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AN INTERINDUSTRY MODEL OF PRODUCTION AND CONSUMPTION FOR ECONOMIC PLANNING IN NORWAY[1]

by Per Sevaldson

(*Central Bureau of Statistics of Norway*)

I. INTRODUCTION

THE subject of this paper is a discussion of the utilization in Norwegian national budgeting of a detailed interindustry model of production and a set of coefficients of consumption based on Engel elasticities. The practice of Norwegian national budgeting and the application of the model in preparing the budgets for the year 1961 and for the period 1961–5 (the long term programme) is described. The precision of the model is tested by applying it to the periods 1954–7 and 1957–8, and comparing the results with national accounts data for the same periods. Deviations between model estimates and accounts are studied in some detail. A comparative study of estimates for the period 1961–5 on the basis of models of varying degrees of aggregation and actuality is reported in the concluding section of the paper.

II. GOVERNMENT ECONOMIC PLANNING IN NORWAY

A brief account of established methods of government economic planning in Norway in the postwar period will provide a necessary background for our discussion. (An exhaustive account may be found in P. J. Bjerve: *Planning in Norway 1947–1956*, on which I have drawn in the following presentation of the budgeting procedure.) The Government's economic policy plans for the year are set out annually in a national budget, which is presented to the Stortinget (the legislature) in September of the year preceding the budget period. Long-term policy plans have been published for periods of four to five years' length in long-term national budgets. The two types of budgets do not differ much in conceptual framework or methods of preparation. They both give a presentation of the

[1] In the preparation of this paper I have benefited from frequent discussions with my colleague Mr. Arne Amundsen. He and Mr. Odd Aukrust have also read the manuscript and offered valuable comments. The numerical work was carried out in the Central Bureau of Statistics of Norway under the supervision of Messrs. Osmo Forsell, Per Skagseth and Reidar Øines of the Input-Output unit.

Government's forecasts of economic development and its plans for economic policy in the budget period. The forecasts and plans are quantified within the framework of a comprehensive and rather detailed system of national accounts, and they take the national accounts figures for the last year previous to the budget period as their reference basis. Consequently all estimates are quantified in terms of changes in national accounting items from the year preceding the budget period.

The magnitudes which are of particular interest in this system are those which are considered to be pertinent to the Government's welfare judgements, and those which may be considered to be under direct influence by Government actions. Other magnitudes are of interest in so far as they influence the interrelationships between the two former types of parameters. It must be a main target in budgeting to choose those values for the magnitudes that are subject to direct Government control, which through the various reactions in the economy lead to optimal values of those magnitudes which influence social welfare.

If this choice is not going to be arbitrary, it must be based on some assumptions about relationships in the economy; in other words on a model of the economy.

In the earlier budgets only the definitional relationships represented by the accounting framework were explicitly formulated as part of the budgets. Other assumed economic relationships have more or less explicitly and more or less consistently been taken into account in the preparation of various partial budget estimates, and in the final adjustments of budget figures.

The actual preparation of the budget takes the shape of an administrative process, in which a number of Government agencies are active. General directives are issued by the Government, and administrative agencies make up preliminary forecasts and suggestions in the light of these directives and on the basis of detailed information about particular branches of the economy. The preliminary figures are reviewed and adjusted in the National Budget Office in the Ministry of Finance and by the National Budget Committee of the Cabinet. New and more specific directives are issued in the light of the preliminary figures and revised estimates are worked out by the various planning agencies and so on through a number of successive approximations. The whole process might be classified as an 'implicit national budget model' (Bjerve).

Whereas this process has a number of advantages, such as the utilization of specialized information at various administrative levels, and the interest in contributing to the fulfilment of the budgets, evoked in those agencies which have been instrumental in their preparation, it also suffers from obvious imperfections.

Those who work out the details of the partial budgets will have to base their estimates on a number of assumptions about economic trends, economic relationships and economic policy. To a considerable extent these assumptions will be of an *ad hoc* nature, not utilizing to the full extent information which is in fact available.

There is no guarantee that the assumptions about economic trends and economic interrelationships forming the bases of the estimates are mutually consistent, or that assumptions about policies in one field made by an agency in order to estimate the development in another are consistent with the policy actually planned.

There is also a considerable risk that several agencies will expend their resources in the working out of estimates of the same key variables, estimates which they are not particularly well equipped to prepare.

Those who are in the last instance responsible for the co-ordinated budget cannot know on which assumptions the subordinated budget agencies have built their estimates, and are thus not in a favourable position for evaluating these estimates. The entire process is so complicated that a testing of the implications of alternative assumptions concerning economic trends or behaviour seems impracticable and in some respects impossible.

III. ADVANTAGES OF A FORMALIZED BUDGET MODEL

The majority of the merits of the established process may be conserved and a majority of its defaults may be remedied if the conceptual framework is formalized into an economic model. Characteristic of such a model would be that, starting from a list of all the budget variables, all assumed relationships between them would be written out explicitly and be subjected to a critical evaluation on the basis of available theoretical and practical information about the economy. The coefficients would be estimated on the basis of existing statistics. Certainly, some bad

theory and some bad estimating procedures would be eliminated and some useful ones introduced in this process.

It is hardly conceivable that a fully determinated system would be achieved within a reasonable time. A number of variables would have to be determined by more or less intuitive guesses by individuals with specialized knowledge of particular fields of the economy. However, the guesses would be restricted to those variables, to the determination of which the model could not contribute, and all information entailed in the model could be taken into account in the guessing procedure. Further, guesses in various fields might be tested for consistency.

