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Documents

# The Importance of Disaggregation in Economic Modelling

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**Abstract:**
This paper explores the potential costs of aggregate versus disaggregate modelling in the context of predicting the aggregate. An estimated aggregate export equation for Norwegian exports of manufacturing goods is compared with an alternative approach where manufacturing exports are divided into eight sub-groups. Important variation in estimated elasticities across commodities is found. As a consequence, the disaggregated equations clearly out-perform the aggregate relationship in periods where explanatory variables develop differently across commodities and when the share of each commodity in the aggregate changes rapidly. When this is not the case, the two alternative approaches perform equally well.

**Keywords:** Aggregation; Manufacturing exports; Forecasting

**JEL classification:** C43, F12, C53, F17

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# 1. Introduction

Which level of aggregation to chose in economic modelling is an important but difficult question. While consistent aggregation implies restrictions that are unlikely to hold in practice, and econometric results may depend on the chosen level, the researcher will often be forced to aggregate. In applied work, the choice of level of aggregation or disaggregation depends on many factors, such as the purpose of the exercise, the specification errors involved, the data available, and the need for simplicity and parsimony, cf. Barker and Pesaran (1990) for a discussion.

If theory variables can be observed without measurement errors and the data generating processes are correctly specified, a disaggregated modelling approach can not do worse than an aggregate equation and in general will do better, cf. Barker and Pesaran (1990).[1] Normally an aggregate approach involves a loss of information and also faces an aggregation bias problem defined as the deviation of the macro parameters from the average of the corresponding "micro" parameters. On the other hand, measurement errors are most likely to be present, and the quality of the disaggregated data may be poor. Aggregation reduces this problem if measurement errors at the micro level cancel each other out, cf. Aigner and Goldfeld (1974). And furthermore, since we in general do not know the data generating processes, we may face a trade-off between errors of misspecification in the disaggregated system and the aggregation bias problem, cf. Pesaran et al. (1989). Also, if the purpose is forecasting, and sub-groups show large variations while the aggregate has a smoother development, the aggregate may be easier to model and forecast than the disaggregates, cf. Ilmakunnas (1990). Barker and Pesaran (1990) conclude that the appropriate level of aggregation is an empirical question that needs to be answered in the context of particular applications. Even if this is true, and the level of aggregation must be decided independently from case to case, some aspects of importance are common. This paper illustrates one such aspect, which, if possible, should be examined before making a decision about the level of aggregation in a particular application.

In this paper, the question of which level of aggregation to choose is addressed in the context of predicting Norwegian exports of manufacturing goods. An estimated aggregate export equation is compared with a system where manufacturing exports are divided into eight different sub-groups of goods. The single commodities classified in the same group of goods have important features in common, and are assumed to be relatively close substitutes. The estimated export volume equations presented in this paper can be interpreted as Armington-equations with national product differentiation, cf. Armington (1969). Support is found for the hypothesis that Norwegian exporters face downwards sloping foreign demand curves, and that exports depend on a measure of foreign demand and relative prices. Important variation in estimated elasticities across commodities is found. The paper concludes that in periods where explanatory variables develop differently across commodities and when the share of each commodity in total manufacturing exports change rapidly,

[1] Important aspects concerning aggregation in economic modelling is discussed in Barker and Pesaran (1990), see also Pesaran et al. (1989) and Lee et al. (1990). These references also discuss the main contributions within the field of aggregation.

the disaggregated approach clearly out-performs the aggregate equation. When explanatory variables are closely related, the aggregate relationship and the disaggregated equations perform equally well.

Section 2 presents the estimated export equations, while a comparison of the forecasting properties is given in section 3. The conclusions are summarised in the final section.

## 2. The estimated export equations

In Armington (1969), a theory of demand for products distinguished by place of production is put forward. The main assumption is that firms within a geographical area or country produce identical products of a commodity, while products of the same commodity produced in different countries are heterogeneous. We assume constant elasticities of substitution in demand between products of the same commodity and long-run price homogeneity. Foreign markets are treated as one aggregate market. Using a log-linear error-correction specification, foreign demand for Norwegian exports is defined in equation (2.1). The long-run solution of the model is given in (2.2). Lower case letters indicate that the variables are in logarithms, and $\Delta v_t = \log(V_t/V_{t-1})$, i.e. the first difference of the logarithm of a variable.

