EDUCATED MANPOWER BEHIND NORWAY'S EXPORTS, DOMESTIC CONSUMPTION, AND INVESTMENT*

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This paper contains some of the main results of an investigation into the use of educated manpower in Norwegian industries. An input–output model with labour inputs specified by education is presented. Per unit of final delivery, Norwegian exports in 1960 used relatively less labour, and less educated labour, but more capital (measured by depreciation) than the other categories of final demand. But when the use of labour is compared to the income created by the final deliveries, the differences are much smaller.

1. INTRODUCTION

In most economic models, manpower is treated as a homogeneous factor of production, and is often measured in number of man-years or man-hours. If one is interested in estimating the requirements for manpower with a particular education, such an aggregative approach is obviously not adequate. Furthermore, if one tries to trace the causes behind economic growth, it is probably of great importance to take into account the educational composition of the labour force, cf. the debate about "the unexplained residual".

What one really is seeking in this field is production functions where labour with different types of education enters explicitly, so that one may derive the marginal productivity of each type of labour, the elasticities of substitution between different labour categories, etc. However, so far, very limited progress has been made in this field.

Our purpose in this investigation is to take a small step in the direction of describing the relationships between the output of the industries and their use of different types of educated manpower. We do this, i.a., by describing how the economically active population in Norway in 1960, specified in 14 educational categories, was distributed among the different industries.[1] On the basis of our model and our data we try to answer the following questions:

(1) How many economically active persons, by education, were "behind" one million crowns (Norwegian crowns) of final delivery from each industry?
(2) How many economically active persons, by education, were "behind" each main category of final demand (exports, private consumption,

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[1]A more comprehensive report on the investigation is Thonstad/Kobberstad (1971), to be completed later this year.

etc.)? In particular, how much educated labour was used per unit of exports, consumption, and investment, delivered from Norwegian industries?

In this paper, which reports on only part of the investigation, we shall in particular deal with (2). It is, for example, of interest to know whether Norwegian exports is what one might call an "intelligence industry", and whether it is labour- or capital-intensive compared to the other categories of final demand. In this connection, we shall briefly try to compare our results for Norway with similar results for the United States obtained by Leontief,[2] cf. the so-called "Leontief paradox".

2. Input–Output Model with Labour Inputs Specified by Education

We shall use an input–output model of the simplest type, but we extend it by treating each type of educated labour as separate inputs, instead of treating labour as only one factor of production. We use the following symbols:

X_i = output of Industry i
S_i = total final delivery from Industry i (for exports, consumption and investment)
N_{ej} = number of economically active persons with Education e in Industry j
N_e = total number of economically active persons with Education e (all industries).

In our empirical analysis, we classify into 14 educations and 30 industries. Output, deliveries of inputs, and final deliveries are measured in a set of fixed prices, in millions of Norwegian crowns.

The number of economically active persons with Education e is:

$$N_e = \sum_{j=1}^{30} N_{ej} \qquad (e = 1, \ldots, 14). \tag{3}$$

Total output of Industry i equals total deliveries to other industries plus final delivery. We assume, as in the traditional input–output models, that deliveries of inputs stand in a fixed proportion to the output of the receiving industries, and let a_{ij} represent the required delivery from Industry i to Industry j per unit of output in the latter industry. Consequently, we use the familiar input–output system:

$$X_i - \sum_{j=1}^{30} a_{ij} X_j = S_i \qquad (i = 1, \ldots, 30). \tag{4}$$

All a_{ij} are assumed to be non-negative, and $\sum_{i=1}^{30} a_{ij} < 1$ for all j.[3] It is then possible to express the X'es (outputs of each industry) by the S'es (the final

[2]Leontief (1953) and (1956).

[3]These conditions ensure the existence of a non-negative inverse matrix $(I-A)^{-1}$. See p. 118 in Hadley (1965).

deliveries from each industry):

$$X_i = \sum_{j=1}^{30} h_{ij} S_j \qquad (i = 1, \ldots, 30). \tag{5}$$

The coefficients h_{ij} are the elements of the matrix $(I-A)^{-1}$, where I is the unity matrix of order 30, and A is the matrix of input–output coefficients a_{ij}. The coefficient h_{ij} can be interpreted as output in Industry i per unit of final delivery from Industry j.

For 1960, we observe the ratio (to be denoted ϕ_{ei}) between the number of economically active persons with Education e in Industry i, and the output of that industry (in millions of crowns):

$$\phi_{ei} = \frac{N_{ei}}{X_i}. \tag{6}$$

We do not claim that the ϕ-s will remain fixed over time. We do assume, however, that all deliveries from an industry in 1960 were homogeneous in the sense that they directly and indirectly required identical amounts of each type of educated labour per unit delivered.