In the construction of a budget model one would be justified in introducing a number of relationships resting on rather weak theoretical and numerical bases, since the only criterium for acceptance or rejection of a relationship would be whether a better process for estimating one of the variables could be substituted for it.

The experiments which are the subject of this paper do not bring us very far towards a fully determinated model for national budgeting in Norway, but they may imply an important step in that direction.

The primary aim of these experiments was to utilize the detailed Norwegian interindustry model of production, and to draw on the knowledge about consumer reactions obtained through extensive consumers' budget surveys. In order to merge the budget variables into the framework of these two sets of data, it was also necessary to specify a number of other relationships. These were, however, formulated and estimated on a rather utilitarian basis, and consisted mainly in the extrapolation of trends and relative magnitudes observed in previous years.

Conferences with participation from the National Budget Office in the Ministry of Finance, the Oslo University Institute of Economics and the Central Bureau of Statistics for the purpose of exchanging information and discussing possibilities for formulating national budget models have been held regularly through several years.

Tentative efforts at utilizing interindustry figures in the budgeting process were made also in earlier years, particularly in the preparation of the annual budgets for 1959 and 1960.

The introduction of the model consequently did not have to

be pressed upon the National Budget Office from the outside. Since the required changes in routines were not too radical, there was also little mental resistance at lower and higher administrative levels, although in the case of the annual budget a 'parallel' budget for the year 1961 was prepared by traditional methods as a sort of check on the model estimates.

The adaption of the administrative staff to thinking in 'model terms' and the corresponding adjustment of the budgeting process, as well as the better knowledge acquired by the model operators in the Central Bureau of administrative needs, is perhaps one of the most important results of the experiments that were carried out.

IV. THE MODEL

Relations:

The model, then, consists of the following parts:

A. An interindustry model of production in 129 sectors of production. This model is, with a few exceptions, in 1954 prices. The coefficients are weighted averages of coefficients for 329 production processes, estimated on the basis of statistics for one or more years in the period 1948–54. Production in 1957 is used as weights. (Detailed information about the interindustry model may be found in: Central Bureau of Statistics of Norway: *Input-Output Analysis of Norwegian Industries 1954*, Oslo, 1960.)

B. A relationship determining the major part (about two-thirds) of private consumption, 'endogenous consumption', as a function either of total wage payments and of entrepreneurial earnings in agriculture, forestry and fishing (the model applied for the annual budget) or of total gross national product (the model applied for the long-term budgets). Some particular items of private consumption, 'exogenous consumption', are not included in endogenous consumption. (See below.)

C. A set of relationships determining endogenous private consumption of goods from each of the sectors of production and import as functions of total private consumption. (These relationships are simply Engel elasticities transformed to absolute form on the basis of 1957 figures.)

D. A set of relationships determining direct final deliveries from each sector of production and import as functions of the deliveries to exports, gross investment and Government

consumption specified by commodity classes. The assumption is simply that the relative composition of sector deliveries to each commodity class is constant and equal to that of 1959.

E. Price indexes, which make it possible to translate figures in current prices to the price system of the model, and to translate figures in 'model prices' back to current prices.

Exogenous variables of the model:

Figures for the following economic magnitudes are exogenous to the model, and must be estimated by independent forecasts in the budget agencies, or by other methods.

A. Exports to foreign countries specified in sixty-eight commodity classes.

B. Gross investment in production capital specified in thirty-two commodity classes.

C. Central Government consumption specified in twenty-four commodity classes.

D. Local government consumption in one item.

E. Total production in sectors where the volume of production is considered to be relatively independent of changes in demand, e.g. because capacity limitations or conditions of nature are held to be decisive. In the annual budget model this group includes thirty-one production sectors, in the long-term budget model it includes twenty-one production sectors.

F. Private consumption of a number of goods ('exogenous consumption') the consumption of which is considered to be relatively independent of income. As typical examples may be mentioned housing and a number of social services, etc., and further, passenger cars and TV sets. The reason for including the two latter items is that rationing on cars was abolished in the fall of 1960 and regular TV programmes were started about the same time, so that a sharp increase in the consumption of these items was expected, irrespective of income developments. In 1957 this group of items represented about 21 per cent of total private consumption.

G. The annual rate of growth of the economically active population.

H. In the model for the annual budget also the following variables were exogenously determined, whereas they were not included in the long-term budget model:

(*a*) The percentage increase in entrepreneurial incomes

in agriculture, forestry and fishing in the budget period.

(*b*) The elasticity of disposable income from wages with respect to total wage incomes.

(*c*) The percentage change in real wage rates in each industry (only given for a very aggregated industry classification). (The change in real wage rates was defined as the change in wage rates corrected for changes in consumer prices.)

(*d*) The percentage change in labour productivity in each industry (given for the same industry classification as the estimates of changes in wage rates).

The model estimates

By the use of the model, estimates are obtained for gross production in each of the production sectors (where production is not estimated independently), total demand of goods from sectors where production is estimated independently, total imports from each import sector and gross national product for each sector in an aggregate specification of forty-three production sectors. Estimates are also obtained for depreciation, and for total wages, total indirect taxes and total subsidies. The three latter items are estimated in 1958 prices, and refer to rates in 1958. The model also gives total private consumption in a specification of thirteen commodity groups. Finally the wage total may be broken down by industry through some additional calculations.

Computations

In preparing the national budget for 1961 it was necessary first to estimate figures for 1960, since national accounts were not available (the year not ended), and since budget estimates should give changes from 1960. Preliminary computations giving 'accounting estimates' for 1960 and budget estimates for 1961 were carried out in the beginning of August. Revised figures were computed at the end of the month, when exogenous estimates had been adjusted, in the light of the preliminary results.

