ETLA ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B, 00120 Helsinki 12, Finland, tel. 601322

Keskusteluaiheita
Discussion papers

Pekka Ilmakunnas*

TESTS OF THE EFFICIENCY OF SOME FINNISH MACROECONOMIC FORECASTS: AN ANALYSIS OF FORECAST REVISIONS

No 287 30.03.1989

* I am thankful to Kari Takala for comments.

ISSN 0781-6847

ILMAKUNNAS, Pekka, TESTS OF THE EFFICIENCY OF SOME FINNISH MACROECONOMIC FORECASTS: AN ANALYSIS OF FORECAST REVISIONS. Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 1989. 19 p. (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847 ; 287).

ABSTRACT: The efficiency of the forecasts made by the Research Institute of the Finnish Economy for the growth rates of the major GDP categories is studied. The efficiency tests are based on the correlation patterns of successive revisions of forecasts of the same event. The results show signs of inefficiency in some of the forecasts for GDP, exports, imports, and government investment and consumption. Alternative interpretations of such correlations include genuine informational inefficiency, conscious smoothing of changes in the forecasts, and the effect of autocorrelation in successive data revisions.

KEY WORDS: Forecast evaluation, informational efficiency of forecasts, data revisions.

1. Introduction

It is likely that many firms and individuals base their own view of the future development of the economy directly on publicly available forecasts or at least the forecasts form an important part of the information on which own expectations are based[1)]. Analysis of the properties of public forecasts is important both because it tells something about the efficiency of the forecasting process, and because it gives indications of whether people base their expectations on unbiased or efficient information. If the forecasts did not comform to the rational expectations hypothesis of efficient information use, it would not be surprising to find violations of rationality in directly observable expectations data, e.g. in consumer attitude and business surveys.

The purpose of this note is to study the efficiency of some Finnish macroeconomic forecasts by testing whether changes in successive forecasts of the same event are correlated. Following the recent work of Berger and Krane (1985) and Nordhaus (1987) this can be used as a test of the informational efficiency of the forecast: if all past information has been used efficiently in the forecasting process, it should not be possible to predict future forecast revisions from past revisions. This test has the advantage that it avoids many of the difficulties involved in the traditional forecast evaluation. Tests of unbiasedness are typically made by regressing realized values on the forecasts and efficiency by studying whether forecast errors are correlated with past realizations or past forecast errors. One basic difficulty in these tests is the serial correlation pattern of the residuals caused by information lags and forecasting several periods ahead. There are also difficulties in deciding which realization series should be used in forecast evaluation, since the series the forecasters are forecasting may actually be preliminary values and not the final values, which are often obtained much later and may have been corrected afterwards several times.

2. Efficiency tests

Typical analysis of forecast (or expectations) rationality proceeds by regressing realized values on the forecasted ones and a constant, and testing whether the constant is zero and the slope coefficient is equal to one. Usually the realized and forecasted values refer to percentage changes. Let X_t denote a realization and X^f_{it} a corresponding forecast made i periods earlier. If the interval between successive forecasts is the same as that between successive realizations, the forecast has been made at time t-i. However, if several forecasts are made within a time period, the forecast interval is shorter than the realization interval. The model is $X_t=a+bX^f_{it}+u_{it}$, and the joint test of a=0, b=1 is a test of forecast unbiasedness. Rationality can be tested by testing whether forecast errors $\epsilon_{it}=X_t-X^f_{it}$ are correlated with the information that was available when the forecast was made. Since the specification of the relevant information set is difficult, often this test is done in a weak form by testing whether forecast errors are correlated with past realizations or past forecast errors. Then a test of $\alpha=\beta=0$ in the model $\epsilon_{it}=\alpha+\beta\epsilon_{i,t-1}+u_{it}$, or in the model $\epsilon_{it}=\alpha+\beta X_{t-1}$, is a weak test of the rationality of the forecast (more lags could be included in the models)[2].

It is well known that the error term may be serially correlated in these regressions. One instance where this is likely to happen is when the present period value of the variable to be forecasted is not yet known when a forecast for the next period is made. For example in the above models, this is the case if at time t a forecast $X^f_{1,t+1}$ is made, but the value of X_t is not yet known. Also for several periods ahead forecasts the error of the last steps are correlated with the errors of the forecasts for the intervening periods. In the above examples, this is the case $i > 1$. The error u_{it} follows a MA(i-1) process, where i is either the forecast horizon or the length of the information lag.

