EXPORTS IN THE ECONOMETRIC MODEL KOSMOS*

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Abstract

Equations for exports of manufactured goods and for services in KOSMOS, the macroeconometric model at NIER, are estimated. The equations are interpreted as representing foreign demand for Swedish exports. The formulation is based on the Armington-assumption and demand depends on a measure of foreign income and the Swedish export price, relative to a measure of the competitor's price. The parameter-estimates in both equations are reasonable and the forecasting behavior of the models is acceptable. The estimated long run price elasticities are: −1.3 for manufactured goods, and −0.7 for services. The estimated long run income elasticities are: 0.8 for manufactured goods, and 1.2 for services.

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Sammanfattning

I pappret skattas ekvationer till KOSMOS, Konjunkturinstitutets makromodel, för exporten av bearbetade varor och tjänster. Det i empiriska sammanhang vanliga antagandet om att handlade varor är imperfekta substitut används här. Armington-antagandet innebär att olika länder producerar olika varor och att det svenska exportpriset kan avvika från konkurrenternas pris på lång sikt. Alternativet till Armington-antagandet är ett antagande om homogena varor, så att priset blir bestämt på världsmarknaden. Utrikeshandeln i KOSMOS bygger på Armington-antagandet och därför skattas ekvationer enligt denna ansats. En specifik efterfrågefunktion för svenska varor antas existera och skattningarna av ekvationernas långsiktsvillkor tolkas som att de representerar utländsk efterfrågan på svensk export. Efterfrågan beror på ett mått på utländsk inkomst och på svenskt exportpris i förhållande till ett mått på konkurrenternas priser. Paremeterestimaten i båda ekvationerna är rimliga och prognosförmågan är acceptabel. De skattade långsiktiga priselasticiterna är -1.3 för bearbetade varor och -0.7 för tjänster. De skattade långsiktiga inkomstelasticiteterna är 0.8 för bearbetade varor och 1.2 för tjänster.

Då testresultat pekar på att relativpriserna för exporten av bearbetade varor kan betraktas som stationära, redovisas även ett försök till en alternativ skattning, där priset antas vara bestämt på världsmarknaden.

1 Introduction

Sweden is a country with a relatively large degree of openness, where total exports accounted for 30-35 per cent of GDP during the last few years. The large foreign trade sector indicates that foreign shocks could be an important factor behind fluctuations in the domestic economy. Therefore, it is essential to have well-specified empirical foreign trade models, both for forecasting and for simulations.

The purpose of this paper is to estimate equations for exports in KOSMOS, the macroeconometric model developed and used at NIER[1]. The structure of KOSMOS is taken as given in this study, which implies that the estimated equations must fit into KOSMOS without any major change in other parts of the model. The modeling strategy follows the approach ordinarily used at NIER, where most behavioral equations are modeled as single error-correction equations, and where the long run relation is derived from economic theory.

KOSMOS has two (private) production sectors: industry, which is labeled Sector 1 and corresponds to ISIC 2 and 3, and other business, labeled Sector 2 and defined as ISIC 1 and 4-9. Firms in Sector 1 produce four sector specific goods and firms in Sector 2 produce two sector specific goods. One good, raw materials, is produced in both sectors.

Table 1. The production sectors and the goods in KOSMOS

	Sector 1	**Sector 2**	**Both sectors**
Goods	Share of exports	Share of exports	Share of total exports
Manufactured goods	86.4	-	72.1
Services	-	97.1	16.1
Raw materials	9.6	2.9	8.4
Others	4.0	-	3.4
	100.0	100.0	100.0

In KOSMOS only the first two categories, manufactured goods and services, are endogenous. The group “others” consists of a heterogeneous residual. In this paper equations determining exports of manufactured goods and services are estimated. Together they account for 88 per cent of total exports, cf. Table 1. Some efforts were made to find both theoretically and statistically adequate models for exports of raw materials but the attempt had to be abounded at this stage.

The paper is organized in the following way: Section 2 contains a general discussion on specifying export equations in a model like KOSMOS. In Section 3 the estimated equations

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are presented. Section 4 contains an alternative equation for manufactured goods and Section 5 concludes.

