An explanation of the occupational and educational structure of employment by means of multinomial logit

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AN EXPLANATION OF THE OCCUPATIONAL AND EDUCATIONAL STRUCTURE OF EMPLOYMENT BY MEANS OF MULTINOMIAL LOGIT

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CONTENTS

SUMMARY

The fixed coefficient manpower requirements approach provides information on shifts in the occupational and educational structure of employment over time, but neglects the substitution between the various occupations and educational groups. In this study shifts in the structure of 83 occupations within 21 branches of industry in The Netherlands from 1981 to 1985 are explained by past occupational structures and technological developments. Besides, the educational structures according to 58 educational groups within the occurring combinations of the 83 occupational classes and 21 branches of industry in The Netherlands from 1981 to 1985 are explained by past educational structures, technological developments and the skill structure of labour supply. The explanation of both employment structures are carried out by means of multinomial logit.

ACKNOWLEDGEMENT

This study was carried out as part of a long-range research project commissioned by the Ministry of Education and Sciences. The objective of the project is to develop an education/labour-market information system to help secondary and university students choose a right type of school and/or occupation (ROA 1990).

This study reports an intermediary step towards the construction of the education/labour-market information system. Its specific purpose is to extend and improve the occupational and educational studies that already were carried out within the Research Centre for Education and Labour Market. This study can be seen as the logical continuation of these previous studies.

This study was carried out under the supervision of J.A.M. Heijke, director of the ROA, and A. de Grip. The investigation would probably have been much more cumbersome without advices of the authors of preceding studies within the ROA concerning the occupational and educational shifts. So I like to thank these authors, J.A.M. Heijke, A. de Grip, R.J.P. Dekker and Th.B.J. Beekman for their helpful advices. Beside these persons thanks are due to L. Borghans who also contributed much to this study.

1. INTRODUCTION

In the course of years the composition of employment has ever been changing. Looking at the composition of occupations the arising of new occupations, the vanishing of old trades and shifts of employment between occupations can be observed. These occupational shifts are determined by the changing demand of employers due to product market, technological and organizational developments, and other underlying processes. Beside and possibly partly because of these shifts the educational structure of employment has also undergone noticeable changes.

Both the occupational and educational structure of employment have been studied extensively. Many empirical studies have been carried out by considering the occupations or the highest educational level reached of the employed population within branches of industry. Singelmann and Browning (1980) used a "shift and share" method to analyze the occupational structure of several branches of industry in the U.S. from 1960 until 1970. This method resembles the "fixed coefficient" method, which assumes that shares of numbers of employed persons within industries are constant in time so that substitution between occupations (or educations) is impossible. This fixed coefficient method is compared by Freeman (1980) with a method that takes into account the changing accompanying wage structure of occupations. Freeman (1986) thereby examines among others the fixed coefficient method applied to the educational structure within industries. The results of these studies do not reject this relatively conservative method.

On the one hand the purpose of this study is to explain the occupational structure within branches of industry and on the other hand to explain the educational structure within both occupations and branches of industry in The Netherlands. Both problems have already been examined within the Research Center for Education and Labour Market (Dekker et al. (1988) and Beekman et al. (1989)). The difference between this study and the two studies mentioned above concerns mainly the estimation method used; here the Multinomial Logit method is used whereas in the two previous studies the models were estimated by Weighted Least Squares. Moreover the explanatory models here take into account the rigidity of the occupational and educational structure by relating the present structures to past structures.

Other Dutch studies of occupational and educational shifts within industries during last decades are found among others in Bekkering et al. (1988) and Van Opstal (1988) respectively. Contrarily to Van Opstal and Bekkering here a large number of occupations and educations are distinguished. We distinguish 83 occupations and 58 educations whereas Bekkering takes into account (mostly) 14 occupational groups and Van Opstal 14 educational groups. The reason for analyzing the occupational and educational structures at such a disaggregated level originates from the research project of the Research Centre for Education and Employment aiming at the creation of an information system on education and labour market that among others has to be suitable for educational and vocational counseling purposes. Medium term labour market forecasts for occupational and educational groups are an important part of this information system; at this moment the information system explores a model to forecast at medium term the working population within 21 branches of industry, 83 occupations and 58 educations. Because the Dutch Central Planning Bureau provides the industrial forecasts, here the occupational and educational parts have only to be considered.

