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A DYNAMIC ANALYSIS OF FINNISH EXPORT PRICES

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ABSTRACT

In this paper the degree of dependency of Finnish export prices on the exchange rate, competitors' prices and domestic costs is investigated. A distinction is made between heterogeneous and homogeneous output. A dynamic model selection procedure, especially in the form of an error correction mechanism, is utilized in both aggregated and disaggregated frameworks. The conclusion is that changes in exchange rates and in competitors' prices are transmitted to Finnish export prices fairly quickly and virtually in full, while the effects of domestic costs are relatively modest.

I. INTRODUCTION

It is often assumed that the tradeables goods of small open economies are relatively homogeneous with prices being determined primarily by world market prices. Empirical evidence for this proposition in the case of Finland is given in Aurikko (1980, 1982), Korkman (1980), Vartia and Salmi (1981) and Sukselainen (1984). For extensive studies with Swedish and UK data, see Calmfors and Herin (1979) and Ormerod (1980). However, even if the law of one price is, as a first approximation, a suitable assumption for import prices in the case of export goods the degree of substitutability and market power of the producers might be greater.

Export prices of relatively homogeneous, easily substitutable products are likely to move closely in line with world market or competitors' prices, although some at least temporary divergence in prices, can occur as a result of domestic cost developments. Export prices of relatively heterogeneous products, which are more incompletely substitutable, might reflect stronger cost pressures. These considerations also suggest that it is necessary to study export price formation in a disaggregated framework.

The aim of this paper is to test systematically the degree of dependency of Finnish export prices on the exchange rate, competitors' prices and domestic cost developments. In the testing of the models a dynamic model selection procedure, especially in the form of the so-called error correction mechanism, is utilized. First, the issue is investigated in an aggregated framework and then disaggregated models are examined. In the next section some theoretical considerations of export price determination are discussed. Section III presents the estimation and test results. The final section concludes.

II. THEORETICAL CONSIDERATIONS

Recently, it has been recognised that changing prices is costly, notably in foreign markets, both because of the administrative costs involved and the implicit costs arising from the possible reaction of customers, particularly in the case of large price changes.[1] Other reasons for the failure of prices to adjust to clear markets continuously may be connected with the monopolistic power of exporters and various frictions such as information costs, imperfect information and rationing.

As standard market clearing models would probably require substantial price changes in response to often volatile supply or demand changes in domestic or international markets, it is assumed [see Minford (1978)] that market clearing takes place through the adjustment of quantities rather than through the relatively more costly adjustment of prices. Consequently, export prices are kept comparatively stable in the long-run equilibrium. Alternatively, introducing uncertainty concerning demand or supply conditions allows for the possibility of either price- or quantity-setting behavior modes or both [Leland (1972)]. In the framework of a stochastic demand curve for a monopolist, the conditions for the optimal behavior are dependent on the shape of the marginal cost function [Lim (1980)].[2]

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[1]See Barro (1972) for one of the first theoretical treatments on this subject. For a recent intertemporal study, see Rotemberg (1982). Emprical support for the proposition that in the short-run quantities tend to be more flexible than prices in the adjustment behavior of firms is given by Kawasaki, McMillan and Zimmerman (1982).

[2]Lim argues that quantity setting behavior is preferable to price setting behavior for risk neutral firms with increasing marginal costs (strictly convex cost curve) known with certainty. However, this result is entirely due to the asymmetric and incomplete treatment of costs. Taking also costs of price adjustment into account symmetrically with costs of quantity adjustment, it is easily seen that the proposition is valid only if the cost curve is more convex than the price adjustment cost curve, i.e. if it is costlier to change quantities than prices. As argued above the converse might be a more realistic assumption.

In the following, assuming optimal price-setting behavior, some dynamic microeconomic considerations resulting in partial price adjustment are discussed. With non-negligible costs of changing prices and monopolistic competition, the problem is to maximize the expected present discounted value of profits less the costs of price adjustment. The solution to this standard optimal control problem is a linear difference equation which gives optimal price as a function of the price in the previous period and expectations of future optimal prices [Rotemberg (1982)]. If these are assumed to follow a random walk the solution reduces to the partial adjustment equation implying that increasing the costs of price adjustment tends to make price movements more sluggish.

Above it was argued that firms are price setters with partial price adjustment with respect to equilibrium prices (PX^*). The specification of equilibrium export prices is based on the approach by Bruno (1979), according to which a reduced-form domestic currency equilibrium price equation for a profit maximizing monopolistic firm is of the form

$$PX^* = F(PFOR, CD, CUT) \, , \qquad (1)$$

where PFOR is competitors' prices and CD domestic costs, all measured in domestic currency, and CUT an index of domestic capacity utilization. Equation (1) is derived subject to diminishing returns to scale, with the capital stock fixed in the period under consideration, perfect competition in the markets for the inputs and less than perfect competition in the market for output implying monopolistic competition. Since variable CUT in (1) is the ratio of actual output to potential output, it approximates the positive scale variable effect from the demand function and the negative productivity effect from the production function. Equation (1) is linearly homogeneous with respect to PFOR and CD, and for small open countries competitors' prices tend to dominate export price formation.[3]

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[3] Empirical support is provided in Amano (1974).