2 Specifying export equations

The standard approach is to estimate a demand function under the assumption that manufactured goods produced in different countries are imperfect substitutes for each other. This assumption implies that the Swedish export price is allowed to differ from the competitor's price, even in the long run. The theoretical assumptions behind this approach are presented in Armington (1969), and they are also discussed in an overview written by Goldstein and Kahn (1985). A theoretical model based on a dynamic optimization problem is presented in Clarida (1994).[2] The main alternative to the Armington-assumption is to assume that goods produced in different countries are homogenous, so that they will be perfect substitutes. If a country is small in the market, the price of the exported good will be determined in the world market, and exogenously given to that country.

These two approaches have fundamentally different implications for the relation between the Swedish export price and the foreign price. In the first approach the Swedish export price is allowed to differ from the competitor's price, while in the second approach, the Swedish export price must follow the competitor's price in the long run. In other words, in the first case the price elasticity of demand is finite, while in the second case since it is infinite. In practice, however, if the estimated price elasticity is very large, the difference between the two approaches becomes small. Normally, the estimated price elasticity in an Armington model is (incredibly) low, indicating low punishment for deviation from the competitor's price, and a possibility of sustainable price differences. This is problematic if we believe that relative competitiveness matter for exports. Furthermore, practitioners often assume that the Swedish export price could not deviate too much from the competitor's price in the long run. The trade flows in KOSMOS follow the Armington-assumption in the long run, c.f. Markowski and Nandakumar (1993).

The Armington-assumption implies that we can identify a specific foreign demand relation for Swedish goods, and therefore I will estimate equations containing a cointegrating demand relation. The estimations will be carried out conditional on the assumption of a cointegrating relation describing foreign demand, although I present some tests to discuss the empirical evidence of the maintained hypothesis. Note, that with only 24 years of semi-annual observations, unit root tests are not very reliable.

The supply side in KOSMOS is described by a technology with constant returns to scale, and thus marginal cost is independent of the production level. Hence, the supply function is horizontal and the goods sold at the export and the home markets are determined

[2]This model is not used here since I do not have the necessary data. It could probably be introduced as a theoretical background to import behavior in KOSMOS.

by demand in the long run. The property of constant marginal costs in KOSMOS provides an identifying assumption for long run demand.

2.1 Theoretical restrictions on foreign demand

Generally, theory puts few restrictions on demand relations; prices of all goods consumed and income should be included and the relations should be written in terms of relative prices and real income. In empirical applications on foreign trade, see for example Goldstein and Kahn (1985), it is common to include only one relative price even if it is assumed that more than two goods are consumed. This simplification is obtained by introducing restrictions on preferences. Total utility is assumed to be weakly separable in subutilities from consumption of different groups of goods. If the subutility is homothetic, demand for goods in the same group can be studied without considering prices of goods in other groups, cf. Varian (1978) p. 149. The demand for one good depends on the price of the good, relative to the average price of the group of goods, and on real expenditure on that group. The assumption of a homothetic subutility implies a unit elasticity of demand with respect to the real expenditure on that group of goods.

For exports of *manufactured goods* I will use the separability assumption described above. Imports and import-prices of manufactured goods in the OECD will be used as the empirical measures of real expenditure and the average (foreign) price in the market, respectively. The expenditure and price measures should ideally include both imports and domestic deliveries of production in the foreign countries. Otherwise, exporters do not compete with domestic producers, which for most traded goods is an unrealistic assumption. However, data on domestic deliveries and prices are not directly available[3], and imports and import prices are used as proxies. Since the average growth of domestic deliveries normally is slower than the growth of imports, the estimate of the income elasticity is likely to be biased downwards. Therefore, I choose not to impose the theoretical restriction of unit income elasticity in the estimation of the equation for manufactured goods.

When estimating the equation for *services* I will use a broad measure of prices of other goods consumed, the CPI. Real income is measured by GDP in the foreign countries. These proxies may be even further from the ideal, but no better variables are easily available.

In all equations, the demand function is assumed to have constant elasticities:

$$\ln x_t = a \ln(rp)_t + b \ln(m)_t + e_t$$

where x denotes Swedish exports, rp relative prices $\left(p_x / p^*\right)$, m is foreign real expenditure on manufactured goods in the equation for manufactured goods, and real income in the equation for services, a is the price elasticity, b is the income elasticity and e_t is a i.i.d

[3]It is possible to construct measures of domestic deliveries of manufactured goods, see Johansson (1994), but several approximations have to be done, especially in the computation of the prices.

$\left(0, s_e^2\right)$ demand shock. The aggregation of demand from several countries is described in Appendix A.