Another revision of the budget estimates for 1961 was made up in January 1961, when preliminary accounts figures for 1960 were available. Even this budget revision was implemented by use of the model.

Also for the long-term budget for the period 1960–5 two

successive 'rounds' of calculations were carried out, the latter round being based on exogenous estimates that were revised in the light of results from the first round. In the first round three alternatives were tested, in the second two. The calculations were carried out on the Central Bureau's electronic computer, DEUCE, and each solution required about four hours on the machine.

Comments on the model

A few remarks on parts of the model are in order:

A. The interindustry model of production is in certain respects provisional. The classification and the estimates of input coefficients for sixty-two of its sectors are based on rather intensive statistical studies, whereas the remaining sixty-seven sectors are accepted at their classification in the national accounts, and input coefficients are computed on the basis of accounting figures for one single year, namely 1954.

All imports are treated as non-competitive, i.e. charged directly to receiving sectors. This means that the model does not allow for any substitution between the use of domestic and foreign intermediate goods in production.

B. The specification of private consumption on deliveries from individual sectors is based only on income elasticities, derived from cross-section data with no allowance for the effects of price changes, in particular with no allowance for substitution between import and domestic goods, and with no accounting for variations over time in the patterns of consumption.

C. The connections between production and total private consumption rest on rather shaky bases. Income is derived from estimates of changes in the volumes of production with no regard to the effects of changes in relative prices, and the income concepts of the model are probably not very well adapted as bases for estimates of consumption.

D. I shall not comment on the more *ad hoc* relationships that were used.

E. The Central Bureau has in the last few years dedicated a considerable amount of work to the construction of a comprehensive set of price indexes for all national accounts items. The present indexes are made up on the basis of price estimates for

about 2,500 items. Nevertheless, the hazards involved in constructing price indexes for the deliveries from 129 domestic sectors and a corresponding classification of imports should not be overlooked.

V. EVALUATION OF THE MODEL

How should the performance of the model be evaluated? Admittedly, the proof of the pudding lies in the eating. But when the dish is made up of so many ingredients of varying quality as the case is here, one should be careful not to reject the 'edible' constituents with the inedible.

A model may be tested by testing individually all the relationships of which it is made up. On the basis of such tests it should in principle be possible to derive conclusions about the precision in the model estimates, and a direct relationship between the precision in individual relationships and model results might be established. Further, the nature and causes of variations in structural parameters could be examined. I believe this is the way we should go in order to achieve the best possible basis for evaluating the input-output model of production. Research for this purpose is at the present being carried out at the Central Bureau of Statistics of Norway, but there is still a good deal of work to cover before results will emerge.

Meanwhile, in assessing what we have attained, and how much there is still to be done, we would be greatly guided by an overall comparison between predicted and realized figures for a reasonably large number of experiments. Since the budgeting periods to which the model has been applied have still not elapsed, this possibility is barred. An overall test of the assumption of the model proper, i.e. all the assumptions apart from the fundamental one, that exogenous parameters can be forecast with sufficient precision, may be obtained by inserting historical values for all the exogenous variables, and by comparing the resulting model predictions with registered historical values. This test may be carried out for the entire model, and it may be applied separately to each part of it. It is also possible to compute how much errors in separate parts of the model have contributed to the total errors. Tests of this type, carried out over a couple of periods, for parts of the model, each consisting of a group of fundamental relationships, may reveal important characteristics of the model, even if full information can be

obtained only through a systematic study of the fundamental relationships themselves.

VI. TESTS OF THE INTERINDUSTRY AND ELASTICITY OF DEMAND RELATIONSHIPS

It was of particular interest to test that part of the model which contained the interindustry relationships and the relationships based on Engel-elasticities of demand. We therefore decided to test this 'central' part of the model separately, and to make independent tests of the other, more roughly formulated parts.

Time shortage made it necessary to restrict the number of test periods to two. We decided to try one period of several years, and one of one year, in order to see to which degree year-to-year disturbances were compensated over a longer period.

Data made the choice of periods within the range 1954 to 1958 most convenient, and we chose 1954–7 and 1957–8. The test then consisted in inserting accounts figures for the changes in final deliveries from each sector of production to exports, gross investments (including inventories), Government consumption, and some items of private (exogenous consumption), and also the accounts figure for the total change in the rest of private consumption (endogenous consumption), and finally the changes in total production in twenty-one production sectors. On the basis of these data we computed the changes in total deliveries of goods and services from each domestic sector of production, the changes in imports, broken down by sector of origin, and the changes in gross product in each sector of production in a forty-five-sector specification. The results were compared with accounting data for the same items. Accounting data were available in constant 1955 prices, so application of the model implied deflation of exogenous data from 1955 prices to 1954 prices, which is the price system of the model. Comparison of model estimates of endogenous variables with accounts implied inflation of these estimates from 1954 prices to 1955 prices.

Before we take a look at the results, it may be well to review the possible sources of error:

A. Errors of measurement. National accounts data are by no means free from errors of measurement. A difference between

accounts and model estimates cannot indiscriminately be ascribed to defaults in the model. Whereas Norwegian national accounts are probably among the most accurate and comprehensive that are produced at present, and whereas the macroeconomic totals are probably estimated with a sufficient degree of accuracy, there are nevertheless considerable uncertainties attached to important groups of individual estimates. In particular, the general revision of the accounts, which has been accomplished recently, was more thorough for the years 1956 and onwards than for earlier years. This may have caused some discontinuities in particular series. It has happened in the past that errors in the national accounts estimates were discovered just because figures for particular years did not check with average input-output coefficients.

