-1999:4	SEECM	goods + services	world trade volume 1.09	REEV18 -0.88			
Strauß (2003)	1974:2-1999:4	SEECM	goods + services	$IPRO^*$ 1.34	REEV38 -1.00			WTI 0.41
Meurers (2003)	1975:1-1999:4	JOH	goods	$IPRO^*$ 1.65	$P_X/CPI^*\cdot E$ -0.69			

Time series in logs; $s9101$: step dummy for German reunification; $s9301$: step dummy for European Single Market; GDP^*: foreign GDP; P_X: export prices; P^*: foreign price level; E: exchange rate; PPI^*: foreign producer prices; $IPRO^*$: foreign industrial production; P^*_{gdp}: foreign GDP deflator; REEV18: real external value of the German mark in relation to 18 countries; REEV38: real external value of the German mark in relation to 38 countries; CPI^*: foreign consumer prices; WTI: world trade intensity; SEECM: single equation error correction model; JOH: supply and demand are estimated simultaneously using the Johansen approach (only cointegration relationship).

Table 1: Literature survey: income and price elasticities of German exports

The paper is organized as follows. In Section 2 and 3, the determinants of exports are discussed briefly and the data is presented. In Section 4, a set of variables that are widely recognized in the literature as export determinants are tested systematically for their ability to explain German exports to the euro area. This procedure leads to four alternative export equations which are subjected to a forecasting exercise in Section 5 in order to determine which one is best suited for short-term forecasting. Section 6 concludes.

2 Determinants of exports

The basic explanatory variables are typically derived from consumer theory[2], according to which aggregate demand depends on aggregate income and commodity prices. Hence, given that consumers have no money illusion, the demand for exports depends on real income abroad and the relative export price, which measures the exporters' price competitiveness. Recent literature additionally includes a proxy for the growing international division of labor (Strauß 2000, 2003; Lapp, Scheide, and Solveen 1995; Döpke and Fischer 1994). Thus, the export function to be estimated is:

$$x = x\left(\frac{Y^*}{p^*}, \frac{p}{e \cdot p^*}, d\right), \tag{1}$$

where x is the quantity exported, Y^* and p^* are the aggregate income and the price level abroad, p is the export price, e is the nominal exchange rate and d is a proxy for the increasing market integration. Given the usual assumptions that exports are normal goods, that the demand curve has the normal negative slope and that domestic and foreign goods are imperfect substitutes, the export demand has a positive income elasticity, a negative own-price elasticity and a positive cross-price elasticity. The growing international division of labor has a positive effect on exports.

[2] The functional form of an export equation can also be derived from a production function. For the case of a CES production function see e.g. Clostermann (1996) or Strauß (2001).

3 Data

In this study we use seasonally unadjusted quarterly data for the period 1981:1 to 2003:2. The time series for real German exports to the EMU member countries ($XGEWU95$) contains figures for West Germany until 1989:4 and figures for a unified Germany afterwards.[3] The set of explanatory variables is chosen following the literature (see, e.g. Leamer and Stern 1970; Goldstein and Khan 1985, Sawyer and Sprinkle 1999). It is complemented by further variables that account for specific peculiarities of German trade with the euro area.

The chosen activity variables are real gross domestic product ($GDP95^*$) and industrial production ($IPRO95^*$) of the euro area.[4] Since almost two-thirds of German exports to EMU member countries are investment goods, we also use investment in fixed capital ($IFC95^*$) and investment in machinery and equipment ($IMEQ95^*$) in the euro area.

The price competitiveness of German exporters is measured by a set of different real effective external values of the German mark in relation to the currencies of the EMU member countries ($REEV$). Since the relative prices should correspond to the above-mentioned activity variables, real effective external values on the basis of the following price indices are calculated: consumer prices (CPI), prices of investment in fixed capital ($PIFC$), prices of investment in machinery and equipment ($PIMEQ$) and GDP deflator ($PGDP$).

Even if economic activity in the euro area and the price competitiveness of German exporters remain unchanged, German exports to the euro zone would continue to increase due to stimulating effects coming from European market integration. The variable that accounts for this effect is real intra-EMU exports and imports (excluding Germany) over real EMU GDP (excluding Germany) ($TRADE$). Since the calculation of this time series is very time-

[3] In the foreign trade statistics the switch is in 1990, whereas in the national accounts statistics it is in 1991.

[4] The asterisk indicates that the time series refers to the foreign country.

consuming, we also check whether a linear trend can also serve as a proxy for the growing international division of labor. All time series are in logs. A detailed discussion of variable construction, the listing of data sources and the graphs of the time series are provided in the appendix.