(2.1) $$\Delta xa_{it} = \Sigma_j[\eta_{ij}\, \Delta pa_{i,t-j} + \mu_{ij}\, \Delta pw_{i,t-j} + \nu_{ij}\, \Delta pk_{i,t-j} + \delta_{ij}\, \Delta m_{i,t-j} + \zeta_{ij}\, \Delta xa_{i,t-j-1}] + \tau_{i0} + \tau_{i1} xa_{i,t-k} + \tau_{i2}\,(pa_{i,t-l} - pw_{i,t-m}) + \tau_{i3}\,(pk_{i,t-n} - pw_{i,t-o}) + \tau_{i4}\, m_{i,t-p} + \tau_{i5}\, t_t$$

(2.2) $$xa_i = \alpha_{i0} + \alpha_i\,(pa_i - pw_i) + \beta_i\,(pk_i - pw_i) + \gamma_i\, m_i + \kappa_i\, t$$

where $\alpha_{i0} = -\tau_{i0}/\tau_{i1}$, $\alpha_i = -\tau_{i2}/\tau_{i1}$, $\beta_i = -\tau_{i3}/\tau_{i1}$, $\gamma_i = -\tau_{i4}/\tau_{i1}$, $\kappa_i = -\tau_{i5}/\tau_{i1}$, i=1,..,n commodities, j=0,..,J and k,..,p describe the lag structure. $XA_i$ is Norwegian exports of commodity i in constant prices; $PA_i$ is the Norwegian export price of commodity i; $PW_i$ is competitors' prices in the world market of commodity i, i.e. the price of close substitutes produced abroad; $PK_i$ is the price of other commodities on foreign markets; $M_i$ is a measure of world demand for commodity i in constant prices; t is a deterministic trend variable included to capture systematic effects of other factors of importance for the development in Norwegian exports. The variables are measured in Norwegian kroner (NOK). The relative price term between $PK_i$ and $PW_i$ in the general model is included because we use world demand variables based on more aggregate data than the measures for competitors' prices, and we therefore need to take into account substitution effects between different commodities. Our interpretation of no significant effect of $PK_i$ is that the chosen world demand variables proxy the trend in foreign demand for different commodities well. No effect of $PK_i$ also supports the hypothesis of separability in demand between different commodities. The $\eta_{ij}$'s, $\mu_{ij}$'s, $\nu_{ij}$'s, $\delta_{ij}$'s and $\zeta_{ij}$'s are short-run coefficients, while the $\tau$'s represent the long-run structure. $\tau_{i1}$ is the error-correction coefficient. $\alpha_i$ and $\beta_i$ are the long-run elasticity of the own price and the price of other commodities on foreign markets respectively, while the long-run elasticity of competitors' prices equals $-(\alpha_i+\beta_i)$. $\gamma_i$ and $\kappa_i$ are the long-run elasticity of world demand and the trend variable respectively, and $\tau_{i0}$ and $\alpha_{i0}$ are intercepts. The theoretical predictions are that $\alpha_i < 0$, $\beta_i > 0$, $-(\alpha_i+\beta_i) \geq 0$ and $\gamma_i > 0$.

The aggregate relationship for manufactured goods is similar to the commodity specific equations, but in this case the general model includes only one relative price term. The price of other commodities on foreign markets is not included.

The data for $XA_i$ and $PA_i$ are from the Norwegian national accounts[2]. The empirical proxies for $M_i$ and $PK_i$ are based on data for total imports of goods by Norway's principal trading partners published by the International Monetary Fund (IMF). When aggregating these foreign import volume and price variables, we use weights that reflect the importance of each country for Norwegian exports of different commodities. As proxies for competitors' prices in the disaggregated equations, $PW_i$, it was necessary to use Norwegian import prices. This may involve a measurement error problem and bias the price elasticities towards 0. On the other hand, the long-run elasticities obtained from cointegrating error-correction models are consistent if the measurement error is integrated of order 0 and thus has a finite variance, cf. Engle and Granger (1987). Lindquist (1993) finds that Norwegian import prices follow the same trend as import prices by our principal trading partners at the aggregate level, but there are short-run discrepancies. The ADF-statistic on the difference of the log of the two aggregate relative prices for manufactured goods is -2.86. A constant term is included. The critical value at the five per cent significance level is -2.98. We use the method suggested in MacKinnon (1991) to calculate the critical value with 25 observations. Although not formally supported at the five per cent level, we accept integration of order 0 as a plausible hypothesis in this case. Lindquist (1993) compares the results from estimating export equations for different commodities using both Norwegian import prices and aggregate import prices abroad. The conclusion is that commodity specific price information, rather than international price information at an aggregate level, is important for explaining Norwegian exports of different manufacturing goods.