Finally, there are some conceptual differences between the terms of the model and the national accounts, and some difficulties have been met in achieving full comparability for certain items.

B. Errors in price indexes. As mentioned earlier, exogenous data are inserted at 1955 prices. These figures are then converted to 1954 prices, and the model estimates are again converted back from 1954 to 1955 prices. The results are compared to changes in national accounts figures which have been deflated to 1955 prices.

The price index for the gross national product increased by about 16 per cent from 1954 to 1958, and the gross national product at 1955 prices increased by only 10½ per cent. A relatively small error in the index numbers may therefore cause a relatively important error in the deflated figures. Total deliveries of goods and services from domestic sectors were 50,800 million kroner in 1957, and an error of one single index point for the total would change this deflated value by 508 million kroner, or 10 per cent of the total change from 1954 to 1957, which was 5,113 million kroner. From 1957 to 1958 the total change was only 60 million kroner. The gross national product in 1957 was 28,400 million kroner, and a 1 per cent error of deflation would mean 284 million kroner, whereas the total change from 1954 to 1957 was 2,650 million kroner and from 1957 to 1958 only 22 million kroner.

C. Errors in the model. 1. Endogenous private consumption was in these tests inserted at its actual value according to the

accounts, so that only the specification on deliveries from domestic and import sectors was decided by the model. The main source of error is probably that the effects of changes in relative prices are not taken into account. Compared to 1954 the consumer price index for food had increased by 13 per cent in 1958, with variations from a fall of 5 per cent for groceries to an increase of 26 per cent for dairy products and eggs. Beverages and tobacco increased by 12 per cent, clothing by only 6 per cent and so on. Not only effects from changes in relative prices, but also the effects of trends in consumer preferences are excluded from income elasticities of demand based on cross-section data.

2. The provisional nature of the coefficients for some of the sectors of production has been pointed out earlier, as well as the unsatisfactory treatment of imports. In this connection it should be pointed out that the imports of intermediate goods in the Norwegian economy amounts to more than a fifth of the gross national product. An error in the production estimate in one sector caused by erroneous coefficients or by changes in import proportions will have repercussions on the production estimates also in other sectors.

Results

On the most aggregated level the model provides an estimate of the division of a given sum of final deliveries between that part which originates from imports and that part which originates from domestic activity. Further it provides an estimate of total domestic production of goods for endogenous private consumption and intermediate use (use in production). (Domestic production for other final uses is exogenously given.)

The results for the two test periods were as shown in Table I on page 35.

We find that compared to the absolute levels of 1957 a 9·4 per cent change in the gross domestic product is predicted with an error of 0·4 per cent points and a 0·1 per cent change is predicted with an error of 0·5 per cent points. A 10·7 per cent change in the estimated part of imports is predicted with an error of 2·3 per cent points and a 1·9 per cent change is predicted with an error of 1·1 per cent points. A 7·9 per cent change in domestic production for private consumption and intermediate use is predicted with an error of 1·5 per cent points and a 1·0 per cent change with an error of 0·1 per cent points. That we should

come out so favourably is quite remarkable in view of the simple and unsatisfactory treatment of imports into production and of consumer behaviour in this model.

TABLE I

Gross national product, import and domestic production of goods for private consumption and intermediate use according to national accounts and model estimates. Million kroner at 1955 prices

	Absolute level	Changes 1954–7			Changes 1957–8		
		Accounts	Model	Difference (2)–(3)	Accounts	Model	Difference (5)–(6)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Gross national product	28,168	2,651	2,540	111	27	163	−146
Deliveries from 21 production sectors[1] to private consumption and intermediate use	3,073	302	292	10	−82	−100	18
Imports for endogenous private consumption and intermediate use	8,166	872	1,060	−188	158	69	89
Sum (= given total)[2]	39,407	3,825	(3,892)	(−67)	103	(132)	(−39)
Domestic production of goods for private consumption and intermediate use	26,033	2,045	1,661	384	−256	−203	−53

[1] The 21 sectors, for which total production is estimated exogenously.
[2] The items in parentheses reveal a statistical discrepancy introduced through deflation and inflation.

The results at this level may be compared to the outcome of computations with a rough macroeconomic regression model, giving gross national product, imports and private consumption as functions of total exports and of the sum of gross investment and Government consumption. The coefficients of this model were estimated on the basis of national accounts figures for the period 1949–60.

(If we have:

X_1 = gross national product,
X_2 = total imports,
X_3 = private consumption,

I = gross investment plus government consumption,
A = total exports,
all in million kroner, then the model takes this form
$\log X_i = a_i \log I + b_i \log A + c_i$ (i = 1, 2, 3).

The estimates of the coefficients are

	i = 1	2	3
a_i	0·44 (0·10)	0·56 (0·25)	0·33 (0·21)
b_i	0·31 (0·06)	0·46 (0·14)	0·24 (0·11)
c_i	1·38	−0·09	1·88
r_i	0·997	0·991	0·979

r_i is the coefficient of multiple correlation and the figures in parentheses are the standard errors.

(We shall not discuss the theoretical merits of this model, which was computed by Mr. Arne Amundsen for special purposes.)

The estimates by this model are presented in Table II.