4 Econometric analysis

4.1 Unit root and cointegration tests

All variables under consideration are integrated in levels and stationary in first differences (see Table 4, appendix).[5] Thus, a cointegration analysis is appropriate. Since there are $n > 2$ variables in the model corresponding to equation (1), up to $n - 1$ linear independent cointegration vectors could exist. Therefore, we apply the Johansen cointegration test to determine the number of cointegration vectors. The Johansen (1995) procedure is based on a multivariate VAR model which can be reparameterized as a VECM. In the first step, a vector autoregression is set up, with the lag order determined by using the Akaike information criterion. Then the corresponding VECM is estimated to test for the number of cointegrating vectors using the trace test. Since the data are seasonally unadjusted, centered seasonal dummies are used. Regarding the deterministic trend specification, it is assumed that there are linear trends in the levels of the data but no trend in the cointegration vectors. Consequently, the Johansen test is specified with an intercept both in the cointegrating relations (error correction term) and in the VEC equation outside the cointegrating relations. Only in the specific case, when we check whether a linear trend could serve as a proxy for the growing international division of labor, we consider a linear trend in the Johansen test, which is restricted to the cointegration space.

The sets of variables that are tested for cointegration are displayed in Table 5 and Table 6 in the appendix. In seven out of ten cases the Johansen test indicates exactly one cointegration vector. For these specifications we check

[5] Eviews 4.1 was used for the econometric analysis.

in a second step whether all variables except exports are weakly exogenous. If this is the case, deviations from the long-run equilibrium are corrected solely through the error correction mechanism of the export equation; the VECM can then be reduced to a conditional single equation error correction model for exports that can be interpreted as a structural export function.[6] In three cases (model 1, 2, and 10) the export equations do not contribute to the adjustment of the system. These models are therefore excluded from the analysis. In all other cases, deviations from the long-run equilibrium are corrected solely (model 3, 5, and 7) or mainly (model 8) through an adjustment of exports. In the following section, we present the corresponding structural export functions.

4.2 Export equations

The alternative export equations are derived applying the 'general to specific' approach: the estimation procedure starts with four lags for all variables; insignificant ones are excluded one by one. The EC terms are estimated using nonlinear least squares. Since the time series are transformed into logs, the estimated coefficients can be interpreted as elasticities. For ease of presentation we use the short-hand notation for the variables that was introduced in Section 3. *csd* stands for centered seasonal dummy. A set of impulse dummies is needed to correct for outliers: i9301 and i9002 account for changes in the foreign trade statistics due to completion of the European Single Market and German unification. The dummy variables i8801 and i8402 are necessary to avoid deviations from normality and ARCH effects in the regression errors. T-values of the estimated coefficients are indicated in parentheses. For the residual and specification tests p-values are given in brackets.

[6] It is possible to estimate a single equation error correction model (SEECM) even if some of the explanatory variables are not weakly exogenous. In this case, however, the single equation approach is no longer efficient, because available information is neglected. It is typically argued that contemporaneous changes of explanatory variables which are not weakly exogenous should not be included in the SEECM. This is not true. Hassler and Wolters (2006) show that if explanatory variables are correlated with the regression error, cointegration tests based on conditional error correction regressions are more powerful than those based on unconditional error correction regressions.

Sample 1981:1-2003:2

Model 3

$$
\begin{aligned}
&\Delta \ln XGEWU95_t = \\
&\underset{(-5.5)}{-0.35}\,[\ln XGEWU95_{t-1} \underset{(-41.1)}{-2.03} \ln IRPO95^*{}_{t-1} \underset{(5.9)}{+1.06} \ln REEV_{cpi_{t-1}}] \\
&\underset{(-3.7)}{-0.25}\,\Delta \ln XGEWU95_{t-5} \underset{(6.5)}{+0.73}\,\Delta \ln IRPO95^*{}_{t} \underset{(2.9)}{+0.31}\,\Delta \ln IRPO95^*{}_{t-3} \\
&\underset{(-1.7)}{-0.46}\,\Delta \ln REEV_{cpi_t} \underset{(-1.9)}{-0.48}\,\Delta \ln REEV_{cpi_{t-2}} \underset{(0.3)}{+0.01}\, csd_{1t} \underset{(0.9)}{+0.02}\, csd_{2t} \\
&\underset{(-1.5)}{-0.05}\, csd_{3t} \underset{(-0.9)}{-0.24} \underset{(-2.9)}{-0.06} i9301_t \underset{(-3.3)}{-0.07}\, i9002_t \underset{(-2.1)}{-0.04}\, i8801_t \\
&\underset{(-4.0)}{-0.08}\, i8402_t + \hat{\varepsilon}_{3t}
\end{aligned}
$$