If the market elasticity $\gamma_i$, i.e. the elasticity of world demand, equals one and the trend effect $\kappa_i$ is zero, this implies a constant market share at constant relative prices. "Market share" is defined as the ratio of exports of a commodity to world demand. Changes in market shares are assumed to reflect the development in "total" competitiveness of trading industries, and includes changes in both price and non-price competitiveness. The development in relative export prices, i.e. the ratios of the Norwegian export price to competitors' prices, picture the development in price competitiveness. Estimated market elasticities and trend effects are assumed to reflect the development in non-price competitiveness. In general, non-price competitiveness depends on a large number of factors such as production capacity, trade barriers, product quality, marketing and advertising, delivery reliability, after sales service, etc. Because the export prices applied are unit value indices, our data for export volumes and prices include quality changes. Most variables influencing firms' non-price competi-

[2] Norwegian national account data have been revised during the last years, but we use old national account data. The data are revised back to 1978, while we use long-time series starting in 1962.

tiveness are difficult to observe or express in quantitative terms. For this reason, empirical analyses tend to either neglect most of these factors, in which case the market elasticity should be interpreted as a "gross elasticity", or to add simple deterministic or stochastic trends in the export equations to capture long term trends in these variables, cf. Anderton and Dunnett (1987) and Anderton (1992). A market elasticity below unity or a negative trend coefficient is assumed to indicate a loss of non-price competitiveness, while the opposite is true with a market elasticity above one or a positive trend coefficient. This interpretation of the market elasticity presupposes that there has been a relatively steady growth in world demand over time. If the estimated long-run market elasticity in the Armington model deviates from unity, we test whether this can be explained by a deterministic trend variable.

Table 2.1. gives the manufacturing commodities that are modelled. The aggregate of these commodities is also modelled. The classification of the commodities follows that in MODAG[3].

**Table 2.1. Manufacturing commodities included in this analysis**

| | Share of manufacturing exports in percent, current prices | | | |
|---|---|---|---|---|
| Commodity | 1963 | 1973 | 1983 | 1993 |
| Food products | 18.7 | 18.0 | 15.9 | 14.5 |
| Beverages and tobacco | 0.2 | 0.2 | 0.4 | 0.3 |
| Textiles and wearing apparels | 3.5 | 3.0 | 2.1 | 1.8 |
| Miscellaneous industrial products | 9.6 | 13.4 | 13.3 | 18.7 |
| Wood products, furniture and fixtures | | | | 3.6 |
| Chemical and mineral products | | | | 12.6 |
| Printing and publishing | | | | 0.3 |
| Mining products | | | | 2.2 |
| Paper and paper products | 18.9 | 11.4 | 9.7 | 8.7 |
| Industrial chemicals | 9.1 | 6.7 | 10.0 | 10.0 |
| Metals | 27.7 | 28.4 | 28.4 | 23.8 |
| Machinery and metal products (excl. ships) | 12.3 | 18.8 | 20.2 | 22.3 |
| Total manufacturing exports, billion NOK[1] | 6.7 | 20.7 | 53.1 | 94.7 |

[1] Excl. fuel, petrol and ships, incl. mining products. I.e. the commodities above.

Source: Økonomiske analyser 9/94, Statistics Norway.

Paper and paper products, Industrial chemicals and Metals are basically industrial raw materials and intermediate goods. For these commodities one may assume a model with homogeneous goods and price taking behaviour to be more promising than the differentiated products approach. Lindquist (1993) tests this hypothesis and finds that the Armington-model clearly encompasses the price taking hypothesis for all commodities in table 2.1 except for Metals. For this latter commodity, Lindquist is unable to discriminate between the two alternatives. In this paper we apply the Armington-equation for all commodities, however.

[3] MODAG is an annual large scale macromodel for Norway developed by Statistics Norway, cf. Cappelen (1992).

The econometric package PC-GIVE Version 6.1 is used, cf. Hendry (1989). We use ordinary least squares (OLS). The data cover the period 1962-1992[4]. The 1988-1992 observations are not included when designing the models, and these observations are used for ex-post forecast comparisons. Asymptotic t-values of the long-run elasticities are calculated by the method suggested in Kmenta (1971), see Bårdsen (1989). AR(j) and ARCH(j) are F-form tests of the LM-test of j'th order autocorrelation (Harvey (1990)) and heteroscedasticity (Engle (1982)) respectively. NORM is the $\chi^2$-test of normal residuals with two degrees of freedom (Jarque and Bera (1980)). The Hausman-Wu test (Godfrey (1988)) is applied to test for weakly exogenous export prices, and the validity of the instruments used is tested by the specification $\chi^2$-test with j degrees of freedom denoted SPEC(j) (Sargan (1964)). To test for cointegration, we use the test suggested in Kremers et al. (1992) based on the t-ratio of the error-correction coefficient ($t_{ECM}$). We follow the recommended procedure when this statistic deviates from the standard normal distribution and use the critical values of the Dickey-Fuller test. We also report the Dickey-Fuller (DF) and the Augmented Dickey-Fuller (ADF) test of cointegration (Engle and Granger (1987)). According to Kremers et al., these tests have lower power compared with the $t_{ECM}$-test, however. Critical values of the DF-test consistent with our sample size are calculated by the formulae provided by MacKinnon (1991). With respect to the ADF-test, we use the critical values at 50 observations in table 2 and 3 in Engle and Yoo (1987). Restrictions on the coefficients are tested by simple t-tests of adding one of the variables with a restricted coefficient. We report the t-statistic from testing long-run price homogeneity (Restr. p) and a long-run market elasticity equal to unity (Restr. m). The long-run price homogeneity test may be regarded as a test of the validity of the empirical variables applied just as much as of the theoretical model.