To relate this discussion more directly to the analysis of Finnish forecasts, consider the typical forecasting situations. In this paper the empirical data is on the forecasts made by the Research Institute of the Finnish Economy (ETLA). Traditionally, ETLA has published two forecasts annually, one in the spring and another in the fall. At both times annual forecasts for the current year and the following year are made. Recently the timing of the forecasts has been changed so that these forecast are made slightly earlier, and two updates of the forecast are made during the year. The present discussion refers to the old system, and in the new system to the first and third forecasts of the year.

For the year t value of X, the variable to be forecasted, four different forecasts are made, the first in the spring of year t-1, the second in the fall of year t-1, the third in the spring of year t, and the last one in the fall of year t. The forecast intervals do not coincide with the realization intervals. The interval between two successive forecasts is approximately half a year, whereas the realization interval is one year, since annual changes are forecasted. Let us denote these forecasts X^f_{it}, i=4,3,2,1, respectively. In addition, $X^f_{0t}=X_t$ is the realization. It should be noted that the index i is here, strictly speaking, not the length of the forecast horizon, but rather shows the order of the forecasts. In particular, the interval between the realization and the last forecast depends on which realization series is used.

When the spring forecast is made, preliminary data for the whole of the previous year is not yet available, but in the fall it is used. Hence, the forecast error processes of forecasts X^f_{it}, i=4,3,2,1, are MA(2), MA(1), MA(1), and white noise, respectively. In practice the determination of the error process is not this straightforward. First of all, basing the forecasts on preliminary data, which is subsequently revised, probably increases the order of the MA process of the forecast error. On the other hand, although only annual figures are forecasted, there is much quarterly and monthly information, which is available before the preliminary past annual figures, and is used in the forecasting process. This tends to shorten the information lag. It is difficult to determine the combined effect of these opposing factors. The recent changes in the timing of the forecasts may also have affected the error processes, since less information is now available when the forecasts are made.

There is another difficulty in forecast evaluation: which realization should be used in calculating the forecast errors? It is likely that forecasters are trying to forecast preliminary figures, since also the available information on the immediate past is mainly preliminary figures. Since the final figures for X_t may deviate considerably from the preliminary ones that the forecasters are aiming at, the errors calculated as differences of the final figures and the forecasts may actually have even more complicated error structures than those outlined above. Use of the final figures can also give misleading results in the efficiency tests, since forecast errors may then be regressed on such realizations that were actually not in the information set when the forecast was made. Forecast evaluation would therefore require careful collection of past preliminary data relevant for each time period.

Given these difficulties, it would be useful to have an alternative testing strategy that does not involve the use of realizations. Berger and Krane (1985) and Nordhaus (1987) have recently suggested such an approach that is based on studying the correlations of forecast revisions. Forecast revisions are defined as differences of successive forecasts of the same event. These may be called fixed event revisions, in contrast to rolling event revisions, which are differences of successive forecasts with the same horizon, but a different target. The former revision is defined as $e_{it}=X^f_{it}-X^f_{i-1,t}$, whereas the latter is $X^f_{it}-X^f_{i,t-1}$. In the case of ETLA's forecasts, there are four fixed event revisions $e_{3t}=X^f_{3t}-X^f_{4t}$, $e_{2t}=X^f_{2t}-X^f_{3t}$, $e_{1t}=X^f_{1t}-X^f_{2t}$, and the final forecast error $e_{0t}=X_t-X^f_{1t}$. Since e_{0t} involves the realization, it is subject to the reservations discussed above.

Consider the forecast error of a horizon i forecast: $\epsilon_{it}=X_t-X^f_{it}$. This can be expressed as a sum of subsequent forecast revisions, i.e. $\epsilon_{it}=e_{i-1,t}+...+e_{0t}$. According to the definition of forecast efficiency, the forecast error should be uncorrelated with the information that was available when the forecast was made. In a weak test this information can be specified to consist of past revisions. It follows that the sum of subsequent revisions should be independent of past revisions, and that each revision separately should be independent of all previous revisions (see Nordhaus (1987)).

Formally, the hypothesis of weak informational efficiency implies that

(1) $E(e_{it}e_{i,t-j}) = 0$ for all $j > 0$,

(2) $E(e_{it}e_{i+k,t}) = 0$ for all $k > 0$.

In addition, unbiasedness of the forecasts requires that the expectation of each revision is zero, i.e. $E(e_{it})=0$ for all i.