$\bar{R}^2$=0.91, S.E. of regr.=0.0191, LM(1)=[0.64], LM(4)=[0.84], ARCH(1)=[0.54], ARCH(4)=[0.71], White test=[0.87], RESET test=[0.79], NORM=[0.21], Cusum/Cusum^2: stable

Model 5

$$
\begin{aligned}
&\Delta \ln XGEWU95_t = \\
&\underset{(-5.3)}{-0.43}\,[\ln XGEWU95_{t-1} \underset{(-4.3)}{-0.71} \ln IMEQ95^*{}_{t-1} \underset{(4.4)}{+0.69} \ln REEV_{pimeq_{t-1}} \\
&\underset{(-2.3)}{-0.39} \ln TRADE_{t-1}] \underset{(-3.5)}{-0.25}\,\Delta \ln XGEWU95_{t-5} \underset{(3.3)}{+0.42}\,\Delta \ln IMEQ95^*{}_{t} \\
&\underset{(-3.2)}{-0.67}\,\Delta \ln REEV_{pimeq_t} \underset{(1.4)}{+0.06}\, csd_{1t} \underset{(-0.8)}{-0.01}\, csd_{2t} \underset{(-1.0)}{-0.04}\, csd_{3t} \\
&\underset{(2.4)}{+1.04} \underset{(-2.6)}{-0.06} i9301_t \underset{(-3.5)}{-0.08}\, i9002_t \underset{(-2.8)}{-0.06}\, i8801_t \underset{(-2.8)}{-0.06}\, i8402_t + \hat{u}_{5t}
\end{aligned}
$$

$\bar{R}^2$=0.90, S.E. of regr.=0.0202, LM(1)=[0.46], LM(4)=[0.85], ARCH(1)=[0.11], ARCH(4)=[0.17], White-Test=[0.86], RESET-Test=[0.78], NORM=[0.16], Cusum/Cusum^2: stable

Model 7

$$\Delta \ln XGEWU95_t =$$

$$\underset{(-5.2)}{-0.46} [\ln XGEWU95_{t-1} \underset{(-4.4)}{-0.72} \ln IFC95^*{}_{t-1} \underset{(2.9)}{+0.37} \ln REEV_{pifc_{t-1}}$$

$$\underset{(-4.9)}{-0.57} \ln TRADE_{t-1}] \underset{(-3.1)}{-0.22} \Delta \ln XGEWU95_{t-5} \underset{(2.8)}{+0.45} \Delta \ln IFC95^*{}_{t}$$

$$\underset{(-3.1)}{-0.72} \Delta \ln REEV_{pifc_t} \underset{(-2.4)}{-0.52} \Delta \ln REEV_{pifc_{t-4}} \underset{(1.0)}{+0.04} csd_{1t} \underset{(-2.9)}{-0.04} csd_{2t}$$

$$\underset{(-2.3)}{-0.07} csd_{3t} \underset{(0.4)}{+0.17} \underset{(-3.5)}{-0.08} i9301_t \underset{(-3.3)}{-0.07} i9002_t \underset{(-2.7)}{-0.06} i8801_t \underset{(-2.5)}{-0.06} i8402_t + \hat{u}_{7t}$$

$\bar{R}^2$=0.90, S.E. of regr.=0.0202, LM(1)=[0.67], LM(4)=[0.91], ARCH(1)=[0.02], ARCH(4)=[0.03], White-Test=[0.98], RESET-Test=[0.40], NORM=[0.40], Cusum/Cusum^2: stable

Model 8

$$\Delta \ln XGEWU95_t =$$

$$\underset{(-4.7)}{-0.45} [\ln XGEWU95_{t-1} \underset{(-7.6)}{-0.94} \ln IFC95^*{}_{t-1} \underset{(3.4)}{+0.53} \ln REEV_{pifc_{t-1}}$$

$$\underset{(-4.7)}{-0.004} Trend] \underset{(-2.7)}{-0.21} \Delta \ln XGEWU95_{t-5} \underset{(3.1)}{+0.49} \Delta \ln IFC95^*{}_{t}$$

$$\underset{(1.9)}{+0.27} \Delta \ln IFC95^*{}_{t-1} \underset{(1.6)}{+0.25} \Delta \ln IFC95^*{}_{t-2} \underset{(-2.4)}{-0.58} \Delta \ln REEV_{pifc_t}$$

$$\underset{(-2.1)}{-0.47} \Delta \ln REEV_{pifc_{t-4}} \underset{(0.8)}{+0.04} csd_{1t} \underset{(-0.4)}{-0.01} csd_{2t} \underset{(-0.8)}{-0.03} csd_{3t} \underset{(1.3)}{+0.75}$$

$$\underset{(-2.8)}{-0.07} i9301_t \underset{(-3.4)}{-0.08} i9002_t \underset{(-2.1)}{-0.05} i8402_t + \hat{u}_{8t}$$