The estimated equation for Food products needs some comments. Export of this commodity is basically processed fish, and in addition to the Norwegian export price and competitors' price on foreign markets, the price of fresh fish enters significantly. (Fresh fish is not included in the manufactured commodity Food products.) As a proxy for the price of fresh fish we use the Norwegian export price of fresh fish (PA13). The inclusion of this price-variable implies non-separability in demand between processed and fresh fish. This export equation also includes output in the Norwegian fishing sector and imports of fresh fish (XI13=output+imports). Our interpretation of the inclusion of this variable is that the domestic food processing industry is rationed in its access to raw materials. Negative autocorrelated residuals may indicate a problem with over-parameterisation, however. We find significant autocorrelation at the second but not at the first lag. We prefer the specification that includes these extra variables to one that does not, however, because if we exclude PA13 and/or XI13 we need as much as four lags on the remaining price variables to achieve a satisfactory equation. Long-run price homogeneity is not supported by the data for this commodity. In general, it was difficult to find an export equation with a plausible interpretation that satisfied all statistical tests for Food products.

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[4] Consistent national account data are calculated for 1993 also, but this observation is not included because of an inconsistency problem in the export market demand variables ($M_i$). There is a discontinuity in the trade statistics for the EU-countries in 1993, and these trade data are used in the calculations of the $M_i$'s.

**Table 2.2. The estimated export equations**

| Variable | Estimated coefficients[1] | | | | |
|---|---|---|---|---|---|
| | Food products[2] | Beverages and tobacco | Textiles and wearing app.[3] | Miscellan. industrial prod. | Paper and paper prod. |
| $\Delta xa_{t-1}$ | | | | 0.32 (1.9) | |
| $\Delta m_t$ | | 0.54 (1.6) | | 1.33 (6.9) | 1.27 (7.4) |
| $\Delta m_{t-1}$ | | | | -0.77 (-3.0) | -0.64 * |
| $\Delta pa_t$ | -0.40 (-4.4) | -0.84 (-7.4) | | -0.52 (-2.4) | -1.37 (-5.2) |
| $\Delta pa_{t-1}$ | | 0.84 * | | 0.78 (2.8) | |
| $\Delta pw_t$ | 0.40 * | 3.48 (6.8) | | 0.52 * | 1.37 * |
| $\Delta pw_{t-1}$ | | -1.74 * | | -0.78 * | |
| $\Delta pk_t$ | -0.40 * | | | | 0.83 (6.2) |
| $\Delta xi13_t$ | 0.67 (5.1) | | | | |
| $xa_{t-1}$ | -0.17 (-1.7) | -0.98 (-6.7) | 0.57 (5.6) | -0.91 (-5.0) | -0.43 (-3.4) |
| $m_t$ | | | 0.78 (4.2) | | |
| $m_{t-1}$ | | 0.20 (1.1) | | 1.13 (4.9) | 0.23 (2.8) |
| $m_{t-2}$ | 0.17 * | | | | |
| $p_t$ | | | -1.29 (-3.4) | | |
| $p_{t-1}$ | -0.37 (-2.9) | -1.62 (-7.8) | | -1.19 (-4.4) | -1.21 (-5.6) |
| $pkw_{t-1}$ | -0.37 * | | | | 0.30 (2.8) |
| $xi13_{t-1}$ | 0.17 * | | | | |
| Constant | -0.96 (-2.0) | 5.83 (6.5) | 4.94 (4.9) | 10.29 (5.0) | 4.68 (3.3) |
| TREND | | 0.08 (5.6) | -0.04 (-5.3) | | |
| $El_M XA$ | 1.00 * | 0.20 (1.0) | 1.82 | 1.25 (44.1) | 0.53 (4.0) |
| $El_{PA} XA$ | -4.26 ( ) | -1.66 (-9.3) | -2.99 | -1.31 (-4.2) | -2.83 (-4.4) |
| $El_{PW} XA$ | 2.13 * | 1.66 * | 2.99 * | 1.31 * | 2.12 * |
| $El_{PK} XA$ | 2.13 * | | | | 0.71 (2.1) |
| $El_{XI} XA$ | 1.00 * | | | | |
| Est.period | 1965-1987 | 1965-1987 | 1966-1987 | 1964-1987 | 1965-1987 |
| SER | 0.056 | 0.066 | 0.045 | 0.032 | 0.035 |
| DW | 2.67 | 2.38 | 2.38 | 2.33 | 1.97 |
| AR(2) | 3.11 | 0.44 | 3.27 | 1.01 | 1.08 |
| ARCH(2) | 0.18 | 0.70 | 0.14 | 0.47 | 0.67 |
| NORM | 1.09 | 0.37 | 0.28 | 0.47 | 0.43 |
| Hausman[4] | 1.14 | 0.90 | -1.29 | -0.29 | -1.38 |
| SPEC(j) | 0.32 (3) | 2.37 (2) | 7.16 (6) | 5.60 (5) | 5.50 (5) |
| $t_{ECM}$ | | (s) | .. | (s) | |
| DF/(ADF) | (-4.59) (s) | -4.48 (s) | -2.54 | (-3.91) (s) | (-3.39) |
| Restr. p | -1.51 | 0.49 | 0.48 | -1.20 | -1.50 |
| Restr. m | -0.10 | | | | |
| Restr. xi | -0.21 | | | | |

[1] t-statistics in brackets.