In practice the most likely cases are that a revision is correlated with the corresponding revision made a year earlier in forecasting a different event, but with the same forecast horizon, or that it is correlated with the previous revision made in forecasting the same fixed event, i.e. the cases $j=1$ in (1) and $k=1$ in (2). In the first case a positive correlation implies that there is a consistent pattern for a same kind of revision to be made in the same phase of the forecasting sequence each year. The second case means that if the correlation is positive, changes in the forecast have been smoothed so that a big change is made in successive small revisions in the same direction. A negative correlation implies a zig-zag pattern in the revisions.

The first test is a test of whether e_{it} is correlated with $e_{i,t-1}$ and the second test is a test of whether e_{it} is correlated with $e_{i+1,t}$. This corresponds to the testing strategy in Berger and Krane (1985), if it is assumed that the correlation of e_{it} and $e_{i,t-1}$ is the same for all t, and that the correlation of e_{1t} and $e_{i+1,t}$ is the same for all t. In contrast, Nordhaus (1987) assumes that for a fixed t, the correlations of e_{it} and $e_{i+1,t}$ are the same for all i. A general model that encompasses both approaches, but cannot be tested in practice, is such that the correlations are variable over both t and i. On the other hand, a more restricted model would be such that the correlations are the same over both i and t.

Given ETLA's four different forecasts of a fixed event, and hence three revisions and the final forecast error, the hypotheses (1) and (2) are tested by estimating the two models:

(3) $e_{it} = a_i + b_i e_{i,t-1} + u_{it}$, $i=0,1,2,3$

(4) $e_{it} = a_i + b_i e_{i+1,t} + u_{it}$, $i=0,1,2$

and performing a joint test of the null hypothesis $a_i=b_i=0$ for each i separately in each model. The error term u_{it} is assumed to be normally distributed with zero mean and variance σ_i^2. In addition, under the null hypothesis the error terms are serially uncorrelated (except possibly for i=0). Hence the models can be consistently estimated and tested with OLS.

The Nordhaus (1987) test would in this case involve the estimation of model (3) with parameters dependent on time, but not on i. However, there are only three data points for each t with which the two parameters a_t and b_t would have to be estimated. This testing strategy is applicable only to fairly long series of successive fixed event forecasts.

To allow for the revisions to be correlated with other revisions besides the immediately previous one, i.e. k≥1 in (2), additional terms are added in model (4). It is estimated in the form

$$(5) \qquad e_{it} = a_i + \Sigma^3_{j=i+1} b_{ij} e_{j,t} + u_{it}, \qquad i=0,1,2$$

and the null hypothesis $a_i=b_{i,i+1}=\ldots=b_{i3}=0$ is tested.

Another possible way of testing that future revisions are uncorrelated with past revisions is to regress cumulative future revisions on cumulative past revisions. The cumulative past revision at a time when forecast i is made is the same as the difference of the previous forecast i+1 and the first forecast (here forecast 4). The cumulative future revision, on the other hand, is the forecast error $\epsilon_{i+1,t}$. Nordhaus (1987) uses this test for each target year separately. Again, the available time series of revisions are too short to estimate the model. However, if it is assumed that the parameters vary over the forecast interval and not over time, the following model can be estimated:

$$(6) \qquad (\Sigma^i_{j=1} e_{jt}) = a_i + b_i(\Sigma^3_{j=i+1} e_{jt}) + u_{it}, \qquad i=1,2.$$

The joint test of $a_i=b_i=0$ is a test of weak forecast efficiency.
If one wants to use also the data on the realizations, the model can be estimated so that the sum in the left hand side of (6) starts from j=0, with i=0,1,2.

3. Empirical results

The above tests will be used for the forecasts made by ETLA for the growth rates of the volumes of the main GDP categories. Data on the forecasts are available from the year 1971 onwards. Forecasts 3 to 1 are available for 1971, so that revisions e_{2t} and e_{1t} can be calculated for that year. For the forecasts concerning the years 1972-1988 all the revisions can be calculated, and for the year 1989, the revision e_{3t} is available, since two forecasts for that year have already been made in 1988. The last revisions, or the final forecast errors, were calculated using the latest available figures (at 1985 prices) for past realizations. The forecast errors should be treated only indicative, since no attempt was made to gather past preliminary data which would be more relevant in forecast evaluation.