The estimates for gross national product and imports are not significantly better in the regression model than in the inter-industry model for the period 1954–7, although this period includes three of the twelve years on which the estimates of regression coefficients are based. For the one-year period 1957–8 the interindustry model gives better estimates than the regression

TABLE II

Gross national product, imports and private consumption according to national accounts and estimates by regression model. Million kroner at 1955 prices

	Changes 1954–7			Changes 1957–8		
	Accounts	Model 57 minus accounts 54	Model 57 minus model 54	Accounts	Model 58 minus accounts 57	Model 58 minus model 57
Gross national product	2,661	2,525	2,633	27	187	323
Deviations from accounts figures	—	−136	−28	—	160	296
Imports	1,589	1,933	1,556	391	541	197
Deviations from accounts figures	—	344	−33	—	150	−194
Private consumption	1,148	1,957	1,180	20	952	143
Deviations from accounts figures	—	809	32	—	932	123

model. This should, of course, not be surprising, since the interindustry model utilizes much more information than the regression model.

The results in the interindustry model for the gross national product broken down into four broad industrial groups are given in Table III. The fit of these four sectors is still on the average around one percentage point of the absolute level (in 1957).

As we go to finer sector breakdowns the deviations between accounts and model increase in relative magnitude.

In Table IV we have set off the average numerical value of the deviations between accounts and model against the average numerical value of the changes in gross national product per sector at varying levels of aggregation. We see that the average deviations increase from 11 per cent of the average numerical change in a four-sector specification to 31 per cent in a forty-two-sector specification for the three-year period, and from 47 per cent to 62 per cent for the one-year period.

TABLE III

Gross national product by industrial sector according to national accounts and model estimates. 1955 prices

	Absolute level 1957	Changes 1954–7			Changes 1957–8		
		Accounts	Model	Difference (2)–(3)	Accounts	Model	Difference (5)–(6)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(Million kroner)							
Extractive industries	3,788	171	105	66	−202	−54	−148
Manufacturing	6,889	688	778	−90	−64	−53	−11
Trade and transportation	9,411	1,226	1,087	139	80	124	−44
Other	8,080	566	571	−5	209	149	60
Total	28,168	2,651	2,541	110	23	166	−143
Average numerical value of deviations		664		75	139		66
Per cent of total 1957:							
Extractive industries	100·0	4·5	2·8	1·7	−5·3	−1·4	−3·9
Manufacturing	100·0	10·0	11·3	−1·3	−0·9	−0·8	−0·1
Trade and transportation	100·0	13·0	12·2	1·2	0·9	1·3	−0·4
Other	100·0	7·0	7·0	−0·1	2·6	1·8	0·8
Total	100·0	9·4	9·0	0·4	0·1	0·6	−0·5
Average numerical value of deviations		8·7		1·1	2·5		1·4

TABLE IV

Gross national product per sector. Average numerical values of changes according to the national accounts and of deviations between accounts and estimates by the model

	Changes 1954–7			Changes 1957–8		
	Accounts	Accounts minus model	(2) in per cent of (1)	Accounts	Accounts minus model	(5) in per cent of (4)
	(1)	(2)	(3)	(4)	(5)	(6)
Gross national product total	2,651	109	4·1	23	143	621·7
Average per sector in a specification of:						
4 sectors	664	75	11·3	139	66	47·4
7 sectors	395	56	14·2	121	60	49·8
30 sectors	97	25	25·8	38	21	56·3
42 sectors	72	22	30·8	30	19	61·5

We might also have computed the gross national product in each of the 129 production sectors, but this was not done. Instead we may investigate the deviations between model and accounts for the estimates of domestic production and imports of intermediate goods and consumer goods. (It will be remembered that, whereas the total deliveries to endogenous private consumption is exogenously given, the breakdown by sector of origin is estimated by means of the model)

Again looking at the average numerical deviations we get the following picture:

TABLE V

Domestic production of intermediate goods and goods for 'endogenous' private consumption. Average numerical value per sector of changes according to the national accounts and of deviations between accounts and estimates by the model. Million kroner at 1955 prices

	Changes 1954–7			Changes 1957–8		
	Accounts	Accounts minus model	(2) in per cent of (1)	Accounts	Accounts minus model	(5) in per cent of (4)
	(1)	(2)	(3)	(4)	(5)	(6)
Total	2,045	384	18·8	−256	−53	20·7
Average per sector in a specification of:						
4 sectors	511	177	34·6	166	160	96·5
7 sectors	292	90	30·9	95	94	98·9
31 sectors	72	40	55·7	27	28	106·7
45 sectors	51	31	60·2	20	21	106·0
129 sectors	22	16	75·5	9	10	108·2

TABLE VI

Imports of intermediate goods and goods for 'endogenous' private consumption. Average numerical value per sector of origin of changes according to the national accounts and of deviations between accounts and estimates by the model. Million kroner at 1955 prices

	Changes 1954–7			Changes 1957–8		
	Accounts	Accounts minus model	(2) in per cent of (1)	Accounts	Accounts minus model	(5) in per cent of (4)
	(1)	(2)	(3)	(4)	(5)	(6)
Total	872	−188	−21·6	158	89	56·3
Average per sector of origin (abroad) in specification of:						
4 sectors of origin	198	63	31·8	43	35	81·9
7 sectors of origin	113	60	53·4	29	27	92·9
25 sectors of origin	46	28	61·0	16	12	79·8
76 sectors of origin	20	16	78·7	9	7	82·1

For the three-year period, with an average change in domestic deliveries to private consumption and intermediate use of 21·6 million kroner per sector in the 129-sector specification, there were fifteen errors of more than 40 million kroner and sixty-three of less than 10 million kroner. For the one-year period with an average change of 9 million kroner, there were seventeen errors of more than 20 million kroner and ninety-two of less than 5 million.

As one would expect, there appeared to be a strong correlation between the absolute magnitudes of changes in the observed values and the deviations between observations and model estimates, whereas on the average the relative magnitudes of deviations decreased with increasing changes.