In this study, a distinction is made in the terminology of e.g. Calmfors and Herin (1979) between heterogeneous and homogeneous output. In the former category, which consists of imperfectly substitutable products and has considerable monopoly power in the markets, pricing is significantly dependent on domestic costs. In the latter class price formation is strongly dominated by competitors' or world market prices.

In the case of relatively heterogeneous output, equation (1) is specified in the log-linear form as

$$PX^* = \alpha_1 PFOR^{\alpha_2} ULCD^{\alpha_3} CDO^{\alpha_4} CUT^{\alpha_5} , \qquad (2)$$

where ULCD and CDO are domestic unit labor costs and other domestic costs measured in domestic currency.This division of total costs is adopted to capture the different weights of the cost elements in the price formation. In (2) according to the above discussion $\alpha_2 + \alpha_3 + \alpha_4 = 1$. The specification of long-run equilibrium export prices in the case of relatively homogeneous output is nested in (2) with $\alpha_3 = \alpha_4 = 0$, implying that export prices closely follow world market prices. The specification also implies that in the long-run exchange rate changes are fully passed through to the export prices expressed in domestic currency.

III. EMPIRICAL RESULTS

III.1. Data and Estimation Methodology

The data utilized in the estimation of the models are quarterly and seasonally adjusted, cover the period 1962.1 - 1983.4, and obtained from the data base of the quarterly model constructed by the Research Department of the Bank of Finland.[4] A description of the data can be found in the Appendix.

[4]See Bank of Finland (1983).

In the estimation of an aggregate export price model, an error correction mechanism (ECM) [see Salmon (1982)] taking into account the dynamic relationships and steady state properties suggested by economic theory is first tested. Model discrimination is then accomplished by utilizing the dynamic model selection and hypotheses testing procedures suggested by Mizon (1977). Finally, disaggregated export price models are estimated and tested in the ECM and a more general dynamic framework making use of the distinction between homogeneous and heterogeneous categories of goods.

III.2. Aggregated Export Prices

It was assumed above that the long-run export price equation is linearly homogeneous with respect to competitors' prices and domestic costs. Together with the dynamics reflecting slow adjustment of prices and expectations formation mechanisms, this suggests the use of a simple ECM assumed to exist only with respect to competitors' prices and labor costs. An aggregated dynamic export price model is first written in the framework of specification (2) as

$$\log PXG = a_0 + \sum_{1}^{4} a_i \log PXG_{-i} + \sum_{0}^{1} b_j \log PFOR_{-j} + \sum_{0}^{1} c_k \log CDFO_{-k} \qquad (3)$$

$$+ \sum_{0}^{1} d_h \log PMID_{-h} + \sum_{0}^{1} e_l \log FXSUS_{-l} + \sum_{0}^{4} f_m \log CUT_{-m}$$

where relatively short lags are assumed and variable CDFO represents relative unit labor costs and PMID is assumed to approximate relative other costs.[5] Exhange rate FXSUS is added

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[5]Use of the relative cost variable in (3) to reduce multicollinearity is based on the homogeneity properties of (1) with the coefficients of PFOR and CD summing to one in logarithmic form. Thus (1) can be expressed as
(1') $\log PX^* = a' + \log PFOR + b'(\log CD - \log PFOR) + c' \log CUT$,
where PFOR in parentheses is approximated by the foreign cost variable.

in (3) to account for the temporary effect arising from changes in exchange rates to export prices expressed in domestic currency but contracted originally in terms of foreign currency. The variables are defined as

CDFO = ((YW4+SOCC4)/(GDP4•FXSUS))/ULCUS
YW4 = wages and salaries in manufacturing industry
SOCC4 = employers' social security contributions in manufacturing industry
GDP4 = volume of production in manufacturing industry
ULCUS = unit labor cost in USA
PMID = PMIUS/PMUS
PMIUS = import prices of investment goods in USD
PMUS = import prices of USA in USD.