$\bar{R}^2$=0.90, S.E. of regr.=0.0206, LM(1)=[0.79], LM(4)=[0.97], ARCH(1)=[0.13], ARCH(4)=[0.24], White-Test=[0.93], RESET-Test=[0.36], NORM=[0.28], Cusum/Cusum^2: stable

Model 3 uses EMU industrial production and a real external value based on consumer prices to explain German exports to the euro area. The other models use EMU investment aggregates, real external values and a proxy for the growing international division of labor. Let's have a closer look at these specifications: Models 5 and 7 explain exports using EMU investment in fixed capital and EMU investment in machinery and equipment, respectively, the corresponding real external values and the intra-EMU trade intensity to model the export development. Model 8 corresponds to model 7 with regard to the activity variable and the relative export price, but it uses a linear trend instead of the intra-EMU trade intensity to model the growing European market integration.

In all four equations, the adjustment coefficients are highly significant, indicating a cointegration relationship at the 1% significance level.[7] Furthermore, they point to a rapid adjustment of exports: 30 to 50% of the adjustment is already completed after one quarter. All determining factors for German exports have the expected signs. In model 3, the income elasticity is about 2, whereas it is below one in models 5, 7 and 8. However, the high income elasticity in model 3 is in line with findings of other studies (Meurers 2003; Strauß 2003; Lapp, Scheide, and Solveen 1995) which unanimously report income elasticities significantly larger than one for this kind of specification (see also Table 1). In model 3, the estimated price elasticity is also significantly higher than in the other models; the null hypothesis, that the estimated coefficients are equal, can be rejected at the 10% significance level. The error correction terms of models 5, 7 and 8 are similar with regard to the estimated income and price elasticities. It is remarkable that using different proxies for the European market integration does not significantly affect the estimated income and price elasticities. In models 5 and 7, a 1% increase in intra-EMU trade intensity leads to an increase in German exports of roughly 0.5%, indicating that Germany is losing market shares in the EMU in the long run. Similar results are reported by Strauß (2003) for Germany's world market shares.

[7] The critical values at the 1% significance level are -4.27 (model 3) and -4.51 (model 5, 7 and 8) (see Hassler 2004, Table 4).

In all four equations, the short-run adjustment is carried out by lagged values of exports as well as recent and lagged values of the activity variables and the real external values. The variable that accounts for the increasing intra-EMU trade intensity is only part of the long-run relationship.

The reported diagnostic tests show that the models fit the data very well. The usual misspecification tests (White's Heteroscedasticity Test and Ramsey's Reset Test) do not signal any problem. The residuals are not autocorrelated and approximately normally distributed. The CUSUM tests indicate parameter stability in all cases.

5 Forecast evaluation

Regarding the diagnostic tests, the four models perform equally well. Since we are interested in a specification that is well suited for short-term forecasts, the four models are subjected to an in-sample and an out-of-sample forecasting exercise. Since simple univariate models perform well in short-term forecasting, we use the following ARIMA (5,1,0) as a benchmark model:

$$\begin{aligned}&\Delta \ln XGEWU95_t = \\ &\underset{(-1.2)}{-0.12}\, \Delta \ln XGEWU95_{t-1} \underset{(-2.6)}{-0.25}\, \Delta \ln XGEWU95_{t-5} \\ &\underset{(-4.6)}{-0.14}\, i9301_t \underset{(-0.8)}{-0.02}\, csd_{1t} \underset{(-4.8)}{-0.06}\, csd_{2t} \underset{(-10.9)}{-0.14}\, csd_{3t} \underset{(4.6)}{+0.02} + \hat{u}_t.\end{aligned}$$

$\bar{R}^2$=0.81, S.E. of regr.=0.0282, LM(1)=[0.20], LM(4)=[0.40], ARCH(1)=[0.54], ARCH(4)=[0.59], White-Test=[0.16], RESET-Test=[0.90], NORM=[0.81], Cusum/Cusum^2: stable

For the dynamic in-sample forecasts the parameters are estimated using the full sample and kept constant throughout the forecasting exercise. For the dynamic out-of-sample forecasts we estimate rolling regressions. At each new forecasting date the sample is extended by one further observation and the parameters are re-estimated. For each model a sequence of h-step ahead forecasts for h=1, 2, ..., 6 is performed. The exogenous variables are taken as given, since we want to evaluate the forecast errors resulting from the model specification. The forecast period is 1996:1-2003:2, i.e. we have carried out 30 forecasts for each model and h=1, 2, ..., 6 respectively. As a measure of accuracy, h-step root mean squared errors (RMSE) and the overall RMSE are computed for each model.