[2] For this commodity, $\Delta pk_t = \Delta(pa_t - pa13_t)$, $pkw_t=(pa_t - pa13_t)$. PA13 is the Norwegian export price of fresh fish. XI13 is output in the Norwegian fishing sector plus imports of fresh fish.

[3] Left hand side variable is $xa_t$.

[4] The instrumental variables regressions are reported in Lindquist (1993).

* Restricted à priori, (s) Significant at the five per cent level.

$p_t = (pa_t - pw_t)$, $pkw_t = (pk_t - pw_t)$.

**Table 2.2. Continues**

| Variable | Estimated coefficients[1] Industrial chemicals | Metals | Machinery and metal products | Total manufacturing exports[2] |
|---|---|---|---|---|
| $\Delta m_t$ | 1.00 (5.8) | 1.58 (5.1) | 0.39 (2.0) | 0.85 (4.2) |
| $\Delta m_{t-1}$ | | | 1.03 (6.3) | |
| $\Delta pa_t$ | -1.10 (-6.9) | | -0.55 (-3.4) | -0.77 (-3.3) |
| $\Delta pa_{t-1}$ | | 0.47 (1.6) | 0.40 (2.2) | |
| $\Delta pa_{t-2}$ | -0.65 (-6.5) | | | |
| $\Delta pw_t$ | 1.10 * | | | 0.77 * |
| $\Delta pw_{t-1}$ | | -0.47 * | -0.40 * | -0.17 (-1.3) |
| $xa_{t-1}$ | -0.24 (-3.7) | -0.83 (-4.8) | | -0.23 (-1.5) |
| $xa_{t-2}$ | | | -0.29 (-2.2) | |
| $m_{t-1}$ | | 0.61 (4.5) | | 0.23 * |
| $m_{t-2}$ | | | 0.46 (2.5) | |
| $m_{t-3}$ | 0.37 (5.1) | | | |
| $p_{t-1}$ | -0.24 * | -0.54 (-1.9) | | -0.30 (-2.4) |
| $p_{t-2}$ | | | -0.46 (-3.2) | |
| Constant | 2.73 (3.8) | 10.09 (4.8) | 3.37 (2.2) | 3.23 (1.5) |
| TREND | | | | -0.01 (-2.4) |
| $El_M XA$ | 1.53 (8.7) | 0.73 (15.5) | 1.57 (13.0) | 1.00 * |
| $El_P XA$ | -1.00 * | -0.64 (-2.0) | -1.58 (-1.5) | -1.28 (-1.4) |
| Est.period | 1966-1987 | 1964-1987 | 1964-1987 | 1964-1987 |
| SER | 0.036 | 0.060 | 0.027 | 0.029 |
| DW | 1.89 | 2.01 | 2.38 | 2.15 |
| AR(2) | 0.06 | 0.07 | 4.07 (s) | 1.38 |
| ARCH(2) | 0.43 | 0.80 | 0.58 | 0.13 |
| NORM | 0.04 | 1.06 | 0.97 | 0.40 |
| Hausman[3] | -0.09 | .. | -0.06 | -0.71 |
| SPEC(j) | 5.94 (6) | .. | 0.96 (3) | 8.34 (6) |
| $t_{ECM}$ | (s) | (s) | | |
| DF/(ADF) | (-2.22) | -4.04 | -2.68 | -2.39 |
| Restr. m | | | | -0.09 |
| Restr. p | 1.24 | -1.62 | -1.11 | -0.97 |
| Restr. $El_p XA$=-1 | 0.14 | | | |

[1] t-statistics in brackets.
[2] Competing prices are measured by foreign import prices.
[3] The instrumental variables regressions are reported in Lindquist (1993).
* Restricted à priori, (s) Significant at the five per cent level.
$p_t = (pa_t - pw_t)$.