Table 1 presents some descriptive statistics on the revisions. The average and median revisions are fairly small, and for government investment and consumption the medians of all revisions are zero. Interestingly, the average final forecast error of government investment is clearly the largest. This shows that the forecasts of the public sector investment and consumption are very infrequently revised during the forecasting cycle, and the main revision shows up as a large forecast error. This is partly due to the fact that these forecasts are based on government plans, which are not frequently changed. The final error has often been caused by increases in local government spending. Some of the forecast errors are caused by a revision of the data to 1985 prices, which has involved an upward shift in the past growth rates of some of the series.

The forecast revisions are largest for the foreign trade and investment forecasts. Especially for the latter this may be explained by the increase in the amount of information during the forecasting sequence. Preliminary data on investment becomes available with considerable lag and it is often fairly extensively changed during data revisions.

Table 2 presents the estimation results for model (3), where revisions are regressed on the corresponding revision a year earlier. In most cases the explanatory power of the model is low, and there are a few violations of the error normality assumption. In the cases of exports and government investment the departure from normality seems to be caused by some large outliers in the revisions; cf. the last two columns of Table 1. The hypothesis $a_i=b_i=0$ is rejected only for the revision e_{3t} of government consumption. All the other forecasts are efficient according to the tests, although some of the constant terms are significantly different from zero. The tests with e_{0t} as the dependent variable and $e_{0,t-1}$ as the explanatory variable are similar to traditional efficiency tests for the forecasts X^f_{1t}. According to this test all forecasts would be efficient.

Table 3 presents the results for the test of correlatedness of successive revisions of the same event, i.e. results for model (5). For GDP and exports b_{12} is highly significant and fairly high, above one. This indicates that revision e_{2t} is typically followed by e_{1t}, which is of the same order of magnitude. For imports, the parameter is smaller and in the case of government investment, it is negative. The latter result may have been caused by the large number of zero revisions. Parameter b_{13} is negative for GDP and positive for government investment. The implication is that if the first two revisions of these forecasts are made in the same direction, less revision is made in the last forecast. Revisions e_{2t} are clearly not significantly correlated with the revisions e_{3t} for any of the variables. There are again some violations of error normality, but not in the equations with a significant slope coefficient.

When the dependent variable is the final forecast error e_{0t}, the parameters b_{02} and b_{03} for government consumption are negative and significantly different from zero. This shows that all early forecast revisions tend to decrease the final forecast error of government consumption, whereas the influence of the revision in the fall forecast of the current year is small. The significant constant term indicates that the forecast has some systematic bias, which is not corrected in the successive revisions, but shows up in the final forecast error. This can partly be explained by the data revisions, as mentioned above.

Clearly the forecasts studied are not independent of each other, so that inefficiency in one forecast may be transmitted to the others. For example, the export forecast affects the GDP forecast which, in turn, affects the imports forecast. Therefore the underlying causes of the possible informational inefficiencies are difficult to isolate.

Table 4 shows estimation results for the cumulative model (6). The slope coefficient is significant in the case of exports, when e_{1t} is regressed on the cumulative past revision, i.e. on $e_{2t}+e_{3t}$. This is consistent with the results in Table 3. The cumulative model was estimated also so that the cumulative sum in the left hand side of the model started from j=0, i.e. also the realized forecast errors were used (the results are not shown). In that case, government consumption was the only variable for which there was evidence of forecast inefficiency. The total revision still to be made was negatively correlated with the total revision so far made. This result is similar to that obtained in Table 3 and reflects the influence of the final forecast error.

4. Interpretations of the results

The empirical tests made using ETLA's forecasts show that there are some signs of inefficiency. The main cases are the forecasts for government investment and consumption, and for exports, imports and GDP[3).]

There are alternative interpretations of the results. The first is that there are true inefficiencies in the forecasting process in the sense that all past information is not used when the forecasts are made.

Another explanation is that the forecasters have a tendency to smooth their forecasts so that big jumps in them are avoided. Hence, even if it were known that a major revision is necessary, the needed revision may be split in small successive revisions, which are positively correlated. Explanations for this kind of conscious or unconscious behavior may be formalized by assuming that the loss function of the forecasters includes not only terms quadratic in the forecast error, but also terms quadratic in the revisions (see Berger and Krane (1985)). If there are k successive fixed event forecasts, the forecasters' loss function might be $L=\Sigma_{i=0}^{k}(X_t-X_{it}^f)^2+c\Sigma_{i=0}^{k-1}e_{it}^2$. While the first type of terms imply that efficient forecasts show less variation than the realizations, the second type of terms imply smoothing of the forecast revisions to smaller successive revisions.