Equation (3) is re-arranged as

$$\Delta \log PXG = a_0 + \sum_{2}^{4} a_i \log PXG_{-i} + b_0 \Delta \log PFOR + c_0 \Delta \log CDFO \quad (4)$$

$$+ (a_1 - 1)\log PXG_{-1} + (b_0 + b_1)\log PFOR_{-1} + (c_0 + c_1)\log CDFO_{-1}$$

$$+ \Sigma\, d_h \log PMID_{-h} + \Sigma\, e_l \log FXSUS_{-l} + \Sigma\, f_m \log CUT_{-m}.$$

The ECM model is obtained with the following restrictions

a) $a_2 + a_3 + a_4 = 0$

$\Sigma d_h = 0$, $\Sigma e_l = 0$, $\Sigma f_m = 0$ and

b) $(a_1 - 1) + (b_0 + b_1) + (c_0 + c_1) = 0$ or (5)

c) $(a_1 - 1) + (b_0 + b_1) = (c_0 + c_1) = 0$ or

d) $(a_1 - 1) + (c_0 + c_1) = (b_0 + b_1) = 0$.

With restrictions a) and b) (hypothesis H_0) the ECM exists with respect to both competitors' prices and labor costs. Testing the ECM model for aggregated export prices, the hypotheses a) and c) (H_1) and a) and d) (H_2) are nested in H_0. Thus a sequential testing procedure is adopted where the tests are conducted by means of joint F-tests.[6]

TABLE 1. F-test statistics for the hypotheses in (5) (5 % critical values in parentheses)

H_0	H_1	H_2
3.83	3.69	4.78
(2.37)	(2.25)	(2.25)

The test statistics in Table 1 indicate that all the ECM hypotheses are clearly rejected at the 5 % level.[7]

In searching dynamic specifications of the model for aggregated export prices a dynamic testing procedure suggested by Mizon (1977) is adopted. In this framework a general unrestricted dynamic model is taken as the maintained hypothesis and is simplified systematically in the light of empirical evidence. The approach differs from that of distributed lags or time series analysis in that it determines the maximal lags and draws a distinction between systematic and error dynamics in the data generation process of the model. The underlying idea is to begin from the most general model and to test sequentially more restricted models rather than to start from a simple restricted formulation and try to assess if it is necessary to adopt a more general dynamic specification.

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[6]Throughout it is assumed that $a_1 \neq 1$.

[7]Of course, if H_0 is rejected also the more restricted H_1 and H_2 are rejected. However, adding variables PFOR and CDFO lagged for two and three quarters and computing the F-statistics as in Table 1, indicates that H_0 case is not rejected at the 1 % level, implying also that competitors' prices have considerable weight in the explanation of aggregate export prices.

The testing procedure is applicable to autoregressive-distributed lag models. The model discrimination is accomplished in a two-stage procedure based on a simplification search. In the first stage, sequential tests for reducing the order of dynamics in the maintained autoregressive-distributed lag model are conducted either for all the variables simultaneously or for each variable separately. In the second stage, conditional on the first, it is tested whether there are common factors in the model arrived at in the first stage.

In view of a priori considerations, empirical evidence of strong dependency of Finnish export prices on world market or competitors' prices and the relatively large number of regressors, the pre-specified lags for aggregated export prices were set relatively short. The estimation results of the general model (maintained hypothesis) are as shown in Table 2.[8]

The signs of the estimates of the general autoregressive-distributed model in Table 2 are, with the the exception of the coefficient for other relative costs (PMID), as expected and suggest several simplifying restrictions. The validity of the restrictions are tested in Table 3 for each explanatory variable separately and jointly for all the variables. In Table 3, H(20) is the homogeneity test statistics for stability of parameter estimates with the moving regression length of 20 quarters distributed as $F_{20,46}$, C_f, C_b, C_f^2 and C_b^2 are Cusum and Cusum Squares tests statistics for parameter stability where the recursive residual are computed forwards (f) and backwards (b) and Z(8) is a post-sample test statistic computed from the eight quarterly prediction errors for the years 1982-1983 distributed asymptotically as χ_8^2 [see Harvey (1981)].

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[8]In Table 2, Σ denotes the sum of the lagged coefficients, $\bar{R}^2$ the adjusted coefficient of determination, SEE is the standard error estimate of the residual variance and Dm is the Durbin m-statistics. The estimation period is shown in brackets.

TABLE 2. General AD-model of logPXG
(standard error estimates of the coefficients in parentheses)

variable	lag 0	lag 1	lag 2	lag 3	Σ
logPXG	-1.00	.67	.01		-.32
		(.12)	(.12)		
logPFOR	.79	-.38	.07	-.20	.28
	(.10)	(.19)	(.20)	(.10)	
logCDFO	.04	.10	-.01		.13
	(.08)	(.11)	(.07)		
logPMID	.13	-.13	-.13		-.13
	(.06)	(.08)	(.07)		
logFXSUS	.07	-.12	.13	.05	.13
	(.11)	(.17)	(.19)	(.12)	
logCUT	-.17	.32			.15
	(.19)	(.17)			
Constant	.76				
	(.35)				