How we will evaluate the performance of the model in predicting the changes in these more detailed specifications must depend on which expectations we start out with, or which standards of comparison we do possess. As a simple alternative we may test the assumption that deliveries of goods for endogenous private consumption from each sector of origin varies in the same proportion as total endogenous private consumption, and that interindustry deliveries from each sector vary in the same proportion as final deliveries from the same sector. The outcome of this test for the 129-sector specification gives errors with an average numerical value of 35·9 million kroner or 165 per cent of the average change for the period 1954–7.

VII. LOCATION OF ERRORS

Even if we are quite satisfied with the precision of the results on an aggregated level, the fact remains that there are some rather bothersome deviations between model and accounts in the details and it is of interest to try to locate their origin.

(*a*) *Specification of private consumption.*

We first turn our attention to the specification of endogenous private consumption. Comparing model estimates with changes according to national accounts, we obtain the following results when we consider varying breakdowns by sectors of origin.

TABLE VII

Deliveries to private consumption by sector of origin. Average numerical value of changes and deviations. Million kroner at 1955 prices

	Changes 1954–7			Changes 1957–8		
	Accounts	Accounts minus model	(2) in per cent of (1)	Accounts	Accounts minus model	(5) in per cent of (4)
	(1)	(2)	(3)	(4)	(5)	(6)
Total (given)	866	—	—	−76	—	—
Imports	181	−3	−1·7	49	+65	−132·7
Domestic sectors	785	+3	0·4	−125	−65	−52·0
Average per sector of origin in a specification of:						
4 sectors of production (irrespective of geographical origin)	224	68	30·5	45	27	58·5
34 domestic sectors and 30 import sectors	16	10	64·5	6	5	91·2
91 domestic sectors and 49 import sectors	9·1	6·8	74·5	2·9	2·9	100·3

Total deliveries to endogenous private consumption in 1957 were 12,300 million kroner, so the changes were of the order of 7 per cent and less than 1 per cent respectively. In the most detailed sector specification the range of changes for the three-year period was between −29 million kroner and +107 million kroner, except for one item (Trade) of +223. The maximum

value of the deviations for the same period was 99 million kroner (and the next in order 80 million kroner). For the one-year period the range of changes was from −44 million kroner to +25 million kroner, with a maximum deviation of 26 million kroner.

The accounts figures show very uneven distributions of changes. From 1954 to 1957, 49 per cent of the total numerical value of the changes were accounted for by seven items of each more than 40 million kroner change in sector deliveries; and from 1957 to 1958, 35 per cent of the total change was accounted for by six items of each more than 15 million kroner. The errors incurred in predicting these large changes accounted for 28 per cent of the errors for the period 1954–7 and 29 per cent of the errors for the period 1957–8. Available price indexes indicate a slight negative correlation between changes in relative prices and the direction of extreme changes in the accounts, but they do not seem to explain these changes entirely. Further investigations, *e.g.*, into the accuracy of the deflated accounts figures would be required in order to decide the causes of these extreme changes.

(*b*) *The interindustry model of production.*

If we consider all final deliveries from each sector as given, we get a test of the interindustry model of production alone. Such a test was carried out for the period 1954–7. The results are summarized in the following tables:

TABLE VIII

Gross national product, import and domestic production of goods for intermediate use (use in production) according to national accounts and model estimates. Million kroner at 1955 prices

	Absolute level 1957	Changes 1954–7		
		Accounts	Model	Difference (2)–(3)
	(1)	(2)	(3)	(4)
Gross national product	28,168	2,651	2,567	84
Deliveries to intermediate use from 21 production sectors	2,752	215	194	21
Imports of intermediate goods	6,380	694	882	−188
Domestic production of intermediate goods	16,024	1,363	1,053	290

TABLE IX

Gross national product by industrial sector according to national accounts and model estimates. Million kroner at 1955 prices

	Absolute level 1957	Changes 1954–7		
		Accounts	Model	Difference (2)–(3)
	(1)	(2)	(3)	(4)
Extractive industries	3,788	171	171	—
Manufacturing	6,889	688	757	−69
Trade and transportation	9,411	1,226	1,103	123
Other	8,080	566	536	30
Total	28,168	2,651	2,567	84
Average numerical value of deviations		663		56

TABLE X

Gross national product per sector. Average numerical value of changes according to the national accounts and of deviations between accounts and estimates by the model

	Changes 1954–7		
	Accounts	Accounts minus model	(2) in per cent of (1)
	(1)	(2)	(3)
Gross national product, total	2,651	84	3·1
Average per sector in a specification of:			
4 sectors	663	55	8·3
7 sectors	395	46	11·6
30 sectors	97	21	21·4
42 sectors	75	19	24·9

TABLE XI

Domestic production of intermediate goods. Average numerical value per sector of changes according to the national accounts and of deviations between accounts and estimates by the model. Million kroner at 1955 prices

	Changes 1954–7		
	Accounts	Accounts minus model	(2) in per cent of (1)
	(1)	(2)	(3)
Total	1,363	290	21·3
Average per sector in a specification of:			
4 sectors	341	130	38·0
7 sectors	195	65	33·3
31 sectors	49	29	59·0
45 sectors	36	23	64·4
129 sectors	16	13	78·7

TABLE XII

Import of intermediate goods. Average numerical value per sector of origin of changes according to the national accounts and of deviations between accounts and estimates by the model. Million kroner at 1955 prices