Considering the RMSE, the four structural export equations perform equally well in the in-sample forecasting exercise. In the out-of-sample forecasting exercise, however, model 3, 5 and 7 outperform model 8 indicating that the intra-EMU trade intensity is a better proxy for the European market integration than the linear trend.

In-sample forecast							
RMSE for	h=1	h=2	h=3	h=4	h=5	h=6	Sum RMSE
Model 3	0.0179	0.0187	0.0192	0.0189	0.0191	0.0191	0.1129
Model 5	0.0187	0.0188	0.0185	0.0183	0.0191	0.0191	0.1125
Model 7	0.0191	0.0180	0.0174	0.0172	0.0174	0.0174	0.1065
Model 8	0.0208	0.0203	0.0201	0.0199	0.0202	0.0202	0.1214
ARIMA	0.0366	0.0428	0.0479	0.0540	0.0586	0.0646	0.3045
Out-of-sample forecast							
RMSE for	h=1	h=2	h=3	h=4	h=5	h=6	Sum RMSE
Model 3	0.0176	0.0228	0.0258	0.0278	0.0282	0.0295	0.1517
Model 5	0.0232	0.0239	0.0259	0.0255	0.0266	0.0264	0.1515
Model 7	0.0219	0.0249	0.0230	0.0207	0.0204	0.0204	0.1313
Model 8	0.0229	0.0284	0.0295	0.0304	0.0318	0.0321	0.1750
ARIMA	0.0291	0.0405	0.0464	0.0513	0.0601	0.0656	0.2930

Table 2: Results of the in-sample and the out-of-sample forecasting exercise

The RMSE of the conditional error correction models are clearly smaller than the RMSE of the ARIMA benchmark model both in the in-sample and in the out-of-sample forecasting exercise (Table 2). However, are these differences statistically significant? Since simple univariate models perform well in short-term forecasting, we evaluate the *one-step ahead forecasts* of the five alternative models using the Diebold-Mariano (DM) test[8] (Diebold and Mariano 1995). The null hypothesis underlying the DM test is equal predictive accuracy; the null hypothesis is rejected for small p-values. The DM indicates that the conditional error correction models clearly outperform the ARIMA benchmark model both in the in-sample and in the out-of sample forecasting exercise (Table 3).[9]

In-sample forecast			
Model a/Model b	DM test statistic	Model a/Model b	DM test statistic
Model 3/ARIMA	-3.65 [0.00]	Model 3/Model 5	-0.31 [0.38]
Model 5/ARIMA	-3.22 [0.00]	Model 3/Model 7	-0.40 [0.35]
Model 7/ARIMA	-3.63 [0.00]	Model 3/Model 8	-1.12 [0.13]
Model 8/ARIMA	-3.37 [0.00]		
Out-of-sample forecast			
Model a/Model b	DM test statistic	Model a/Model b	DM test statistic
Model 3/ARIMA	-2.87 [0.00]	Model 3/Model 5	-1.83 [0.04]
Model 5/ARIMA	-1.81 [0.04]	Model 3/Model 7	-1.48 [0.07]
Model 7/ARIMA	-2.21 [0.02]	Model 3/Model 8	-2.42 [0.01]
Model 8/ARIMA	-1.85 [0.04]		

H_0: Equal predictive power. P-values in brackets.

- (+) indicates that forecast of Model A is better (worse) than forecast of Model B.

Table 3: Results of the Diebold-Mariano test

[8] The Diebold-Mariano test is adapted to small samples (see Harvey, Leybourne, and Newbold 1997).

[9] Bodo et al. (2000) also show that a conditional error correction model outperforms ARIMA and VAR models in forecasting industrial production in the euro area.

While the four structural export equations possess equal predictive ability in the in-sample evaluation, model 3 performs significantly better than the other models in the out-of-sample evaluation.