$\bar{R}^2$ = .999 SEE = .019 Dm = .05 (1963.1 - 1981.4)

TABLE 3. Estimates and test statistics for a restricted model of logPXG (standard error estimates of the coefficients and 5 % critical values in parentheses)

variable	lag 0	lag 1	lag 2	lag 3	Σ	F-statistics
logPXG	-1.00	.74			-.26	.00
		(.07)				(4.02)
logPFOR	.77	-.38		-.17	.22	.12
	(.08)	(.11)		(.04)		(4.02)
logCDFO		.13			.13	.16
		(.04)				(3.17)
logPMID	.15	-.15	-.11		-.11	.01
	(.05)	(.05)	(.03)			(4.02)
logFXSUS	.09	-.19	.19		.09	.25
	(.04)	(.06)	(.06)			(3.17)
logCUT		.24			.24	.76
		(.08)				(4.02)
Constant	.66					
	(.27)					
Joint F-test						.34
						(2.11)

$\bar{R}^2$ = .999 SEE = .018 DW = 2.03 Dm = .30 (1963.1 - 1981.4)

H(20) = 1.16 (1.80) C_f = .53 (.95) C_b = .66 (.95) C_f^2 = .13 (.19) C_b^2 = .07 (.19) Z(8) = 14.3 (15.5)

The test statistics indicate that the model in Table 3 is very stable. Since the Dm statistic does not indicate any first order autocorrelation, the common factor test can be performed. Testing the validity of common factor restrictions could be based on Wald tests, so that estimation of only the unrestricted model would be necessary [see Harvey (1981)]. However, the constraints between coefficients of more dynamic models would be complicated. Thus the LR-test is used, with the transformed structure being estimated by a nonlinear maximum likelihood algorithm.

The logarithm of the value of the maximized likelihood function of the unrestricted model of PXG is $L_U = 205.0$ and the corresponding value for the common factor restricted model is $L_C = 164.5$. Thus the value of the LR-test statistic $2(L_U - L_C) = 81.0$, distributed approximately as χ^2_5 $[\chi^2_5(.05) = 11.1]$, suggests that the common factor restriction is rejected.

Since the ECM fails to exist strictly in aggregate export price data according to the test statistics in Table 1 above, it is next tested whether the mechanism is operative in disaggregated models.

III.3. Disaggregated Export Prices

In the following export prices of goods are disaggregated into export prices of wood industry products (PXW), paper industry products (PXPA), metal industry products (PXME) and other industrial products (PXO). Based on various tests, not reported here, it is assumed that price setting is homogeneous in the first two export categories and heterogeneous in the last two. The specifications corresponding to these cases are

$$PXWUS = a_1 PXWSWUS^{a_2} P3W^{a_3} CUT^{a_4} \qquad (6)$$

$$PXPAUS = b_1 PXPSWUS^{b_2} P3P^{b_3} CUT^{b_4} \qquad (7)$$

$$PXME = c_1 PMED^{c_2} CDFO^{c_3} PMID^{c_4} FXSUS^{c_5} CUT^{c_6} \qquad (8)$$

$$PXO = d_1 PMED^{d_2} CDFO^{d_3} PMID^{d_4} FXSUS^{d_5} CUT^{d_6} \qquad (9)$$

where the new variables are

PXWUS = prices of production of wood industry products in USD
PXWSWUS = Swedish export prices of wood industry products in USD
P3W = P3US/PXWSWUS
P3US = prices of production in forestry in USD
PXPAUS = export price of paper industry products in USD
PXPSWUS = Swedish export prices of newsprint in USD
P3P = P3US/PXPSWUS
PXME = export prices of metal industry products
PMED = import prices of USA in FIM
PXO = export prices of other industrial goods.

In models (6) and (7) variables PXWSWUS and PXPSWUS are assumed to represent competitors' prices and variables P3W and P3P other relative costs. Labor costs are not included in models (6) and (7) due to the relative importance of materials costs in the determination of export prices of these particular homogeneous products based on wood the prices of which are approximated by prices of production in forestry. It assumed that changes in exchange rates are fully passed through to the export prices in terms of domestic currency so that the dependent variable is expressed in terms of foreign currency. Models (8) and (9) correspond to the specification (2), where variable PMED is a proxy for competitors' prices.

Next, rather than imposing the restrictions untested as is often done in econometric work, it is tested whether the ECM is in fact a suitable specification. The testing proceeds by applying F-tests on the restrictions implying the ECM from a general dynamic model.