Introducing the solution (5) for X_i into (6) yields:

$$N_{ei} = \sum_{j=1}^{30} (\phi_{ei} h_{ij}) S_j \qquad (e = 1, \ldots, 14; i = 1, \ldots, 30). \tag{7}$$

Here the use of e-educated labour in Industry i is expressed as a function of the final deliveries from the different industries. Summing this expression over industries, yields:

$$N_e = \sum_{j=1}^{30} \phi^*_{ej} S_j \qquad (e = 1, \ldots, 14), \tag{8}$$

where

$$\phi^*_{ej} = \sum_{i=1}^{30} \phi_{ei} h_{ij}. \tag{9}$$

The total use of educated labour of type e is here expressed as a linear function of the final deliveries from the different industries. The derived coefficient ϕ^*_{ej} gives the total (direct and indirect) use of e-educated labour in all industries per million crowns of final delivery from Industry j, cf. (1).

Let us finally write down a formula for educated labour of each type incorporated in broader categories of final deliveries. Suppose that per unit of private consumption,[4] δ_j units of final delivery are supplied by Industry j, where the sum over all δ's equals unity. Using (8) and (9) shows that the use of labour of type e per unit of private consumption is given by, cf. (2):

$$\sum_{j=1}^{30} \sum_{i=1}^{30} \phi_{ei} h_{ij} \delta_j \qquad (e = 1, \ldots, 14). \tag{10}$$

[4]We consider only deliveries from Norwegian industries.

The computations to follow are based on estimates of the input–output coefficients a_{ij}, and the ratios ϕ_{ei}, derived from Norwegian data for 1960. The data and their shortcomings are described in the appendix. It should be stressed that the data on the economically active population, by industry and education, are not quite well fitted for our purposes, and probably subject to fairly large errors (see the appendix).

3. The Results

We have obtained a large number of rather interesting results about the manpower requirement of each industry, showing that some are typical "intelligence industries" and others not. We find that in Public production, 66 per cent had some sort of vocational training, in Electricity supply 44 per cent, in Shipping 37 per cent, etc. At the other end of the scale we find that only 11 per cent of the labour force in Forestry had vocational training, and only 9 per cent in Fishing.

We shall, however, concentrate our attention upon the results for the main categories of final demand. Detailed results for each of the 14 educational categories are presented in Table 4 in the appendix. In order to limit the size of

Table 1

Economically Active Population, by Level of Education, and Type of Final Delivery[a]

Educations \ Final Delivery	Private Consumption	Public Consumption	Investment	Exports	All Types of Final Delivery
Number of persons					
University training	14,059	14,129	4,074	4,846	37,108
Vocational training	148,819	60,809	77,530	74,873	362,031
Only general training	452,730	64,635	254,835	229,750	1,001,950
Total	615,608	139,573	336,439	309,469	1,401,089
Percentage distribution, by education					
University training	2·3	10·1	1·2	1·6	2·6
Vocational training	24·1	43·6	23·1	24·2	25·8
Only general training	73·5	46·3	75·7	74·2	71·5
Total	99·9	100·0	100·0	100·0	99·9
Percentage distribution, by type of final delivery					
University training	37·9	38·1	11·0	13·1	100·1
Vocational training	41·1	16·8	21·4	20·7	100·0
Only general training	45·2	6·5	25·4	22·9	100·0
All educations	43·9	10·0	24·0	22·1	100·0

[a]The upper part of the table gives the number of persons of each type directly or indirectly occupied with producing a given type of final delivery.

the tables we shall here classify education into only three broad categories, viz. University training, "Only general training", and the rest is lumped together and called "Vocational training". Note that the category "Only general training" comprises education at several levels, including elementary, secondary and advanced secondary education.

Table 1 gives the number of economically active persons of each type "behind" each of the four main components of the national product. Percentage distributions are also given, by education and by type of final delivery.

Table 1 shows that of the total economically active population of about 1·4 millions, as much as 616,000, or about 44 per cent, were directly and indirectly occupied with producing goods for private consumption. Only 10 per cent were occupied with producing goods for public consumption, while the corresponding figures for investment and export were 24 per cent and 22 per cent, respectively.

For University training, the picture is different. Of particular interest is that public consumption, occupying only 10 per cent of the total number of economically active persons, occupied 38 per cent of the university trained people. One of the reasons for this is, of course, that almost all educational activity is counted as public consumption.

The bottom line of Table 4 of the appendix shows how much labour was used directly and indirectly per million crowns of each type of final delivery. Exports used in 1960 considerably less labour per million crowns of final delivery than all the other categories of final demand.