Table 2.2 shows important variation in estimated price and market elasticities across commodities. We find significant effects of $PK_i$ for Paper and paper products only. In general, the estimated price effects are relatively large for commodities with private consumption as the dominant end use, i.e. for Food products and Textiles and wearing apparels. Large price effects are also found for Paper and paper products, which are mainly industrial raw materials and intermediate goods. Large price effects are assumed to reflect the existence of relatively close substitutes and weak consumer loyalty. The small price effects for Industrial chemicals and Metals, which also are basically industrial raw materials and intermediate goods, suggest that these commodities to a higher degree consist of specialised goods. Alternatively, the small price elasticities for these commodities may be due to misspecification. Particularly for Metals one may expect supply side factors such as output capacity to be important, because investments in increased capacity take time and changes in the capacity utilisation involve high costs. On the other hand, if Norwegian products classified in the same commodity are close rather than perfect substitutes, substitution effects between Norwegian products may reduce the aggregate price elasticity, cf. Lindquist (1993).

The standardised interim multiplier with respect to competitors' prices is negative at t+1 for Beverages and tobacco and Machinery and metal products. This may indicate that relative import prices between commodities abroad matter for these commodities, although such effects are not found to have significant effects. Thus, when competitors' prices increase, a negative effect on Norwegian exports due to a fall in total import demand abroad for these commodities dominates the positive effect of the decrease in the relative export price in the short-run.

According to the disaggregated equations, the mean elasticities over 1964-1987 for manufacturing exports with respect to own price and competitors' prices are -1.54 and 1.22 respectively. Annual export volumes are used as weights when aggregating elasticities across commodities. The mean market elasticity based on the commodity specific equations equals 0.99, and the mean aggregate trend elasticity is very close to zero but negative. This indicates a small loss in or unchanged non-price competitiveness for manufacturing goods. A comparison with the aggregate equation shows that the two approaches are surprisingly consistent with respect to the aggregate long-run elasticities. The aggregation bias reduces the own price elasticity somewhat, this elasticity is -1.28 according to the aggregate equation and should be compared with -1.54. The elasticities with respect to competitors prices and world demand are very close, and equal 1.28 and 1.00 respectively according to the aggregate equation. No effect is found of PA13 or XI13 in the aggregate equation, but a small negative trend effect is included. Hence, the conclusion from the disaggregated equations with respect to non-price competitiveness is supported by the aggregate equation.

The $t_{ECM}$-test rejects the hypothesis of no cointegration for four commodities. If we apply Gaussian rather than DF-critical values, the $t_{ECM}$ supports cointegration for two more commodities. (The equation for Textiles and wearing apparels is not an error-correction model and the $t_{ECM}$-statistic can not be calculated. The DF-test does not support cointegration though.) For Food products, the ADF-test supports cointegration while the $t_{ECM}$-test does not. None of the tests supports cointegration in the aggregate relationship.

Chow-tests based on recursive least squares (RLS) show that the disaggregated equations in table 2.2 are stable in-sample, and the same is true for most equations also post-sample, i.e. over 1988-1992. The 1-step ahead and N-decreasing Chow-tests imply a structural brake around 1980 for the aggregate equation, and the same is true in the late eighties when we include the 1988-1992 observations in the sample. The RLS regression of the aggregate equation shows a negative trend in the price elasticity, i.e. a decline in the price effect, and a positive trend in the market elasticity. This is consistent with the estimated commodity specific elasticities and the development in the export share of important commodities over time.

# 3. Forecasting performance

We now subject our export equations to post-sample forecast tests. For this purpose we use data for 1988-1992. Figure 3.1 shows both actual exports of manufacturing goods and the 1-step predicted values. The aggregate of the commodity specific forecasts shows that the disaggregated approach predicts exports of manufactured goods well. This aggregate hides relatively poor post-sample forecast properties for Beverages and tobacco and Paper and paper products, however. With respect to the aggregate relationship, the in-sample fit is good, but this equation forecasts the 1988-1992 observations poorly compared with the disaggregated system. Hence, while the commodity specific and aggregate equations predict the in-sample development in manufacturing exports equally well, the post-sample forecasting performance clearly favours the disaggregated approach. Also, if we expand the estimation period to cover the period 1988-1992, the estimated price elasticities of the aggregate equation change very much, while this is not the case with respect to the disaggregated system.