The general dynamic model in the homogeneous case (PXW and PXPA) is written as

$$\log PXWUS = a_0' + \sum_{i=1}^{4} a_i' \log PXWUS_{-i} + \sum_{j=0}^{1} b_j' \log PXWSWUS_{-j} \tag{10}$$

$$+ \sum_{k=0}^{4} c_k' \log P3W_{-k} + \sum_{h=0}^{4} d_h' \log CUT_{-h},$$

where four-quarter lags are assumed except for the variable PXWSWUS where only two-period lags are assumed. In the corresponding equation for PXPA, variable PXWSWUS is replaced by PXPSWUS and P3W by P3P.

Re-arranging model (10) as in (4) it is seen that the restrictions implying the ECM are

$$\begin{aligned}
&\text{a)}\quad a_2' + a_3' + a_4' = 0 \\
&\text{b)}\quad \Sigma c_k' = 0 \qquad\qquad (11) \\
&\text{c)}\quad \Sigma d_h' = 0 \\
&\text{d)}\quad (a_1' - 1) + (b_0' + b_1').
\end{aligned}$$

The general dynamic model for the heterogeneous case (PXME and PXO) is written analogously to (3) as

$$\log PXME = a_0'' + \sum_1^4 a_i''\log PXME_{-i} + \sum_0^1 b_j''\log PMED_{-j} + \sum_0^1 c_k''\log CDFO_{-k} \quad (12)$$

$$+ \sum_0^1 d_h''\log PMID_{-h} + \sum_0^1 e_l''\log FXSUS_{-l} + \sum_0^4 f_m''\log CUT_{-m},$$

where again relatively short lags are assumed and the ECM model is obtained with restrictions as in (5).

Joint F-test for the restrictions in (11) implying the error correction mechanism in the case of PXW yielded the test statistic $F_{4,59} = 2.61$, with 5 and 1 % critical values of 2.53 and 3.65, respectively. For PXPA, the statistic is 3.93. Accordingly, the ECM formulation cannot be rejected only for the export prices of wood industry products, while in the model for export prices of paper industry products separate F-tests show that all the other restrictions except $\Sigma d_h' = 0$ are data admissible. The F-test statistics for the hypotheses in (11) are as in Table 4.

TABLE 4. F-statistics for the hypotheses in (11)
(5 % critical values in parentheses)

	F-statistics	5 % critical value
a)	3.69	(4.00)
b)	0.01	(4.00)
c)	5.85	(4.00)
d)	3.52	(4.00)

In the framework of heterogeneous export price formation, i.e. metal and other industrial products, the ECM hypotheses H_0 are rejected as the test statistics $F_{5,58}$ are 7.06 and 7.19, respectively, with 5 % critical value of 2.37.

In searching dynamic specifications of the models of export prices of metal and other industrial products, the dynamic testing procedure is adopted. Again the pre-specified lags for export prices of metal industry products (PXME) were set relatively short. The estimation results of the general model (maintained hypothesis) are as shown in Table 5. The tests for the restrictions as suggested by the estimates in Table 5 are presented in Table 6.

TABLE 5. General AD-model of logPXME
(standard error estimates of the coefficients in parentheses)

variable	lag 0	lag 1	lag 2	lag 3	Σ
logPXME	-1.00	.13 (.12)	.17 (.12)		-.70
logPMED	-.29 (.51)	1.60 (.90)	-.84 (.90)	.18 (.46)	.65
logCDFO	-.58 (.25)	.88 (.33)	-.07 (.23)		.23
logPMID	.31 (.25)	.59 (.31)	-.32 (.26)		.58
logFXSUS	.46 (.53)	-1.03 (.92)	1.28 (1.02)	-.57 (.54)	.14
logCUT	-.95 (.61)	1.38 (.57)			.43
Constant	1.50 (.94)				

$\bar{R}^2$ = .989   SEE = .062   Dm = .25   (1963.1 - 1981.4)

TABLE 6. Estimates and test statistics for a restricted model of logPXME (standard error estimates of the coefficients and 5 % critical values in parentheses)

variable	lag 0	lag 1	lag 2	lag 3	Σ	F-statistic
logPXME	-1.00				-1.00	1.71 (3.15)
logPMED		.97 (.02)			.97	.50 (2.76)
logCDFO	-.37 (.21)	.64 (.22)			.27	.14 (4.00)
logPMID	.52 (.17)	.40 (.17)			.92	1.59 (4.00)
logFXSUS	.36 (.28)	-.36 (.28)	.46 (.24)	-.46 (.24)	0	.98 (3.15)
logCUT	.65 (.33)				.65	2.59 (4.00)
Constant	1.93 (.58)					
Joint F-test						1.01 (1.99)

$\bar{R}^2$ = .989   SEE = .060   DW = 1.69   (1963.1 - 1981.4)

H(20) = 1.42 (1.83) C_f = .64 (.95) C_b = .71 (.95) C_f^2 = .07 (.19) C_b^2 = .14 (.19)   Z(8) = 5.8 (15.5)

A similar simplification search in the case of export prices of other industrial products (PXO) yielded the results in Tables 7 and 8.[9]

In summary, it can be noted that the estimation results are statistically acceptable and theoretically plausible and the parameter estimates reasonably stable.[10] However, the dynamic properties of the estimated export price equations are not immediately obvious. The nature of these can best be illustrated by means of some simulations.