Chapter 2 contains a short description of the available data set and analyzes the occupational and educational structures by means of a shift and share method. As the results of this analysis indicate that the fixed coefficient method traditionally used in manpower requirements analysis does not fully explain occupational and educational shifts, an explanatory model for these shifts is introduced in chapter 3. The explanatory variables and estimation method used are considered only shortly; most explanatory variables were already introduced by Dekker et al. and Beekman et al. and the estimation method, Multinomial Logit, resembles the estimation method introduced by Parks (1980). Chapter 4 presents the estimation results. Finally chapter 5 summarizes the main results and concludes.

Concerning the analyses one remark has to be made. The main purpose of this study is the application of the estimation method, Multinomial Logit, to the occupational and the educational model. The occupational model explains the 83 occupational shares of employed persons within 21 branches of industry whereas the educational model explains the 58 educational shares of employed persons within combinations of branches of industry and occupations. Because of the difficulty to present all results in a surveyable way we introduce two models at a higher level of aggregation that resemble the two models mentioned; in these models only 7 occupational groups and 5 educational levels are distinguished. It should be clear that these models are only presented for illustrative reasons.

2. OCCUPATIONAL AND EDUCATIONAL SHIFTS

2.1. The data

Like all Dutch studies mentioned in the introduction, we also used the Dutch Labour-Force Censuses (from the Dutch Central Bureau of Statistics) for our analyses. In this chapter the results of a shift and share analysis applied to these data are shortly discussed. In advance the way these data were organized for explaining the occupational and educational shifts is scrutinized.

The Dutch Labour-Force Censuses are sample survey's ranging from 2.5% to 5.0% of the total labour force and were held every two year from 1975 until 1985. From persons surveyed the occupational group, the branch of industry and the highest educational qualification reached are of importance for our study. Because the samples of 1975 and 1977 use other educational classifications these years are not taken into account, so only four years are left. In this study the highly disaggregated industries, occupations and educations within the Labour-Force Censuses are aggregated in such a way that a reasonable number of well defined industries, occupations and educations remain[1]. In annexes A.1. until A.3. the final division in 21 branches of industry, 83 occupations and 58 educations and their so called 2-digit codes are given. For convenience's sake the 83 occupations and 58 educations are also aggregated to seven main occupational categories (corresponding to the 1-digit occupations) and the five Dutch educational levels.

Table 1. Occupational categories (1-digit)

Category	Description of occupations	1-Digit ISCO
1	Professional, technical and related workers	0,1
2	Administrative and managerial workers	2
3	Clerical and related workers	3
4	Sales workers	4
5	Service workers	5
6	Agricultural workers, fishermen	6
7	Production and related workers, transport equipment operators and labourers	7,8,9

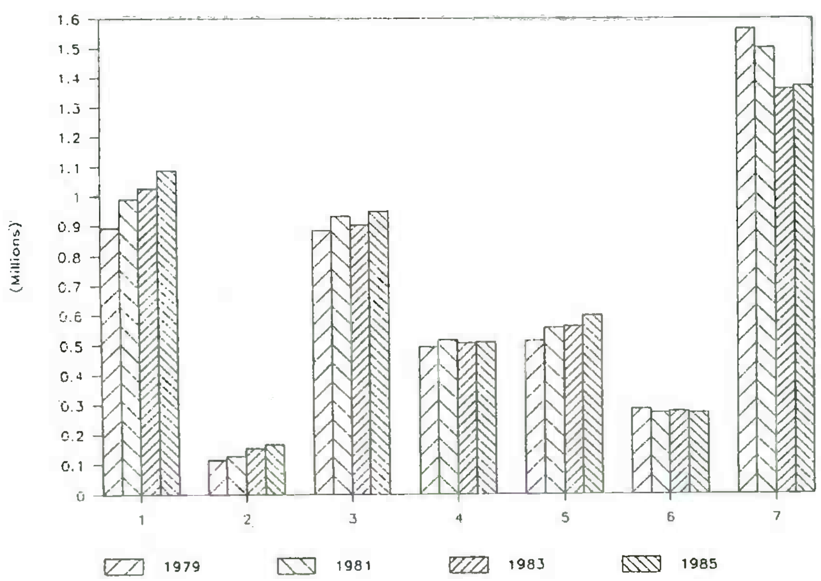
1. The disaggregated occupations and educations are comparable with 2 digit ISCO and 3 digit ISCED level respectively.