**Figure 3.1. Actual and fitted aggregate exports of manufacturing goods, 1988-prices**

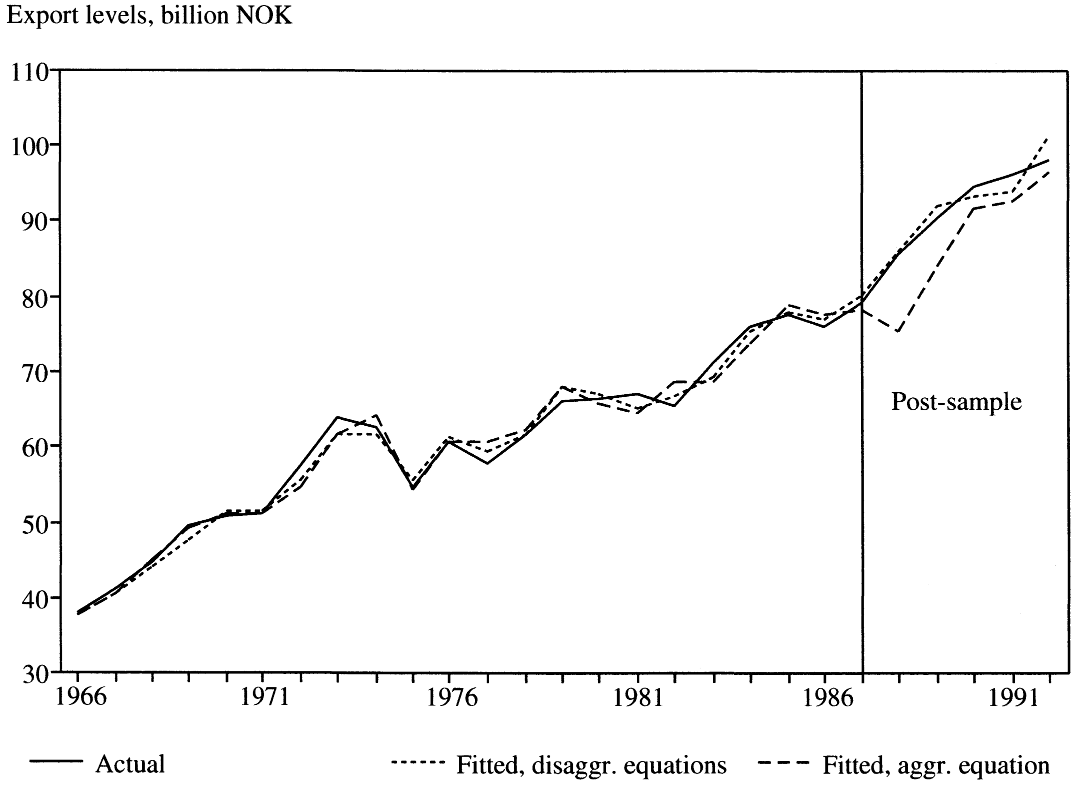
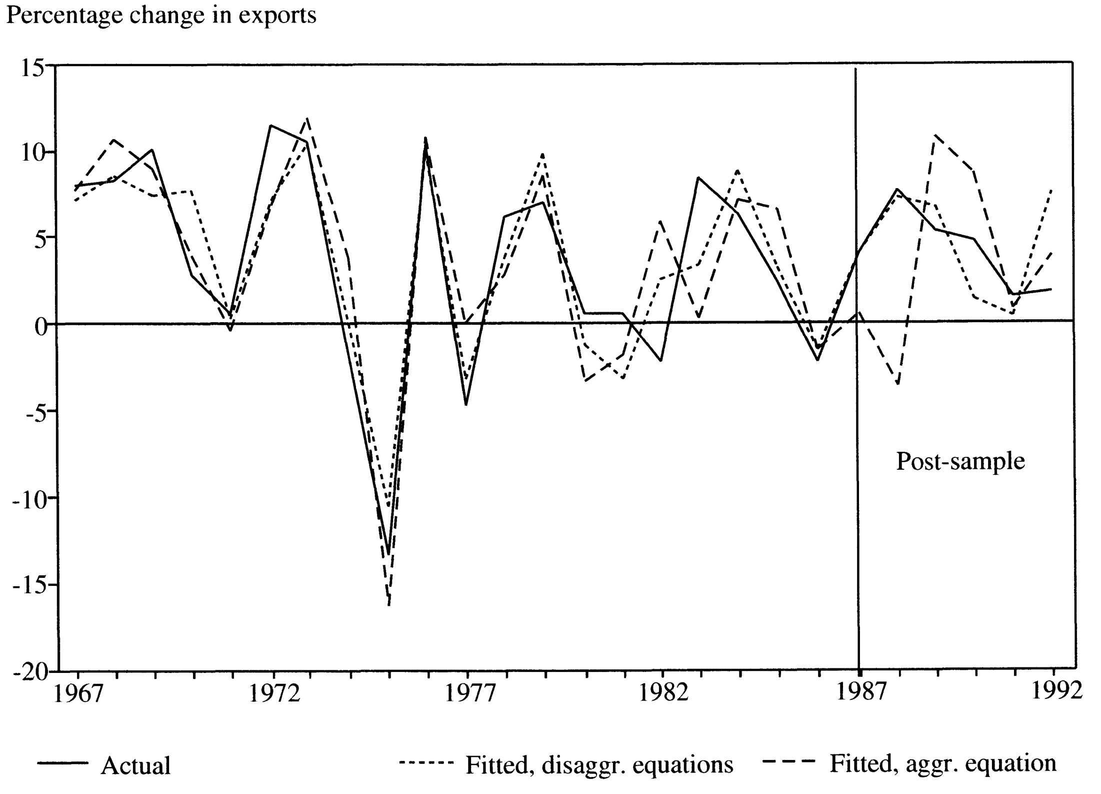