6 Conclusion

In this study, a set of variables that are widely recognized in the literature as export determinants are tested systematically for their ability to explain German exports to the euro area. This approach leads to four structural export equations. Since the alternative models perform equally well in a number of diagnostic tests, we carried out an in-sample and an out-of-sample forecasting exercise using an ARIMA (5,1,0) as a benchmark model. Since simple univariate models perform well in short-term forecasting, we evaluate the one-step ahead forecasts of the five alternative models using the Diebold-Mariano test. While the structural export equations clearly outperform the ARIMA model both in the in-sample and in the out-of-sample forecasting exercise, the structural export equations perform equally well in the in-sample evaluation. In the out-of-sample evaluation, however, model 3 which uses industrial production and a real external value based on consumer prices to explain German exports performs best. So far, however, we have only evaluated the forecast errors resulting from the model specification. We have not focused on the question how to forecast the exogenous variables. Practitioners always want to base their forecasts on timely information. Since figures for industrial production and consumer prices are recorded on a monthly basis and published timely, they are preferable to national accounts data, which are recorded on a quarterly basis and published with some delay. Furthermore, there is evidence that it is much easier to forecast industrial production (Rietzler 2003; Bodo, Golinelli, and Parigi 2000) than investment aggregates. The same applies to the prediction of prices: consumer prices are easier to forecast than prices for different investment aggregates. Taking these arguments into account, too, we can conclude that there are good reasons to favor model 3.

7 Appendix

7.1 Variable construction and data sources

German exports of goods to the euro area are calculated by adding German exports to the other EMU member countries (at current prices), which are converted into real terms by using the price index of export of goods (1995=100) from the German National Accounts Statistics (NAS). The export data (special trade) refers to West Germany until 1989:4 and to the unified Germany afterwards. It is provided by the Federal Statistical Office Germany (Segment 4016). The German NAS is provided by DIW Berlin. All time series are raw data.

Activity variables: Real GDP of the euro area (excluding Germany) is calculated by adding the national GDP figures (at constant prices of 1995) for France (FR), Italy (IT), Spain (ES), the Netherlands (NL), Belgium (BE), Austria (AT) and Finland (FI), which are converted into euro using the corresponding fixed conversion rates.[10] Thus, distortions in the aggregate due to exchange rate fluctuations are avoided (see Beyer, Doornik, and Hendry 2000). The aggregate is transformed into an index series using 1995 as base year. The EMU aggregates for real investment in fixed capital and for real investment in machinery and equipment are calculated analogously. All data is taken from Eurostat (Quarterly National Accounts).

The index of industrial production for the euro area (excluding Germany) (1995=100) consists of the national time series for the NL, BE, FI, PT, ES, IT, FR, AT, IE and GR which are weighted with their corresponding share in German exports. It is calculated as a geometric index. The data comes from the OECD (Main Economic Indicators).

Real external values: The nominal external value of the German mark in relation to the basket of currencies of the other EMU member countries is computed by weighting the bilateral external values by the respective coun-

[10] Ireland (IE), Portugal (PT), Luxemburg (LUX) and Greece (GR) are not included in the aggregate since they do not provide sufficiently long time series according to ESA95.

try's share in German exports (geometric index). The exchange rates are taken from Deutsche Bundesbank.

The European price level (excluding Germany) on the basis of consumer prices (CPI) is calculated by weighting the national price indices with the respective country's share in German exports (geometric index). The data is taken from the OECD (Main Economic Indicators). The European GDP deflator is calculated as nominal EMU GDP/real EMU GDP $\cdot 100$. The European price indices of investment in fixed capital and investment in machinery and equipment are calculated analogously. The data is taken from the NAS provided by Eurostat (Quarterly National Accounts). The group of countries which contribute to the European price levels varies since some European countries do not provide sufficiently long time series for the whole set of price indices. CPI all items: AT, BE, FI, FR, GR, IE, IT, NL, PT, ES; price indices calculated on the basis of the NAS: AT, BE, ES, FI, FR, IT, NL. Multiplying the nominal external value of the German mark by the German price level and dividing it by the price level in the other EMU member countries gives the real external value of the German mark.

Increasing trade intensity in the EMU: Intra-EMU trade (intra-EMU exports plus intra-EMU imports excluding Germany) is calculated on the basis of the Direction of Trade Statistics (IMF). The following countries are considered: AT, BE/LUX, FR, IT, ES, NL, FI. Since exports and imports are denominated in US dollars, they are first re-converted into national currencies and then converted into euro using the fixed conversion rates. This procedure guarantees that the EMU-aggregate will not be distorted by exchange rate fluctuations. Nominal exports and imports are converted into real terms using the respective national export and imports prices which are calculated on the basis of the respective NAS provided by Eurostat. Real intra-EMU trade is the sum of real intra-EMU exports and imports. The ratio of real intra-EMU trade to real EMU GDP (excluding Germany) multiplied by 100 gives the variable that mirrors the increasing trade intensity in the euro area.