2.2 Estimation and identification

When estimating a single error-correction model using OLS, several assumptions on the underlying VAR-system have to be made. Weak exogeneity w. r. t. the parameters in the cointegrating relation are required, assuming just one cointegrating relation between the variables, appearing in the equation for exports only.

The parameters in the cointegrating relation could be given a structural interpretation, but the other parameters are, without further assumptions, reduced form estimates. Reduced forms are sufficient for forecasting purposes. Hence, in principle one cannot give an economic interpretation to the signs or the sizes of the other parameters, since they in general do not measure the effects from the right-hand side variables. However, we want to make a demand interpretation of all parameters in the export equations, i.e. we want them to measure how demand reacts to changes in relative prices and foreign income also in the *short run*. This can be accomplished if one assumes that shocks to relative prices are uncorrelated with foreign income and with shocks to export demand, which we will do here.

3 Estimation results

3.1 Exports of manufactured goods

Manufactured goods are defined as industrial goods (ISIC 3), excluding food, pulp, saw mill and non-ferrous metal industry products. In 1992, the main components were: paper and paperboard, 9 %, iron and steel, 6 %, manufacture of fabricated metal products, machinery and equipment, 60 %, and other manufacturing, 24 %.

The explanatory variables, relative prices and foreign income, are represented by the Swedish export-price, import-prices, and imports of manufactured goods in 14 OECD countries. Appendix B contains details about the data. Figure 1 shows the Swedish market share for exports of manufactured goods to 14 OECD countries and the relative price, measured in Swedish currency. The market share is decreasing during this period, while the relative prices could be stationary, but with high persistence. The *market share* is negatively correlated with the relative price, suggesting the existence of a demand relation.

In the estimation, it is assumed that exports (x), foreign imports (m) and relative prices (rp) are I(1) and that they are cointegrated. The validity of these assumptions is discussed later in this section. The estimation results are presented in Table 2.

Table 2. Estimation results, Swedish exports of manufactured goods

Δm_t	0.88	x_{t-1}	-0.26
	(7.07)		(2.72)
Δrp_{t-1}	-0.31	rp_{t-1}	-0.35
	(1.78)		(2.97)
constant	0.05	m_{t-1}	0.20
	(3.00)		(2.73)
seasonal dummy	-0.04		
	(3.48)		
implied cointegrating relation			
$-0.26[x_{t-1} - 0.78m_{t-1} + 1.34rp_{t-1}]$			
$\bar{R}^2$	83.7	*Normality*	0.649
ARCH	0.991	*LM test for autocorrelation , 2 lags*	0.113

Note: Estimation period is 1971:2-1994:2. Dependent variable: Δx_t. All variables are in logs. *t*-values for the coefficients are reported in parentheses. *P*-values are given for the specification tests. The Engle test for ARCH effects, the Jarque-Bera test for normality, and the Breush-Godfrey test for correlation were used.

The LM test indicates that there could be some residual autocorrelation left. This tendency disappeared when lagged changes in the dependent variable were introduced, but the lagged terms were found insignificant and therefore not included. Recursive estimates do not indicate any changes in the parameters.[4]

Assuming identifiability and taking the estimates at their face values, the income effect is immediate, the short term effect from relative prices is lagged, and the estimated short run price elasticity (-0.3) is lower in absolute value than the long run elasticity (-1.3). These results are typical in empirical studies of foreign trade, cf. Goldstein and Kahn (1985). The size of the point estimate of the long run price elasticity is compatible with the Armington hypothesis. The estimated long run coefficient of foreign imports, (0.8), is lower than one, implying a decreasing market share for Sweden at constant relative prices, cf. Figure 1. As discussed in Section 2, the definition of the market is likely to deflate the size of the estimated income elasticity. This is supported by the estimations in Johansson (1994) where, in a slightly different setting, the market consists of imports and domestic deliveries, for which the estimated long run income elasticity is 1.3. I have not been able to test the restriction of a unit long run income elasticity.[5] However, when the unit restriction is imposed, the estimate of the long run price elasticity becomes –740, and the coefficient in

[4] Chow-tests.

[5] The asymptotic distribution is not standard, see Sims, Stock and Watson (1990).

front of the long run relation is not significantly different from zero. Hence, the market-share formulation is not supported by data.

The equation was re-estimated through 1990 and one-step-ahead predictions were made for 1991-94, cf. Figure 2.