The forecast smoothing explanation is favored both by Berger and Krane (1985) and Nordhaus (1987). A third possible explanation, which in the present author's view is the most plausible one, is data revisions. The forecasts are based on preliminary data on the past development of the economy. When new, revised data becomes available during the forecasting cycle, this is taken into account when the forecasts are revised. If the data revisions, however, are significantly autocorrelated themselves, this autocorrelation is likely to be transmitted to the forecast revisions.

To illustrate this, assume that successive forecasts i=k,...,1 are made of X_t during the year t. The forecasts are based on an AR(1) model $X_t=\beta X_{t-1}+u_t$, where β is known. It is assumed that only preliminary data for the year t-1 is available and that data revision may happen during the interval between successive forecasts. Forecast i is $X^f_{it}=\beta X^p_{i,t-1}$, where $X^p_{i,t-1}$ is the latest preliminary data that is available when forecast i is made. The forecast revision is $e_{it}=\beta(X^p_{i,t-1}-X^p_{i+1,t-1})=\beta r_{i,t-1}$. If the data revision $r_{i,t-1}$ is correlated with the previous revision $r_{i+1,t-1}$, so will also the forecast revision e_{it} be correlated with the revision $e_{i+1,t}$. An efficient forecast would take into account the autocorrelation pattern of the preliminary data (see e.g. Howrey (1978), Boucelham and Teräsvirta (1989)), but in practice the forecasts are made conditionally on the (possibly inefficiently revised) data supplied by the statistical authorities. The results of forecast efficiency tests depend on whether the data revision process is included in the information set the forecasters are assumed to have had.

Footnotes

1. This has been suggested by Holden and Peel (1983), Daub (1987) and Bond (1988), among others.

2. The econometric issues of these tests are discussed e.g. in Hansen and Hodrick (1980), Brown and Maital (1980), and Abel and Mishkin (1983).

3. Takala and Mustonen (1987) reached the conclusion that all the forecasts studied here are informationally efficient. Using the notation of the present paper, this result was based on a regression of forecast errors ϵ_{3t} on X_{t-1}, X_{t-2} and a constant.

References

Abel, A.B. and Mishkin, F.S. (1983), "An integrated view of tests of rationality, market efficiency and the short-run neutrality of monetary policy", *Journal of Monetary Economics* 11, 3-24

Berger, A.N. and Krane, S.D. (1985), "The informational efficiency of econometric model forecasts", *Review of Economics and Statistics* 67, 128-134

Bond, S.R. (1988), "Stabilization policy, expected output and employment", *Oxford Bulletin of Economics and Statistics* 50, 139-158

Boucelham, J. and Teräsvirta, T. (1989), "How to use preliminary values in forecasting the monthly index of industrial production", ETLA, *Discussion Papers*, No. 284

Brown, B.W. and Maital, S. (1981), "What do economists know? An empirical study of experts' expectations", *Econometrica* 49, 491-504

Daub, M. (1987), "An institutional approach to the rationality of expectations", *Applied Economics* 19, 1303-1316

Hansen, L.P. and Hodrick, R.J. (1980), "Forward exchange rates as optimal predictors of future spots: An econometric analysis", *Journal of Political Economy* 88, 829-853

Holden, K. and Peel, D.A. (1983), "Forecasts and expectations: some evidence for the UK", *Journal of Forecasting* 2, 51-58

Howrey, E.P. (1978), "The use of preliminary data in econometric forecasting", *Review of Economics and Statistics* 60, 193-200

Nordhaus, W.D. (1987), "Forecasting efficiency: concepts and applications", *Review of Economics and Statistics* 69, 667-674

Takala, K. and Mustonen, J. (1987), "Taloudellisten ennusteiden osuvuus ja rationaalisuus: VVM:n ja ETLA:n suhdanne-ennusteiden vertailua", Department of Economics, University of Helsinki, *Discussion Papers*, No. 258