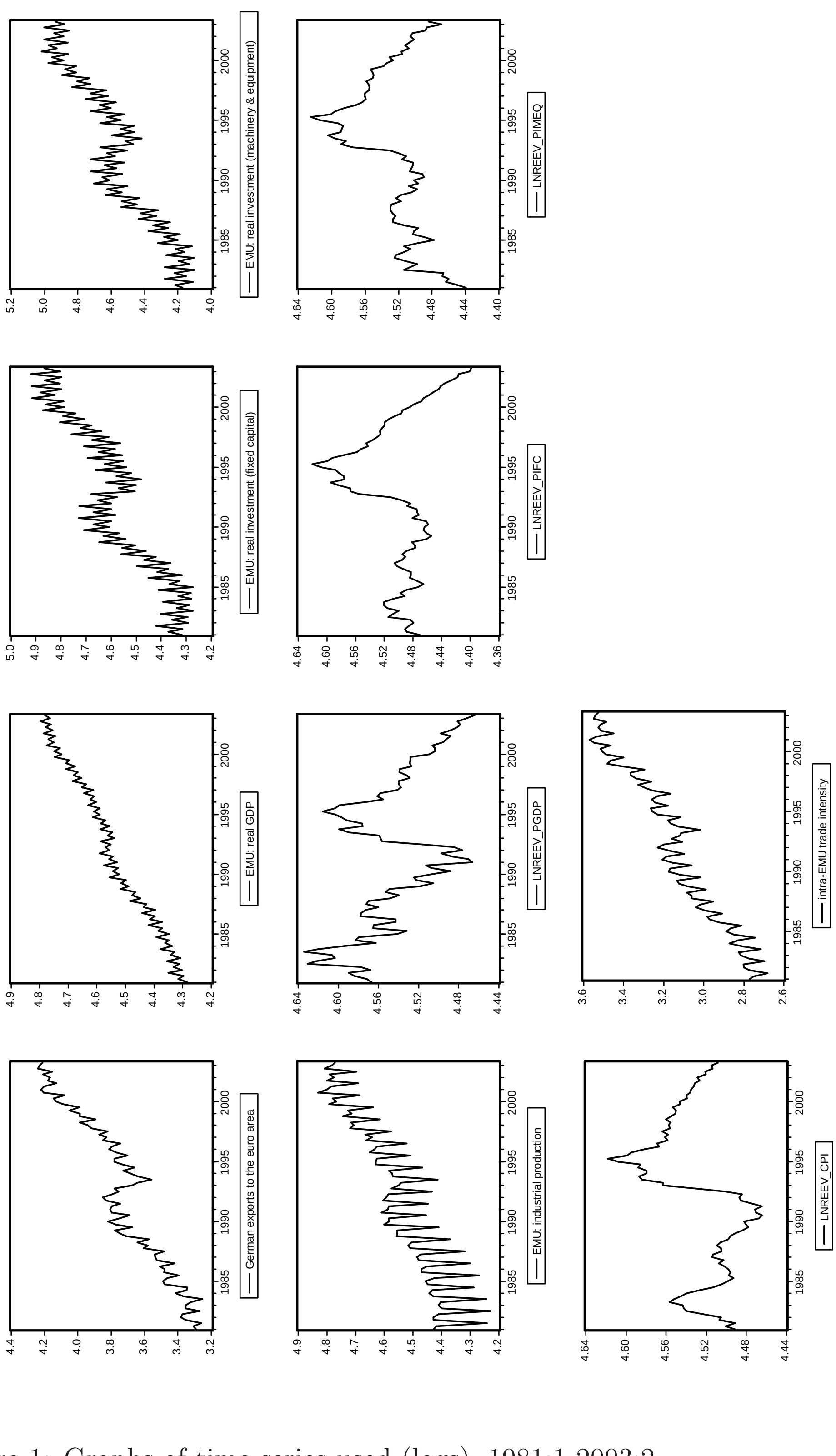

Figure 1: Graphs of time series used (logs), 1981:1-2003:2

Augmented Dickey-Fuller Tests						
	Levels			**First differences**		
Variables	Deterministics	Lags	Test statistics	Deterministics	Lags	Test statistics
$lnXGEWU95$	c, t, csd	3, 5, 11	-2.02	c, csd	5, 11	-8.44**
$lnGDP95^*$	c, t, csd	4, 8	-2.64	c, csd	1, 2, 3	-3.22*
$lnIFC95^*$	c, t, csd	2, 3, 4, 7	-3.24	c, csd	2, 3, 4, 5, 8	-7.57**
$lnIMEQ95^*$	c, t, csd	2, 3, 4, 6	-3.13	c, csd	2, 3, 4, 5, 8	-7.50**
$lnIPRO95^*$	c, t, csd	1, 4, 5, 7, 8, 11	-3.30	c, csd	4, 5, 7	-9.64**
$lnREEV_{pgdp}$	c, csd	1, 3, 4, 5, 7	-1.56	csd	1, 2, 4, 7, 11	-3.53**
$lnREEV_{pifc}$	c	1, 3, 4, 5, 7, 8	-1.97	-	3-5, 7, 8	-6.14**
$lnREEV_{pimeq}$	c	1, 2, 3, 4, 7, 8	-2.63	-	1, 2, 4, 7	-4.30**
$lnREEV_{cpi}$	c	1, 3, 4, 5, 7, 8	-2.02	-	1, 3, 4, 8, 9, 11	-4.92**
$lnTRADE$	c, t, csd	1, 3, 7	-2.65	c, csd	3, 4	-8.49**
c: constant, t: trend, csd: centered seasonal dummies. ** (*) denote significance at 1% (5%) level.						