Figure 3 shows the deviations from the long run relation. The deviations cut the mean value five times, so that they seem to be meanreverting, and hence the assumption of cointegration is not unreasonable. On the other hand, an augmented Dickey Fuller test indicates that the null of nonstationarity could not be rejected[6]. In fact, univariate analysis, using the ADF test, indicates that relative prices could be stationary, while exports and foreign imports are nonstationary. The outcome of this test suggests that a model where the Swedish export price could not deviate from the competitor's price could be a reasonable restriction on data. As earlier mentioned such an approach could not be introduced into KOSMOS without changes in other parts of the model. Section 4 presents results of the estimation of an alternative equation, with stationary relative prices.

3.2 Exports of services

Exports of services are a heterogeneous aggregate with the following main components in 1992: travel, 12 %, shipping, 21 %, other transports, 13 %, and other services, 47 %.

Figure 4 shows the Swedish export price of services divided by foreign CPI and exports divided by foreign GDP. Relative prices have decreased over time while the "market share" has increased, again suggesting that a model with a long run demand function could be a reasonable restriction on data.

It is assumed that there is one cointegrating relation between Swedish exports of services and the explanatory variables that could be interpreted as a long run demand function. The empirical relevance of this assumption will be discussed later. The estimation results are presented in Table 3.

The coefficient in front of the income variable in the cointegrating relation is 1.2, and the estimated long run price elasticity is -0.7. Note that changes in relative prices are included contemporaneously and not lagged as in the case of manufactured goods, and that there is no short run effect from changes in foreign income. This indicates a difference compared to standard results for export equations, where the income-effect normally is immediate and the relative price enters with a lag.

[6]The value of the test statistic is 1.6. The critical value at the 10 percent level for 50 observations is 3.6, computed from the response surface estimates in MacKinnon (1991).

Table 3. Estimation results, Swedish exports of services

Δx_{t-1}	-0.44	x_{t-1}	-0.37
	(3.80)		(3.05)
Δrp_t	-0.66	rp_{t-1}	-0.25
	(3.65)		(1.81)
constant	1.85	GDP_{t-1}	0.43
	(2.98)		(2.13)
seasonal dummy	-0.06		
	(2.48)		

implied cointegrating relation

$-0.36[x_{t-1} - 1.17GDP_{t-1} + 0.69rp_{t-1}]$

$\bar{R}^2$	85.5	*Normality*	*0.853*
ARCH	*0.705*	*LM test for autocorrelation , 2 lags*	0.602

Note: Estimation period is 1971:2-1994:2. Dependent variable: Δx_t. All variables are in logs. *t*-values for the coefficients are reported in parentheses. *P*-values are given for the specification tests. The Engle test for ARCH effects, the Jarque-Bera test for normality, and the Breush-Godfrey test for correlation were used.

The equation was re-estimated through 1990, with the same specification as for the whole sample period, in order to evaluate forecasting accuracy. In Figure 5 the one-step-ahead forecasts are plotted together with the outcome. One reason for the relatively poor forecasting behaviour is that the seasonal pattern is not constant.

The equation was estimated under the assumption that all variables are I(1) and that a linear combination of them is I(0). The hypothesis of a unit root is not rejected by the Augmented Dickey Fuller test, for any of the variables. However, the hypothesis of nonstationarity for the estimated long run relation is not rejected[7]. As can be seen from Figure 6, where the deviations from the long run relation are plotted, there is a shift in the level in 1973, and the deviations seem stationary after 1973. Perron (1989) shows that exogenous changes in the deterministic part of the trends can result in test-statistics signaling non-stationarity.

Note that the value of the estimated long run price-elasticity, -0.7, would be inconsistent with markup pricing.[8]

[7]The value of the test statistic is 2.9.

[8] A formal test is not carried out, since the distribution is nonstandard.

4 An alternative equation for exports of manufactured goods

The result of the test in Section 3 indicates that a model where the Swedish export price follows the competitor's price in the long run, could be a reasonable restriction on the data. To examine if the sharp drop in relative prices in 1992 affects the outcome of the ADF test, the test statistic was calculated recursively, with sample periods ending 1990, 1991….1994. The stationarity of the relative prices is not sensitive to the inclusion of the latest observations, (*p*-values between 5 and 10 per cent). The outcome of the test is probably affected by the large changes in the Swedish exchange rate, so that relative prices tend to be mean-reverting, due to depreciations and not because of the price-setting behavior. In Johansson (1994), where the market consists of imports and domestic deliveries, the hypothesis of stationary relative prices is rejected. Also, conclusions based on historical data may be difficult to use for predicting the future behavior in a different monetary policy regime.