Table 1: Descriptive statistics

	mean	st.dev.	median	min.	max.
GDP					
e_0	.58	1.20	.03	-.75	3.13
e_1	-.06	1.38	.0	-3.5	3.0
e_2	.00	0.77	-.5	-1.5	1.5
e_3	-.32	1.09	.0	-2.5	1.5
Exports					
e_0	.21	3.08	-.09	-7.63	7.22
e_1	-.44	4.18	-1.0	-13.5	7.5
e_2	.41	2.33	.5	-6.0	4.5
e_3	-.50	2.22	-1.0	-4.0	4.5
Imports					
e_0	.10	2.96	.06	-6.20	3.56
e_1	.56	3.55	.0	-6.0	7.5
e_2	.15	2.35	.0	-4.5	4.0
e_3	-.68	3.34	-1.5	-6.0	5.5
Private investment					
e_0	.48	2.77	.08	-3.84	4.81
e_1	.15	3.20	.0	-6.5	5.5
e_2	-.24	2.79	-.5	-6.5	5.0
e_3	-.79	3.38	.0	-9.0	4.5
Government investment					
e_0	2.04	3.76	2.48	-8.20	7.58
e_1	-.59	2.83	.0	-7.0	3.5
e_2	.47	2.85	.0	-2.0	11.0
e_3	-.77	1.92	.0	-6.5	2.0
Private consumption					
e_0	.74	1.59	.56	-1.51	4.38
e_1	.38	1.69	.0	-4.0	3.5
e_2	-.24	1.11	-.5	-2.0	2.5
e_3	-.38	1.18	-.5	-2.5	1.5
Government consumption					
e_0	.69	1.12	.59	-1.21	2.90
e_1	.24	0.77	.0	-1.0	2.0
e_2	-.15	0.63	.0	-2.0	1.0
e_3	.21	0.50	.0	-1.0	1.0

Table 2: Results for the model $e_{it} = a_i + b_i e_{i,t-1} + u_{it}$

	a_i	b_i	R^2	F(2,n-2)	DW	JB
GDP						
e_{0t}	.261	.244	.088	1.845	2.189	8.110**
	(.897)	(1.121)				
e_{1t}	-.128	-.026	.001	.064	1.810	1.548
	(-.353)	(-.096)				
e_{2t}	-.020	.350	.123	.992	1.685	.432
	(-.107)	(1.399)				
e_{3t}	-.523	-.312	.104	2.014	1.367	.202
	(-1.886)*	(-1.272)				
Exports						
e_{0t}	.259	-.101	.010	.100	1.903	2.784
	(.303)	(-.361)				
e_{1t}	-.949	-.027	.001	.471	1.921	40.170***
	(-.970)	(-.116)				
e_{2t}	.341	-.076	.006	.173	1.941	3.690
	(.550)	(-.291)				
e_{3t}	-.925	-.190	.053	1.895	1.586	2.696
	(-1.905)*	(-.885)				
Imports						
e_{0t}	.421	-.072	.006	.208	2.016	1.909
	(.571)	(-.282)				
e_{1t}	.083	.147	.027	.215	1.784	.088
	(.099)	(.628)				
e_{2t}	.141	.163	.026	.221	1.987	.266
	(.227)	(.615)				
e_{3t}	-1.033	.036	.002	.933	1.423	.067
	(-1.282)	(.150)				
Private investment						
e_{0t}	.135	.355	.134	1.108	1.534	.679
	(.193)	(1.421)				
e_{1t}	-.183	-.132	.021	.181	1.824	.312
	(-.241)	(-.549)				
e_{2t}	-.049	-.064	.005	.032	1.506	.894
	(-.069)	(-.251)				
e_{3t}	-1.347	-.289	.096	1.678	1.608	.670
	(-1.632)	(-1.218)				
Government investment						
e_{0t}	2.343	-.355	.145	2.882*	2.276	2.229
	(2.355)**	(-1.487)				
e_{1t}	-.788	.089	.009	.793	1.001	4.765
	(-1.102)	(.358)				
e_{2t}	.429	.017	.0003	.167	2.002	77.402***
	(.555)	(.065)				
e_{3t}	-.205	.248	.149	2.122	2.392	1.488
	(-.623)	(1.563)				
Private consumption						
e_{0t}	.382	.175	.048	1.410	1.905	.411
	(1.029)	(.806)				
e_{1t}	.408	-.063	.0000	.406	1.936	1.912
	(.889)	(-.023)				
e_{2t}	-.325	-.051	.003	.632	1.968	1.348
	(-1.123)	(-.200)				
e_{3t}	-.546	-.176	.033	1.496	1.433	1.366
	(-1.728)	(-.691)				
Government consumption						
e_{0t}	.573	.018	.0004	2.088	1.983	.388
	(1.710)	(.071)				
e_{1t}	.222	-.013	.0002	.566	1.901	.919
	(1.027)	(-.049)				
e_{2t}	-.021	.066	.010	.113	1.836	1.992
	(-.184)	(.380)				
e_{3t}	.314	-.609	.313	5.147**	2.195	.514
	(2.688)**	(-2.526)**				