**Figure 3.1. continues**




The poor forecast properties of the aggregate relationship during the late eighties are very much due to a considerable increase in the price of Metals, in particular the price of primary aluminium, which leads to an increase in the relative export price of manufacturing goods. At the same time exports of Metals (aluminium) increased significantly, but the aggregate relationship predicts a decrease rather than increase in exports. According to the estimated equation for Metals, the impact effect of changes in relative prices is zero and the long-run effect is relatively small. Therefore, according to the disaggregated approach, the effect on manufacturing exports of an increase in the price of Metals is modest. This illustrates that changes in commodity specific explanatory variables can give prediction failures and instability in aggregate equations. Before deciding which level of aggregation or disaggregation to choose in empirical analyses, one should study the development in both endogenous and explanatory variables at a disaggregated level if possible. If the development of corresponding disaggregated variables shows important asymmetric variation, this calls for a disaggregated modelling approach.

Table 3.1 presents different measures to illustrate further the prediction properties of the two alternative modelling approaches. The measures are the root mean squared error (RMSE), the root mean squared percent error (RMSPE), the mean error (ME), the mean percent error (MPE) and Theil's inequality coefficient (U), cf. Pindyck and Rubinfeld (1981) and Theil (1961).[5] RMSE and RMSPE measure the deviation of predicted manufacturing exports from its actual values, while ME and MPE measure the bias in prediction errors, i.e. whether the equations systematically over- or underpredict exports. The last measure is RMSE scaled, $0 \leq U \leq 1$. If U=0 there is a perfect fit, and the larger U is, the poorer is the predictive performance of the model.

**Table 3.1. In-sample and post-sample prediction properties**

| | In-sample; 1966-1987 | | Post-sample; 1988-1992 | |
|---|---|---|---|---|
| | Disaggr. equations | Aggregate equation | Disaggr. equations | Aggregate equation |
| RMSE | 12222 | 16178 | 20659 | 57030 |
| RMSPE | 0.020 | 0.025 | 0.022 | 0.065 |
| ME | -1314 | -589 | 4026 | -48380 |
| MPE | -0.003 | -0.001 | 0.004 | -0.054 |
| U | 0.010 | 0.013 | 0.011 | 0.031 |

Table 3.1 shows that the forecasting errors are smaller in the disaggregated system. In addition, while the aggregate equation clearly under-predicts the growth in manufacturing exports over 1988-1992, the disaggregated system only marginally over-predicts the growth.

To test the post-sample goodness of fit of the aggregate equation, we apply the statistic $\xi(f)=SER^{-2}\Sigma_{j=1}^{f} \varepsilon_{T+j}^2 \sim \chi_f^2$, where $\varepsilon_t$ is the forecasting error when applying the estimated model to forecast post-sample, SER is the standard error of the regression in-sample and f is the number of observations in the forecasting period, cf. Harvey (1990, p. 182). We find $\xi(5) = 20.63$, which is clearly significant at the five per cent significance level. According to Harvey this implies that the chosen model is inadequate either due to misspecification or due to a structural brake.

# 4. Conclusions

This paper compares an estimated aggregate export equation with a system where manufacturing exports are divided into eight different sub-groups of goods. Support is found for the hypothesis of national product differentiation, and exports are basically determined by a measure of foreign demand and relative prices.

Important variation in both estimated long-run elasticities and dynamics are found across commodities. As a consequence, the disaggregated approach clearly out-performs the aggregate equation in periods where corresponding explanatory variables develop asymmetric across

[5] RMSE=$[k^{-1} \Sigma_{j=1}^{k} (A_j^F - A_j^A)^2]^{1/2}$; RMSP= $[k^{-1} \Sigma_{j=1}^{k} (A_j^F/A_j^A - 1)^2]^{1/2}$; M= $k^{-1} \Sigma_{j=1}^{k} (A_j^F - A_j^A)$; MPE = $k^{-1} \Sigma_{j=1}^{k} (A_j^F/A_j^A - 1)$; U=RMSE/$\{[k^{-1} \Sigma_{j=1}^{k} (A_j^F)^2]^{1/2} + [k^{-1} \Sigma_{j=1}^{k} (A_j^A)^2]^{1/2}\}$; k is the number of observations in the prediction period, $A^F$ is predicted exports, $A^A$ is actual exports.

commodities and when the share of each commodity in total manufacturing exports change rapidly. When this is not the case, the two alternative approaches perform equally well.

The results illustrate that changes in commodity specific explanatory variables can give prediction failures and instability in aggregate equations. Before deciding which level of aggregation or disaggregation to choose in empirical analyses, one should study the development in both endogenous and explanatory variables at a disaggregated level if possible. If the development of corresponding disaggregated variables shows important asymmetric variation, this provides strong support for employing a disaggregated rather than an aggregate modelling approach.

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