	Changes 1954–7		
	Accounts	Accounts minus model	(2) in per cent of (1)
Total	694	−188	−27·0
Average per sector of origin (abroad) in a specification of:			
4 sectors of origin	205	49	24·0
7 sectors of origin	132	57	43·0
25 sectors of origin	42	22	52·0
76 sectors of origin	18	11	61·0

TABLE XIII

Domestic production of intermediate goods. Average numerical value per sector, of changes according to the national accounts and of deviations between accounts and estimates by the model. 129 sectors grouped according to the size of registered changes. Million kroner at 1955 prices

	Changes 1954–7		
	Accounts	Accounts minus model	(2) in per cent of (1)
	(1)	(2)	(3)
Average per sector for all 129 sectors	16·1	12·7	78·7
12 sectors with changes over 40 million kroner	75·4	41·8	55·4
21 sectors with changes 20–39·9 million kroner	29·4	27·1	92·2
25 sectors with changes 10–19·9 million kroner	14·7	12·8	87·3
71 sectors with changes 0–9·9 million kroner	2·7	3·5	129·3

Whereas the model appears to give quite good estimates of changes in the gross national product (cf. Table X), the results are not equally encouraging when we look at the estimates of intermediate deliveries from the production sectors in the more detailed sector specifications (cf. Table XI). Table XIII shows that in the 129-sector specification the greatest changes are estimated with the relatively best precision. In absolute value there are only twenty-seven errors of more than 20 million kroner in the 129-sector specification and they account for 63 per cent of the average error, fifteen of these errors are over 30

million kroner, and these alone account for nearly half the average error (46 per cent). If we could reduce the fifteen largest errors to the same average magnitude as the rest, the average would be only 7·8 million kroner instead of 12·7 million, and if we could reduce all the twenty-seven largest errors correspondingly the average would be only 5·8 million kroner.

A preliminary study of the fifteen sectors with the largest errors brings out that of these one is iron and steel works, where the entering into production of a large new plant has led to the substitution of domestic production for imports; three more of these sectors also belong to the group of metal-working sectors, a group in which there are particular problems of obtaining consistency between input-output estimates and national accounts figures. Two, possibly three, of the sectors are affected by the structural change from textiles to plastics as raw materials in many industries. One sector is electricity and is affected by a structural change from coal and oil to hydro-electricity as source of energy; one sector is trade, which is given a very inadequate treatment in the present model, and where the change is particularly great. One sector delivers its products (fertilizers) mainly to agriculture, where we do not expect to find very stable coefficients and two sectors are in the group of four 'unspecified sectors' of the model (for these four sectors taken together the error is only 10·6 million kroner).

Further investigations of the deviations between accounts and model are required, but the conclusion appears to be warranted that the important deviations are due to very special causes, related either to very specific structural changes in the economy, to particular weak spots in the model or to the difficulty of bridging conceptual differences between the national accounts and the model. We also know that unsatisfactory treatment of imports and index problems constitute important sources of error. If these conclusions can be substantiated by further research, I feel that the outcome of our tests is very encouraging for further experiments with input-output models.

VIII. STUDIES OF AGGREGATION

The tests that were reported in the preceding sections all concerned comparisons at various levels of aggregation between forecasts by one and the same 129-sector model and accounting figures. A test of a somewhat different nature was carried out by

comparing the forecast by the 129-sector model for the plan period 1960–5 to forecasts obtained from models with more aggregate sector specifications, some based on data for 1954 and one on older data. This test may throw some light on questions like these:

How does aggregation in the sector specification of the model affect the estimates by interindustry models, and what are the implications of coefficient changes?

Even these questions can only be answered through systematic studies. A 'case study' may, however, bring out some characteristics of the problem. In our experiment we applied the exogenous estimates of the long-term budget for the period 1960–5 to a set of models deviating from the budget model only in the degree of sector specification and base year for the computation of coefficients.

We tried the following models:

1. A model with forty-five sectors of production (the sectors corresponding to those for which gross national products are specified in the budget model) with coefficients based on 1954 accounts.

2. A model with thirty-one sectors of production and with coefficients based on 1954 accounts.

3. A model with seven sectors of production, and with coefficients based on 1954 accounts.

4. A model with five sectors of production and with coefficients based on 1954 accounts, but computed on the basis of values in 1955 prices.

5. A model with thirty-one sectors of production and based on 1948 accounts and computed on the basis of values in 1948 prices. The sector specification of this model did not correspond in detail to the thirty-one sectors specification in the 1954 matrix.

In addition to the interindustry models we also inserted the data for total exports and total gross investment and Government consumption in the crude macroeconomic regression model mentioned earlier, which gives gross national product, imports and private consumption as functions of total exports and of the sum of gross investment and Government consumption.

The results of our comparisons are summarized in Tables XIV and XV.

TABLE XIV

Estimates of changes 1960–5 in gross national product, imports and endogenous private consumption by models with varying numbers of sectors of production. Figures in million kroner at 1954 prices

		Total 1960	Interindustry models						Regression model	
Coefficients based on data for:			1948–57	1954	1954	1954	1954	1948	Estimate 1965 minus accounts 1960	Estimate 1965 minus estimate 1960
Numbers of sectors in the model:			129	45	31	7	5	31		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. Gross national product	million kr.	30,417	6,236	6,655	6,640	6,751	6,569	6,661	4,278	4,705
In per cent of A col. (2)			100·0	106·7	106·5	108·3	105·3	106·8	68·6	75·4
B. Imports	million kr.	9,781	2,675	2,591	2,584	2,495	2,618	2,425	3,002	3,056
In per cent of B col. (2)			100·0	96·9	96·6	93·3	97·9	90·7	112·2	114·2
C. Endogenously determined private consumption	million kr.	13,071	2,185	2,354	2,357	2,373	2,326	2,500	1,221	909
In per cent of C col. (2)			100·0	107·7	107·9	108·6	106·5	114·4	55·9	41·6