Note: t-values in parentheses
F-values are used for testing $a_i = b_i = 0$
DW = Durbin-Watson statistic
JB = Jarque-Bera χ^2_2 statistic for testing normality of residuals
*** significant at 1% level
** significant at 5% level
* significant at 10% level
n=16 for i=1,2,3; n=15 for i=0

Table 3: Results for the model $e_{it} = a_i + \Sigma^3_{j=i+1} b_{ij} e_{jt} + u_{it}$

	a_i	b_{i1}	b_{i2}	b_{i3}	R^2	F(4-i,n-3)	DW	JB
GDP								
e_{0t}	.488	-.024	-.271	.242	.098	.818	1.547	12.642***
	(1.505)	(-.079)	(-.512)	(.738)				
e_{1t}	-.299		1.273	-.571	.513	4.647**	2.005	.487
	(-1.077)		(3.512)***	(-2.214)*				
e_{2t}	.052			.223	.098	.773	1.705	.387
	(.256)			(1.233)				
Exports								
e_{0t}	.870	.348	-.942	.096	.285	1.117	1.770	1.788
	(.979)	(1.202)	(-2.050)*	(.274)				
e_{1t}	-1.228		1.095	.087	.482	4.580**	1.345	.169
	(-1.613)		(3.456)***	(.261)				
e_{2t}	.332			.032	.001	.136	2.093	3.838
	(.522)			(.115)				
Imports								
e_{0t}	.134	-.136	.173	-.329	.163	.621	2.533	1.433
	(.175)	(-.517)	(.460)	(-1.412)				
e_{1t}	-.066		.726	-.135	.262	1.550	1.766	.956
	(-.086)		(2.137)*	(-.554)				
e_{2t}	.357			.247	.120	.988	1.825	.572
	(.589)			(1.380)				
Private investment								
e_{0t}	.419	-.314	-.291	.244	.251	.969	1.186	.906
	(.570)	(-1.307)	(-1.054)	(1.115)				
e_{1t}	-.224		.063	-.044	.004	.035	1.943	.633
	(-.271)		(.193)	(-.173)				
e_{2t}	.230			.299	.143	1.173	1.862	7.045**
	(.340)			(1.531)				
Government investment								
e_{0t}	1.333	-.012	-.311	-.544	.128	1.141	2.530	6.725**
	(1.246)	(-.024)	(-.788)	(-.935)				
e_{1t}	-.196		-.411	.576	.462	4.550**	1.492	.865
	(-.337)		(-2.131)*	(2.005)*				
e_{2t}	.155			-.348	.054	.577	2.500	69.774***
	(.193)			(-.897)				
Private consumption								
e_{0t}	.440	-.094	-.313	.024	.106	.815	1.760	.155
	(1.093)	(-.421)	(-.880)	(.073)				
e_{1t}	.420		.497	-.323	.111	.821	2.117	7.162**
	(.874)		(1.151)	(-.818)				
e_{2t}	-.209			.236	.067	1.153	2.086	7.159**
	(-.716)			(1.000)				
Government consumption								
e_{0t}	.733	.060	-1.254	-1.220	.576	5.819***	2.363	1.593
	(3.275)***	(.226)	(-2.540)**	(-2.812)**				
e_{1t}	.203		.491	.198	.085	.785	2.027	.879
	(.939)		(.994)	(.444)				
e_{2t}	-.035			.023	.001	.045	1.666	2.121
	(-.299)			(.096)				

Note: n=15 for i=0; n=16 for i=1,2
For other explanations, see Table 2

Table 4: Results for the model $(\Sigma^{i}_{j=1} e_{jt}) = a_i + b_i (\Sigma^{3}_{j=i+1} e_{jt}) + u_{it}$