Table 4: Unit root tests, 1981:1-2003:2

Model	1	2	3	4	5
Error correction term					
$\ln XGEWU95$	x	x	1.00	x	1.00
$\ln GDP95^*$ (t-values)	x	x			
$\ln IPRO95^*$ (t-values)			-2.10 (-41.36)		
$\ln IMEQ95^*$ (t-values)				x	-0.43 (-2.46)
$\ln REEV_{pgdp}$ (t-values)	x				
$\ln REEV_{cpi}$ (t-values)		x	1.31 (6.54)		
$\ln REEV_{pimeq}$ (t-values)				x	0.50 (2.75)
$\ln TRADE$ (t-values)					-0.64 (-3.42)
Adjustment coefficients					
α_X (t-values)	0.09 (1.03)	0.01 (0.06)	-0.29 (**-2.80**)		-0.43 (**-3.64**)
α_{Y^*} (t-values)	-0.00 (-0.23)	0.00 (0.08)	0.07 (1.40)		-0.11 (-1.47)
α_{REEV} (t-values)	-0.14 (**-4.75**)	-0.13 (**-4.43**)	-0.03 (-0.95)		-0.08 (-1.72)
α_{TRADE} (t-values)					-0.06 (-0.65)
$\alpha_{Y^*} = \alpha_{REEV} = 0$			[0.25][a]		
$\alpha_{Y^*} = \alpha_{REEV} = \alpha_{TRADE} = 0$					[0.10][a]
Lag length	6	6	5	3	5
Number of cointegration vectors[a]	1**	1**	1**	0	1**

[a] Results of the Wald test. H_0: Variables under consideration are weakly exogenous. P-values from an LR-statistic in parantheses; **: trace test indicates 1 cointegration vector at 5% significance level.

Table 5: Results of the Johansen cointegration test I, 1981:1-2003:2

Model	6	7	8	9	10
Error correction term					
$\ln XGEWU95$	x	1.00	1.00	x	x
$\ln IFC95^*$	x	-0.66	-0.66	x	x
(t-values)		(-4.38)	(-9.81)		
$\ln REEV_{cpi}$				x	x
(t-values)					
$\ln REEV_{pifc}$	x	0.37	0.76		
(t-values)		(3.37)	(8.25)		
$\ln TRADE$		-0.61			x
(t-values)		(-5.73)			
$Trend$			-0.06		
(t-values)			(-13.13)		
Adjustment coefficients					
α_X		-0.52	-0.93		-0.30
(t-values)		(**-3.79**)	(**-5.61**)		(-1.88)
α_{Y^*}		-0.05	-0.22		-0.12
(t-values)		(-0.67)	**(-2.57)**		(-1.46)
α_{REEV}		-0.06	-0.00		-0.12
(t-values)		(-1.26)	(-0.07)		(**-2.73**)
α_{TRADE}		0.01			0.12
(t-values)		(0.11)			(0.99)
$\alpha_{Y^*} = \alpha_{REEV} = 0$			[0.07][a]		
$\alpha_{Y^*} = \alpha_{REEV} = \alpha_{TRADE} = 0$		[0.39][a]			
Lag length	6	5	5	5	6
Number of cointegration vectors	0	1***	1***	0	1***

[a] Results of the Wald test. H_0: Variables under consideration are weakly exogenous. P-values from an LR-statistic in parantheses. ***: trace test indicates 1 cointegration vector at 1% significance level.

Table 6: Results of the Johansen cointegration test II, 1981:1-2003:2

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Publisher: Hans-Böckler-Stiftung, Hans-Böckler-Str. 39, 40476 Düsseldorf, Germany
Phone: +49-211-7778-331, IMK@boeckler.de, http://www.imk-boeckler.de

IMK Working Paper is an online publication series available at:
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ISSN: 1861-2199

Hans Böckler Stiftung

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