III.4. Simulations

In order to assess the degree of dependency of Finnish export prices on the exchange rate, competitors' prices and domestic cost developments, the simulations in Figures 1 and 2 are illustrative. In Figure 1 the aggregate export price model is simulated alternatively for a 10 per cent devaluation or increase in competitors' prices or domestic costs, respectively, from the beginning of 1971 onwards. The corresponding multipliers PXGAD, PXGAF and PXGAC are calculated as a percentage deviation of the disturbed solution and control solution. In Figure 2 the disaggregated export price models are simulated correspondingly and aggregated with volume weights.

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[9] The common factor restriction for the model in Table 8 is rejected as the LR-statistic is 22.4 (11.1).

[10] The estimated equations and test statistics for parameter stability for the models of PXW and PXPA where Σd_h is not constrained equal to zero are

$$\Delta \log PXWUS = \underset{(.33)}{-1.09} - \underset{(.07)}{.25} \log(PXWUS_{-1}/PXWSWUS_{-1}) + \underset{(.05)}{.79} \Delta \log PXWSWUS$$
$$+ \underset{(.05)}{.17} \Delta \log P3W - \underset{(.04)}{.16} \Delta \log P3W_{-2} - \underset{(.10)}{.18} \log(CUT_{-1} \cdot CUT_{-3}) + \underset{(.21)}{.55} \log CUT_{-2}$$
$$\bar{R}^2 = .805 \quad SEE = .025 \quad Dm = .41 \quad (1963.1 - 1981.4)$$
$$H(20) = \underset{(1.79)}{.80} \quad C_f = \underset{(.95)}{.50} \quad C_b = \underset{(.95)}{.67} \quad C_f^2 = \underset{(.19)}{.28} \quad C_b^2 = \underset{(.19)}{.26} \quad Z(8) = \underset{(15.5)}{13.2}$$

$$\Delta \log PXPAUS = \underset{(.25)}{-1.02} \underset{(.06)}{-.23} \log(PXPAUS_{-1}/PXPSWUS_{-1}) + \underset{(.04)}{.81} \Delta \log PXPSWUS$$
$$+ \underset{(.04)}{.16} \Delta \log P3P - \underset{(.07)}{.13} \log(CUT/CUT_{-2}) + \underset{(.15)}{.35} \log CUT_{-1}$$
$$\bar{R}^2 = .825 \quad SEE = .018 \quad Dm = .20 \quad (1963.1 - 1981\text{-}4)$$
$$H(20) = \underset{(1.92)}{1.30} \quad C_f = \underset{(.95)}{.89} \quad C_b = \underset{(.95)}{.99} \quad C_f^2 = \underset{(.18)}{.31} \quad C_f^2 = \underset{(.18)}{.25} \quad Z(8) = \underset{(15.5)}{8.7}$$

TABLE 7. General AD-model of logPXO
(standard error estimates of the coefficients in parentheses)

variable	lag 0	1	2	3	Σ
logPXO	-1.00	-.01	.43		-.58
		(.11)	(.10)		
logPMED	.35	1.11	-.73	-.22	.51
	(.50)	(.87)	(.88)	(.44)	
logCDFO	-.09	.48	-.15		.24
	(.25)	(.32)	(.22)		
logPMID	.08	.36	-.32		.12
	(.24)	(.29)	(.24)		
logFXSUS	-.03	-.57	.48	.45	.33
	(.52)	(.88)	(.94)	(.51)	
logCUT	.06	.54			.60
	(.59)	(.57)			
Constant	.90				
	(.98)				

$\bar{R}^2$ = .991 SEE = .061 Dm = .19 (1963.1 - 1981.4)

TABLE 8. Estimates and test statistics for a restricted model of logPXO (standard error estimates of the coefficients and 5 % critical values in parentheses)

variable	lag 0	1	2	3	Σ	F-statistic
logPXO	-1.00		.42		-.58	.01
			(.09)			(4.00)
logPMED		.88	-.43		.45	.42
		(.18)	(.19)			(3.15)
logCDFO		.38			.38	.28
		(.08)				(3.15)
logPMID	-.27	.27			0	1.62
	(.15)	(.15)				(3.15)
logFXSUS				.54	.54	.55
				(.11)		(2.76)
logCUT		.72			.72	.89
		(.29)				(4.00)
Constant	1.77					
	(.61)					
Joint F-test						.93
						(1.95)

$\bar{R}^2$ = .991 SEE = .060 DW = 2.05 Dm = .28 (1963.1 - 1981.4)

H(20) = 1.08 (1.84) C_f = .82 (.95) C_b = .92 (.95) C_f^2 = .24 (.19) C_b^2 = .26 (.19) Z(8) = 14.4 (15.5)

FIGURE 1.