Now assuming that relative prices are stationsry, they should be included in levels, and the rest of the variables in differences only, provided that exports and imports are not cointegrated, as they are not according to tests. Using this specification, the estimation results are presented in Table 4.

Table 4. Estimation results, alternative equation for exports of manufactured goods

Δx_{t-1}	-0.21	rp_{t-1}	-0.27
	(2.27)		(2.90)
Δm_t	0.88	*seasonal dummy*	-0.02
	(8.63)		(1.14)
Δrp_{t-1}	-0.59		
	(3.94)		
$\overline{R}^2$	82.5	*Normality*	0.056
ARCH	0.500	*LM test for autocorrelation , 2 lags*	0.934

Note: Estimation period is 1971:2-1994:2. Dependent variable: Δx_t. All variables are in logs. *t*-values for the coefficients are reported in parentheses. *P*-values are given for the specification tests. The Engle test for ARCH effects, the Jarque-Bera test for normality, and the Breush-Godfrey test for correlation were used.

Growth in trade of manufactured goods affects exports, but without any long run relation between the variables. The forecasting behavior of this equation is almost the same as that of the corresponding equation in Section 3. If we introduce this alternative specification into KOSMOS, at least the import equation and the price equations have to be reformulated, since this approach implies that both Swedish import and export prices follow foreign prices.

5 Concluding remarks

The equation for manufactured goods has reasonable parameter estimates, and its forecast ability is satisfactory. Likewise, the parameter estimates in the equation for exports of services are reasonable and the forecasting behavior is acceptable. Ideally, the behavior of the equations should also be evaluated by simulations with the entire model.

It may be interesting to return to the price-setting behavior when more data has accumulated from a regime without devaluations. Then testing should comprise all parts of KOSMOS where the choice of price-setting assumption matters.

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Appendix A. Aggregation of foreign demand

Demand for a Swedish export good in country *i* is,

$$X_i = d_i (rp)_i^{a_i} m_i^{b_i},$$

where X_i is country *i*'s import of Swedish goods, $(rp)_i$ is the relative price in country *i*, m_i is real income in country *i*, and d_i, a_i and b_i are parameters. Total demand $\sum X_i$ is non-linear in $(rp)_i$ and m_i, and it is approximated as

$$\Delta \ln \sum X_i \approx \sum w_i^0 \Delta \ln X_i,$$

where $w_i^0 = X_i^0 / \sum_i X_i^0$ is the share of exports to country *i* of total Swedish exports. For each period, total demand is:

$$\ln \sum X_i \approx \sum w_i^0 \left(d_i + a_i \ln(rp)_i + b_i \ln m_i \right).$$

Assuming that the same coefficients apply in all countries, $d_i = d$, $a_i = a$ and $b_i = b$, total demand is given by

$$\ln \sum X_i \approx d + a \sum w_i^0 \ln(rp)_i + b \sum w_i^0 \ln m_i.$$

Appendix B. Data

All Swedish variables are from the KOSMOS database. Imports and import prices of manufactured goods in OECD can be obtained at NIER starting in 1977. These variables were extended to 1971 by Gottfries (1994), with data originally computed at NIER. Semi-annual data on seasonally adjusted GDP and the GDP deflators are from OECD Quarterly Accounts[9]. The CPI's are from OECD, Main Economic Indicators. Imports and import prices of manufactured goods in 14 OECD countries[10] were used as explanatory variables in the equation for manufactured goods. Each country's share of exports of manufactured goods was used in the aggregation. In the equations for services, GDP and CPI in nine OECD countries[11] were used. Each country's share of Swedish exports of services in 1992 was used in the aggregation. The shares were obtained from the Central Bank of Sweden, (Riksbanken). Shipping and parts of other transports are not included in the calculations of the shares. For travels, currency shares instead of country shares were used.

[9]Official quarterly accounts were introduced in Denmark 1977. Earlier observations are constructed by interpolation of annual national account data, using an inofficial quarterly time-series on GDP, originally constructed at the Danish Central Statistical Bureau and provided by Aleksander Markowski.

[10]The countries are Canada, the US, Japan, Belgium, France, Netherlands, Switzerland, Great Britain, Germany, Austria, Denmark, Finland and Norway.

[11]The nine OECD countries are Germany, Finland, Denmark, Great Britain, Switzerland, Norway, France, Italy and the US.