In the computations referred to above we did not explicitly take into account the labour needed to replace depreciated capital equipment. Table 2 shows that depreciation per unit of final delivery was higher in exports than in the other categories of final demand. Therefore, assuming that depreciation shall be covered by investment, we find that the difference between the use of manpower per unit of exports and consumption is reduced.

Table 2 further shows that exports uses much more imports per unit of final delivery than does consumption (cf. that the Norwegian merchant marine has large imports of fuel). Therefore, less income is created per million crowns of exports than per million crowns of consumption.

TABLE 2

IMPORTS AND DEPRECIATION PER MILL. CROWNS OF FINAL DELIVERIES FROM NORWEGIAN INDUSTRIES

	Private Consumption	Public Consumption	Investment	Exports
Imports	0·115	0·075	0·195	0·285
Depreciation	0·158	0·191	0·082	0·262

Table 3 summarizes the results for the amount of manpower contained in the different final deliveries.

TABLE 3

ECONOMICALLY ACTIVE PERSONS, PER UNIT OF FINAL DELIVERY FROM NORWEGIAN INDUSTRIES, AND PER UNIT OF GROSS AND NET NATIONAL PRODUCT CREATED BY THE DELIVERIES

	Per Mill. Crowns of Final Delivery	Per Mill. Crowns of Gross National Product	Per Mill. Crowns of Net National Product
Private consumption	36·1	40·8	49·7
Public consumption	34·8	37·6	47·4
Investment	35·4	44·0	49·0
Exports	23·0	32·2	50·7

The table illustrates the interesting result that the difference between exports and the other categories is considerably reduced when the use of labour is related to the Gross National Product created, instead of to the amount of final deliveries. Furthermore, all categories of final demand seem to have used approximately the same amounts of labour per unit of their contribution to the Net National Product.

4. FINAL REMARKS

To sum up: Per unit of final delivery, Norwegian exports in 1960 used less labour, and less educated labour, but more capital (measured by depreciation) than the other categories of final demand. But when the use of labour is related to the income created by the final deliveries, the differences are much smaller. Furthermore, the relative composition of manpower by broad educational categories is rather similar for private consumption, investment, and exports (see the middle part of Table 1). Public consumption differs considerably from the other categories.

Let us finally briefly compare our results with those of Leontief, without going into details.

Leontief (1953) split imports into two categories, competitive and non-competitive. He found that US exports in 1947 was more labour-intensive and less capital-intensive than the production needed to replace the 1947 competitive imports. In a later paper, see Leontief (1956), he differentiated between different categories of labour, and found that US exports used relatively more skilled labour than the import replacement would require. Therefore, US exports was found to be relatively labour-intensive, education-intensive, but not capital-intensive.

In the Norwegian investigation reported upon here, we did not have data for competitive imports, and had to compare exports with private and public consumption. In contrast to Leontief's results, we have found that Norwegian exports of 1960 were *not* labour- *nor* education-intensive, but capital-intensive (measured by depreciation per unit of final delivery). In interpreting the latter feature, the dominating role of the merchant marine should be remembered.

Some additional computations indicate that the export *increase* from 1960 to 1963 was less labour-intensive than the exports of 1960, and the share of labour with vocational training had risen.

Studies more or less similar to the present one have also been undertaken for Japan, India, West Germany, and Canada. References are found in D.B. Keesing (1965).

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Appendix. The Data[5]

Let us first discuss *sector classification*. We classify manpower into 14 educational categories, using the main classification of the Norwegian Population Census of 1960, see Table 4 at the end of the paper.

The industries are classified into 29 production sectors and an unspecified sector. Our classification does not correspond completely to the classification used in the Population Census. To take an example: One industry in our model consists in some cases of one sector in the Population Census, and in addition a part of another census sector. In such cases we assume that the educational distribution is the same in each part of a census industry as in the whole industry. Using such assumptions we arrived at the educational distribution of manpower within each of the industries of our model. A detailed discussion of some other similar complications will be given in Thonstad/Kobberstad (1971).

The Central Bureau of Statistics provided us with an *input–output table* according to our specifications, with 29 production sectors.[6] This table was based on the national accounts for 1960, with all items in 1960 sellers prices. Imports to each industry were not divided in competitive and noncompetitive imports, but were treated as one item. Final deliveries were split into a number of categories, namely private consumption, public consumption, seven different types of investment, and exports. The primary inputs were the following: Imports, depreciation, wages, ownership income, indirect taxes, and subsidies.

For our purposes it was necessary to undertake a few adjustments of the input–output table. Among these adjustments we mention that exports of used means of transportation were excluded from our figures for exports.

[5]A more detailed discussion will be given in Thonstad/Kobberstad (1971).