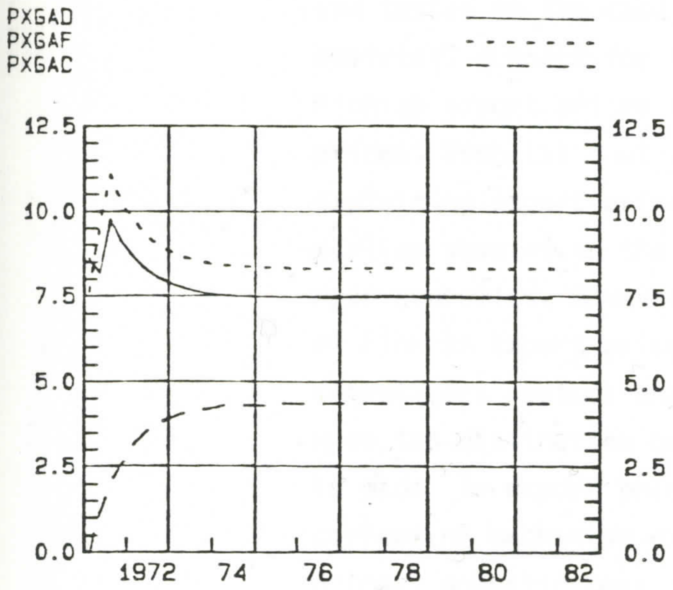
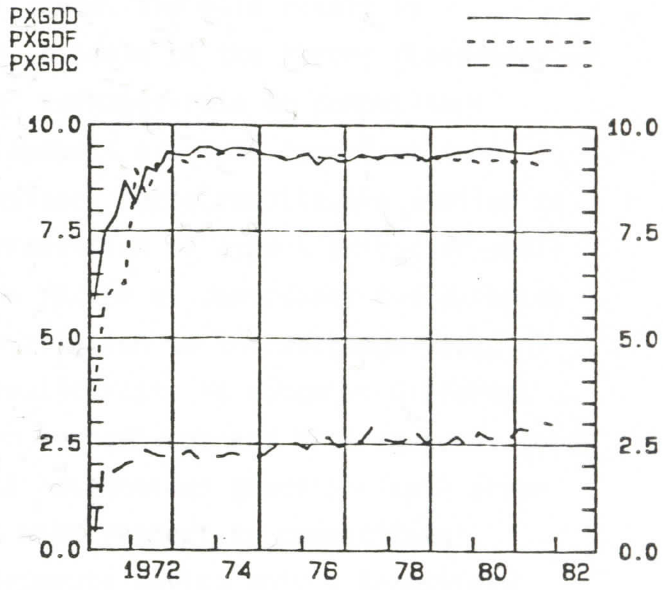


FIGURE 2.



Both simulations indicate strong and, in the long-run, almost complete dependency of Finnish export prices on the exchange rate or competitors' prices, especially in the case of disaggregated models reflecting properties of the ECM. Domestic costs also affect export prices but more modestly, even in the long-run. Of course, these results are only partial and thus not very realistic particularly with respect to the long-run. The most important economic policy implication is that exchange rate policies, even when coupled with successful incomes policies, seem to exert only a transitory and, in the long-run, very weak relative price effect on export volumes. In these circumstances changes in profitability in the export industries can be an important channel through which exchange rate policies affect export volumes.[11]

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[11] For a theoretical and empirical discussion, see Aurikko (1982).

IV. CONCLUDING REMARKS

In this paper dynamic models of export prices are specified and tested in the case of Finland. The main result is empirical support for the hypothesis of the strong dependency of Finnish export prices on the exchange rate or competitors' prices. Domestic cost developments are less important in explaining export price behavior. These results are similar to earlier studies on the determination of export prices of small open economies. However, the degree of dependency and dynamics of Finnish export prices in relation to the exchange rate, competitors' prices and domestic costs is somewhat different when the distinction between homogeneous and heterogeneous goods is made. In export prices of homogeneous goods a simple error correction mechanism exists with respect to competitors' prices, domestic cost developments having only a transitory effect. Export prices of heterogeneous goods are more responsive to movements in domestic costs. The results suggest that imposing restrictions on the dynamics in the form of error correction mechanisms is not always data admissible and must be tested.

REFERENCES

Amano, A.: Export Price Behavior in Selected Industrial Countries, unpublished mimeo. Kobe University, 1974.