TABLE XV

Estimates of changes in gross national product 1960–5. Average numerical value per sector by the 129 sector interindustry model and average numerical value of deviations from these estimates in estimates by alternative models. Figures in million kroner at 1954 prices

		Total 1960	Estimated changes 1960–5	Estimates by aggregated models. Deviations from estimates by the 129 sector model				
Coefficients based on data for:			1948–57	1954	1954	1954	1954	1948
Number of sectors in the model:			129	45	31	7	5	31
Gross national product, total	million kroner	30,417	6,236	419	404	515	333	425
	per cent		100·0	6·7	6·5	8·3	5·3	6·8
Average per sector in a specification of:								
5 sectors	million kroner	6,083	1,247				170	
	per cent		100·0				13·6	
7 sectors	million kroner	4,345	891	60	58	87		75
	per cent		100·0	6·7	6·5	9·8		8·4
24 sectors	million kroner	1,267	260	23	24			36
	per cent		100·0	8·8	9·2			13·8
30 sectors	million kroner	1,014	208	19	21			
	per cent		100·0	9·1	10·1			
43 sectors	million kroner	707	146	15				
	per cent		100·0	10·3				

As regards the macroeconomic totals there is relatively close correspondence between the various input-output models, with all estimates except one within a range of 10 per cent of the changes estimated by the most detailed model, which themselves are of the order of 20–30 per cent. We also note that all the aggregated models give estimates exceeding the most detailed model for gross national product and consumption, and falling short for imports. We have not yet looked into the reasons for this.

The relatively large discrepancy between the results of inter-industry models and those of the regression model is due partly to the fact that some of the exogenous information utilized in the input-output models cannot be used in the regression model; in particular this applies to the exogenous estimates of direct imports to gross investment and Government consumption.

Examining the breakdowns by industrial sectors of the gross national product estimates of the various models, we notice that the deviations from the estimates according to the most detailed model increase as we move from models with a greater to models with a smaller number of sectors, and the deviations also increase with increasing detail in the sector breakdown for the same model.

The deviations are dominated by a few extreme values, but are on the average not appalling for any of the models. The extreme deviations are found particularly in the estimates for trade and inland transportation.

One reason for the relatively close correspondence between estimates resulting from models with varying sector detail is obviously that we have tested a programme of relatively smooth development in all deliveries. Programmes of more extreme composition would certainly give more serious deviations. As an example the following results of a computation of the effects in the various models of a 100 million kroner increase in final deliveries from sawmills may serve:

TABLE XVI

Effects of a 100 million kroner increase in final deliveries from sawmills. Million kroner at 1954 prices

	Estimates on the basis of model with		
	129 sectors	45 sectors	31 sectors
Gross national product	1,032	1,140	1,097
Imports	176	191	232
Private consumption	300	357	343
Production in forestry	494	536	291

We note especially the discord in the results for production in a particular sector, forestry.

IX. SUMMARY OF FINDINGS

(1) The model makes use of a much larger amount of information than a simple regression model, and it turns out more accurate results for the national account totals than does the regression model.

(2) Nevertheless, in year-to-year predictions the errors in the model estimates easily attain the same order of magnitude as the actual changes.

(3) Over a three-year period the relative magnitudes of the errors are reduced to a considerable degree.

(4) The relative magnitudes of the errors increase as we examine increasingly detailed sector specifications in the model forecasts.

(5) The relative magnitudes of the errors are less for the estimates of gross national product than for the estimates of intermediate deliveries at corresponding levels of specification in the model forecasts.

(6) The method of 'final demand blow-ups', which is sometimes suggested as a simple alternative to the input-output technique falls short of this technique by a very great margin. A hypothesis of no change appears to be a much closer contestant.

(7) The errors in model forecasts originating from the coefficients of private consumption are of approximately the same relative order of magnitude as the errors for the model as a whole.

(8) The model in particular fails to predict the large changes in deliveries to private consumption.

(9) It is our guess that some of the shortcomings of the model as concerns private consumption are due to its failure to account for the effects of changes in relative prices, and of structural changes in consumer preferences.

(10) For the interindustry model alone we find that the precision at all levels of aggregation of forecasts is better than for the combined interindustry-consumption model.

(11) The improvement is, however, not spectacular and particularly in the forecasts of intermediate deliveries there are some extreme shortcomings.

(12) A preliminary investigation suggests that the extreme deviations between forecasts and observations are in general related to special changes in the structure of particular production sectors or in the use of particular products or to changes in the market proportion between domestic production and imports, changes which the present model is not equipped to take into account.

(13) The comparative study of more and less detailed and more and less accurate models indicates that the gain in accuracy resulting from application of a detailed interindustry model can only be of moderate size (of the order of 10 per cent of the expected change), and on a very aggregate level, the main difference appears to be between the very detailed model on one hand and all the other more or less aggregated models on the other.

(14) One reason for the relatively close correspondence between the aggregated and the detailed model is that we have considered a programme which does not depart very radically from a proportionate change in all exogenous variables. Extreme disproportionalities in the assumed development in exogenous values would give greater discrepancies between aggregated and detailed models.

(15) It goes without saying that detailed forecasts can only be obtained from a detailed model.

My personal conclusion from the tests reported is that we find encouragement for further research aimed at improvements and utilization of the detailed interindustry budget model, and that even in cases where accurate and detailed models are not at hand, rough, aggregated models may turn out to be very useful.