	a_i	b_i	R^2	F(2,n-2)	DW	JB
GDP						
e_{1t}	-.077	.118	.017	.181	2.020	.876
	(-.208)	(.490)				
$e_{1t}+e_{2t}$	-.181	-.065	.001	.057	1.493	1.155
	(-.337)	(-.137)				
Exports						
e_{1t}	-.764	.617	.296	3.603*	1.631	4.105
	(-.932)	(2.427)**				
$e_{1t}+e_{2t}$	-.533	.155	.004	.118	2.132	37.822***
	(-.351)	(.231)				
Imports						
e_{1t}	.281	.191	.080	.627	1.988	.101
	(.346)	(1.103)				
$e_{1t}+e_{2t}$	.550	.292	.041	.328	1.685	.125
	(.428)	(.771)				
Private investment						
e_{1t}	-.187	.0001	.0000	.030	1.916	.587
	(-.239)	(.001)				
$e_{1t}+e_{2t}$	.021	.274	.053	.414	1.643	4.416
	(.019)	(.885)				
Government investment						
e_{1t}	-.902	-.156	.033	.983	.903	5.699*
	(-1.297)	(-.687)				
$e_{1t}+e_{2t}$	-.104	.372	.073	.735	1.937	.097
	(-.142)	(1.052)				
Private consumption						
e_{1t}	.450	.058	.004	.432	2.004	1.575
	(.919)	(.227)				
$e_{1t}+e_{2t}$	.107	.031	.0003	.014	1.637	2.599
	(.170)	(.060)				
Government consumption						
e_{1t}	.178	.330	.072	1.150	2.028	.832
	(.878)	(1.040)				
$e_{1t}+e_{2t}$	.151	.233	.012	.353	1.776	.224
	(.557)	(.415)				

Note: n=15
For other explanations, see Table 2

ELINKEINOELÄMÄN TUTKIMUSLAITOS (ETLA)
The Research Institute of the Finnish Economy
Lönnrotinkatu 4 B, SF-00120 HELSINKI Puh./Tel. (90) 601 322
Telefax (90) 601 753

KESKUSTELUAIHEITA - DISCUSSION PAPERS ISSN 0781-6847

No 257 SYNNÖVE VUORI, Total Factor Productivity and R&D in Finnish, Swedish and Norwegian Manufacturing Industries, 1964 to 1983. 08.04.1988. 43 pp.

No 258 GEORGE F. RAY, The Diffusion of Technology in Finland. 14.04.1988. 53 pp.

No 259 TIMO TERÄSVIRTA, A Review of PC-GIVE: A Statistical Package for Econometric Modelling. 25.04.1988. 17 pp.

No 260 ERKKI KOSKELA, Saving, Income Risk and Interest Rate Wedge: A Note. 12.05.1988. 10 pp.

No 261 MARKKU KOTILAINEN, Medium-Term Prospects for the European Economies. 02.06.1988. 45 pp.

No 262 RITVA LUUKKONEN - TIMO TERÄSVIRTA, Testing Linearity of Economic Time Series against Cyclical Asymmetry. 08.06.1988. 30 pp.

No 263 GEORGE F. RAY, Finnish Patenting Activity. 13.06.1988. 19 pp.

No 264 JUSSI KARKO, Tekniikkaerojen mittaaminen taloudellis-funktionaalisen ja deskriptiivisen indeksiteorian puitteissa. 28.06.1988. 57 s.

No 265 TIMO SAALASTI, Hintakilpailukyky ja markkinaosuudet Suomen tehdasteollisuudessa. 01.08.1988. 75 s.

No 266 PEKKA ILMAKUNNAS, Yritysaineiston käyttömahdollisuuksista tutkimuksessa. 18.08.1988. 40 s.

No 267 JUSSI RAUMOLIN, Restructuring and Internationalization of the Forest, Mining and Related Engineering Industries in Finland. 19.08.1988. 86 pp.

No 268 KANNIAINEN VESA, Erfarenheter om styrning av investeringar i Finland. 26.08.1988. 17 s.

No 269 JUSSI RAUMOLIN, Problems Related to the Transfer of Technology in the Mining Sector with Special Reference to Finland. 30.08.1988. 32 pp.

No 270 JUSSI KARKO, Factor Productivity and Technical Change in the Finnish Iron Foundry Industry, 1978-1985. 26.09.1988. 77 pp.

No 271 ERKKI KOSKELA, Timber Supply Incentives and Optimal Forest Taxation. 30.09.1988. 32 pp.

Elinkeinoelämän Tutkimuslaitoksen julkaisemat "Keskusteluaiheet" ovat raportteja alustavista tutkimustuloksista ja väliraportteja tekeillä olevista tutkimuksista. Tässä sarjassa julkaistuja monisteita on rajoitetusti saatavissa ETLAn kirjastosta tai ao. tutkijalta.

Papers in this series are reports on preliminary research results and on studies in progress; they can be obtained, on request, by the author's permission.

0033A/30.03.1989