Aurikko, E.: Export Prices and Export Demand (in Finnish with English summary), The Finnish Economic Journal 76, 32 - 42, 1980.

Aurikko, E.: Exchange Rate Policy and Imported Inflation in a Credit Rationing Economy, Empirical Economics 7, 155 - 173, 1982.

Bank of Finland: The Data of the Quarterly Model BOF3 of the Finnish Economy. Discussion Paper 2/83, Bank of Finland Research Department, 1983.

Barro, R.J.: A Theory of Monopolistic Price Adjustment, Review of Economic Studies 39, 17 - 26, 1972.

Bruno, M.: Price and Output Adjustment, Journal of Monetary Economics 5, 187 - 211, 1979.

Calmfors, L. & Herin, J.: Domestic and Foreign Price Influences: A Disaggregated Study of Sweden, Inflation and Employment in Open Economies (ed. by Lindbeck, A.), Amsterdam, 1979.

Harvey, A.C.: The Econometric Analysis of Time Series. Oxford, 1981.

Kawasaki, S.J., McMillan, J. & Zimmerman, K.F.: Disequilibrium Dynamics: An Empirical Study. The American Economic Review 72, 992 - 1004, 1982.

Korkman, S.: Foreign Trade Prices and Inflation in Finland (in Finnish). The Finnish Economic Journal 76, 415 - 423, 1980.

Leland, H.E.: Theory of the Firm Facing Uncertain Demand. The American Economic Review 62, 278 - 291, 1972.

Lim, C.: The Ranking of Behavioral Modes of the Firm Facing Uncertain Demand. The American Economic Review 70, 217 - 224, 1980.

Minford, P.: Substitution Effects, Speculation and Exchange Rate Stability. Amsterdam, 1978.

Mizon, G.E.: Model Selection Procedures, Studies of Modern Economic Analysis (eds. Artis, M.J. and Nobay, A.R.). Oxford, 1978.

Ormerod, P.: Manufactured Export Prices in the United Kingdom and the "Law of One Price". The Manchester School 48, 265 - 283, 1980.

Rotemberg, J.J.: Monopolistic Price Adjustment and Aggregate Output. Review of Economic Studies 49, 517 - 531, 1982.

Salmon, M.: Error Correction Mechanisms. The Economic Journal, 92, 615-629,1982.

Sukselainen, T.: Price Formation in Finnish Industries in 1969 - 1981 (in Finnish). Discussion paper 5/84. Bank of Finland Research Department, 1984.

Vartia, P. & Salmi, K.: A Note on the Short-term Determinants of Finnish Export Prices. The Finnish Journal of Business Economics 30, 3 - 19, 1981.

APPENDIX: Variables and Data Sources

CDFO	= ((YW4+SOCC4)/(GDP4•FXSUS))/ULCUS
CUT	= capacity utilization rate in the Finnish economy, GDPF/GDPOT
FXSUS	= exchange rate FIM/USD
GDPF	= volume of gross domestic product in producers' prices, seasonally adjusted, 1975 prices, in FIM
GDPOT	= volume of potential gross domestic product, 1975 prices, in FIM
GDP4	= volume of production in manufacturing industry, seasonally adjusted, 1975 prices, in FIM
PFOR	= weighted unit value index of imports of most important market economies for Finland, in FIM, 1975=100 (weights UK 37 %, Sweden 31 %, FRG 17 %, France 8 % and USA 7 %)
PMED	= import prices of USA in FIM
PMI	= unit value index of imports of investment goods, 1975=100, in FIM
PMID	= (PMI/FXSUS)/PMUS
PMUS	= import prices of USA in USD
PXG	= unit value index of exports of goods, 1975=100, in FIM
PXME	= unit value index of exports of metal industry products, 1975=100, in FIM
PXPAUS	= unit value index of exports of paper industry products, in USD
PXO	= unit value index of exports of other industrial goods, 1975=100, in FIM
PXPSWUS	= Swedish export prices of newsprint in USD
PXWSWUS	= Swedish export prices of wood industry products, in USD
P3P	= P3US/PXPSWUS
P3US	= prices of production in forestry in USD
P3W	= P3US/PXWSWUS
SOCC4	= employers' social security contributions in manufacturing industry, seasonally adjusted, in FIM
ULCUS	= unit labor costs in USA
YW4	= wages and salaries in manufacturing industry, seasonally adjusted, in FIM.

The data for PMI, PXG, PXME, PXPAUS, PXO and PXWUS are from the Board of Customs Monthly Bulletin. Indices for calculating PMED, PMUS, PXPSWUS and PXWSWUS are obtained from IMF's International Financial Statistics. Variables PFOR and ULCUS are from OECD statistics. The data source for GDPF, GDP4, P3US, SOCC4 and YW4 is the National Income Accounts. Variable GDPOT is estimated from a production function.