[6]We wish to thank Mr. Homb of the Central Bureau for extremely valuable assistance.

In order to find out how the tourists' expenses in Norway were divided among Norwegian delivering industries, we had to make some rough estimates. Finally, we introduced a separate production sector, Public production, covering public administration, defence, education, etc. Its main final delivery is total public consumption. The sector also has some deliveries to private consumption, mainly consisting of paid services from public sectors to private sectors.

Let us next consider the *data on the educated labour force.* From the Population Census of 1960 it is possible to extract data on the economically active population classified by main industry of work and by education.[7]

Data are also available on the fraction of persons with main occupation in one industry having some type of secondary occupation in other industries (as only occupation part of the year, or as extra work coincident with the main occupation). However, these data are not split by industry of secondary occupation, nor are they given for each educational category, but only for all educations combined. We have therefore been forced to classify each person as belonging to only one industry, namely the industry where he has his main work.

Another difficulty is that a person is either classified as economically active, or as inactive, and not according to degree of economic activity.

The census concept "economically active" is briefly explained in the following quotation:[8]

> "Measurements of the economically active population in Norway have been based on the 'gainful worker'—or 'usual activity'—concept. The classifications thus refer to the principal source of livelihood, aiming at giving a "normal" picture of the population. E.g. a person usually working as a plumber is classified as such even if at the time of the census he was temporarily engaged in another occupation. Seasonal work of pensioners, housewives or students is not considered sufficient for including persons from these categories in the economically active population."

Obviously, due to the difference of definition, one might expect that the number of economically active persons might deviate rather considerably from the number of man-years. However, a comparison of the number of computed man-years in each industry with the number of economically active persons shows that the deviations are in most cases very small. The main exception to this rule is for Agriculture where the number of economically active persons was 188,000, versus 258,000 computed man-years. This difference is mainly due to the fact that in the latter figure the housewives' work on the farms is taken into account as well as seasonal work by schoolchildren in the summertime and work by the farmers' own children.

The primary sectors Forestry and Fishing also show deviations, perhaps partly due to the same reasons as those given for Agriculture.

Another considerable difference is found for our sector Public production, where we have an estimated 94,000 economically active persons, versus 126,000

[7]Persons with vocational education were asked to report all exams and tests each requiring normally at least one school-year. See *Population Census 1960*, Vol. IV, Central Bureau of Statistics of Norway, Oslo, 1964.

[8]G. S. Lettenstrøm and G. Skancke (1964), p. 50.

computed man-years. The difference is mainly due to the fact that the census counts a large part of the conscripts as belonging to the production sectors where they worked before they were drafted, while the man-year figure counts the conscripts as members of the armed forces, and therefore as belonging to the sector Public production.

It should be mentioned that only Norwegian manpower is included in our data. The only industry with substantial amounts of imported labour is the Merchant marine.

To sum up: Our data measure the number of economically active Norwegians having their main occupation in each of the industries.

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Some of the detailed results of the investigation are given in Table 4 below. They are used as a basis for some of the more aggregative results given in the main part of this paper.

TABLE 4

ECONOMICALLY ACTIVE PERSONS, BY EDUCATION, PER MILL. CROWNS OF FINAL DELIVERY FROM NORWEGIAN INDUSTRIES

Educations \ Type of Final Delivery	Private Consumption	Public Consumption	Investment	Exports	Total
1. Agricultural schools	1·5560	0·6510	0·6710	0·4682	0·9499
2. Workshop schools etc.	0·7178	0·7160	2·0748	0·6647	0·9943
3. Other vocational schools for industry	0·2754	0·4280	0·2482	0·1168	0·2349
4. Journeymen's tests	0·6273	0·4335	0·8486	0·2681	0·5476
5. Technical schools	0·5433	0·8082	1·3372	0·4407	0·7075
6. Commercial schools	2·4013	2·6798	1·5640	0·9386	1·7988
7. Commercial secondary schools	0·6132	0·8523	0·3611	0·3026	0·4856
8. Seamen's schools	0·5405	0·6682	0·5747	1·8231	0·9516
9. Teachers' training colleges	0·0685	4·3956	0·0266	0·0239	0·4403
10. Nursing schools etc.	0·5669	0·5814	0·0879	0·1668	0·3425
11. Housekeeping schools	0·2476	0·2645	0·0628	0·0750	0·1564
12. Universities etc.	0·8244	3·5193	0·4286	0·3600	0·8427
13. Other schools	0·5685	2·6677	0·3002	0·2728	0·6116
Total with vocational training	9·5507	18·6655	8·5857	5·9213	9·0637
14. General education only	26·5470	16·0990	26·8117	17·0650	22·7530
All educations	36·0977	34·7645	35·3974	22·9863	31·8167