Fig. 1 Market share and relative price
Exports of manufactured goods
Log index 1991='0'

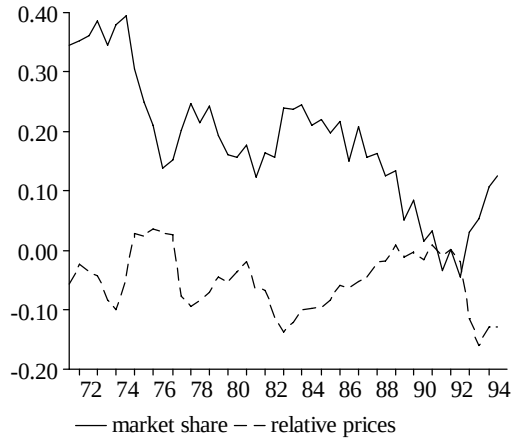

Fig. 2 One-step-ahead predictions
Exports of manufactured goods
Index 1991='1'

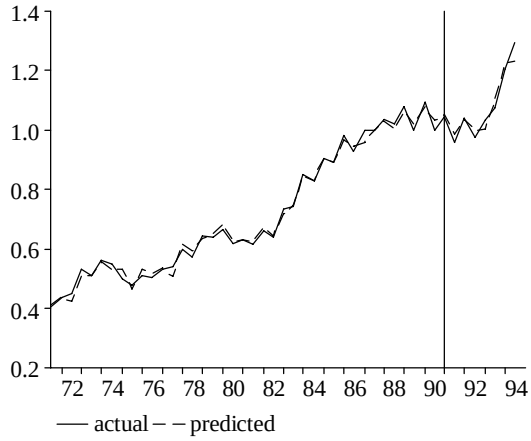

Fig. 3 Deviations from cointegrating relation
Exports of manufactured goods
Log index 1991='0'

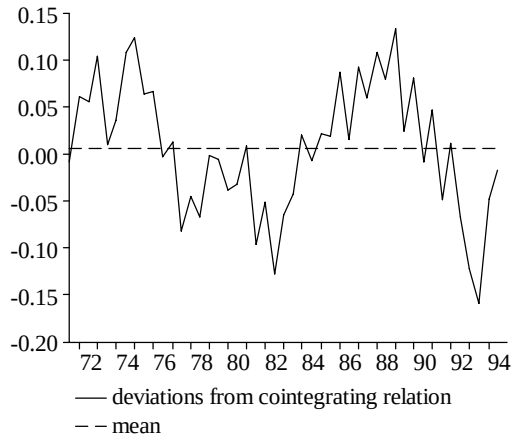

Fig. 4 Market share and relative price
Exports of services
Log index 1991='0'

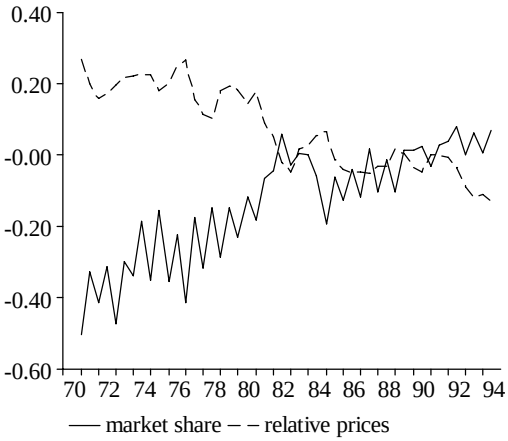

Fig. 5 One-step-ahead predictions
Exports of services
Index 1991='100'

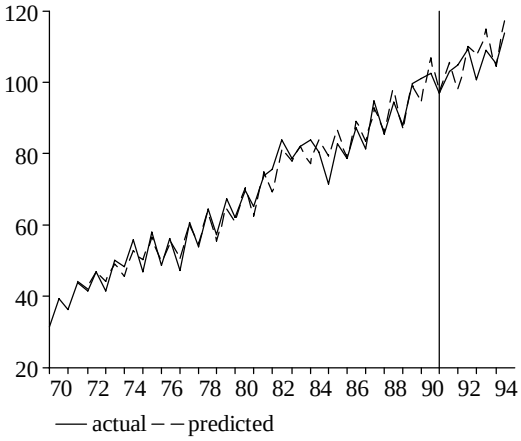

Fig. 6 Deviations from cointegrating Relation
Exports of services