Table 2. Educational levels

Category	Educational level
2	Primary education
3	Secondary education (lower level)
4	Secondary education (higher level)
5	Higher vocational education
6	University education

These categories of occupations and educations are mentioned in table 1 and 2 respectively. Employment shifts between these occupational categories from 1979 until 1985 are shown in figure I, where the seven numbers at the x-axis correspond to the seven categories mentioned in table 1. Obviously the monotonously increasing employment of the professional, technical and related workers (category 1) and the decline of the production and related workers (category 7) catch the eye.

Figure I. Working population within seven occupational categories during 1979-1985



The figures IIa and IIb illustrate the educational background of the employed population in these seven categories in 1979 and 1985. Because the seven categories are ranked from the highest to the lowest level occupations, it is not surprising that occupational category 1 contains relatively less persons with the lowest and more persons with the highest educational level than the other categories. Nevertheless, much more important here are the shifts in almost all occupations from the lower to the higher educational levels during 1979-1985.

Figure IIa. Educational background of persons employed within seven occupational categories in 1979

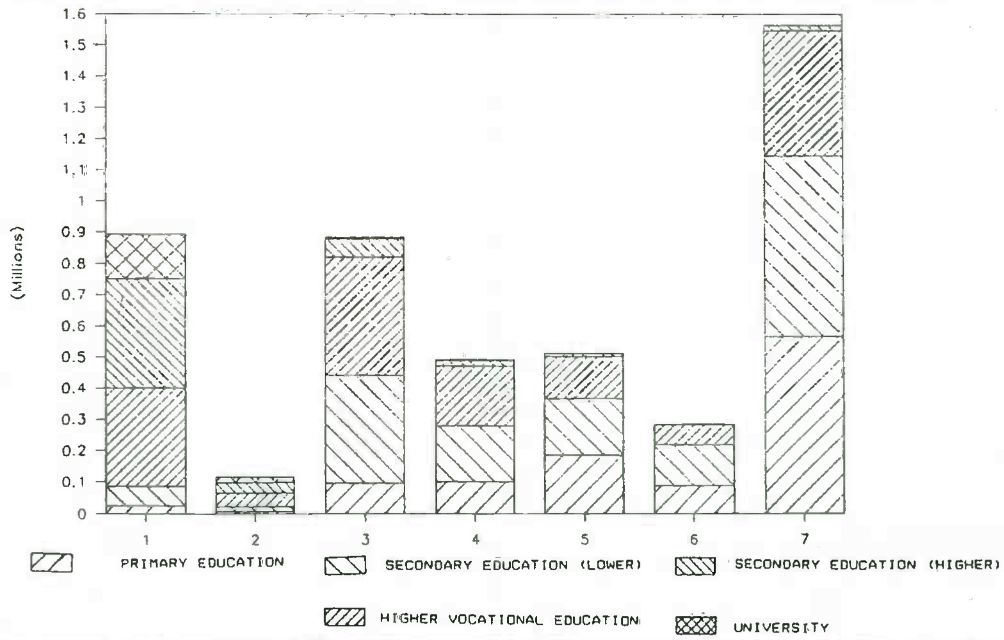
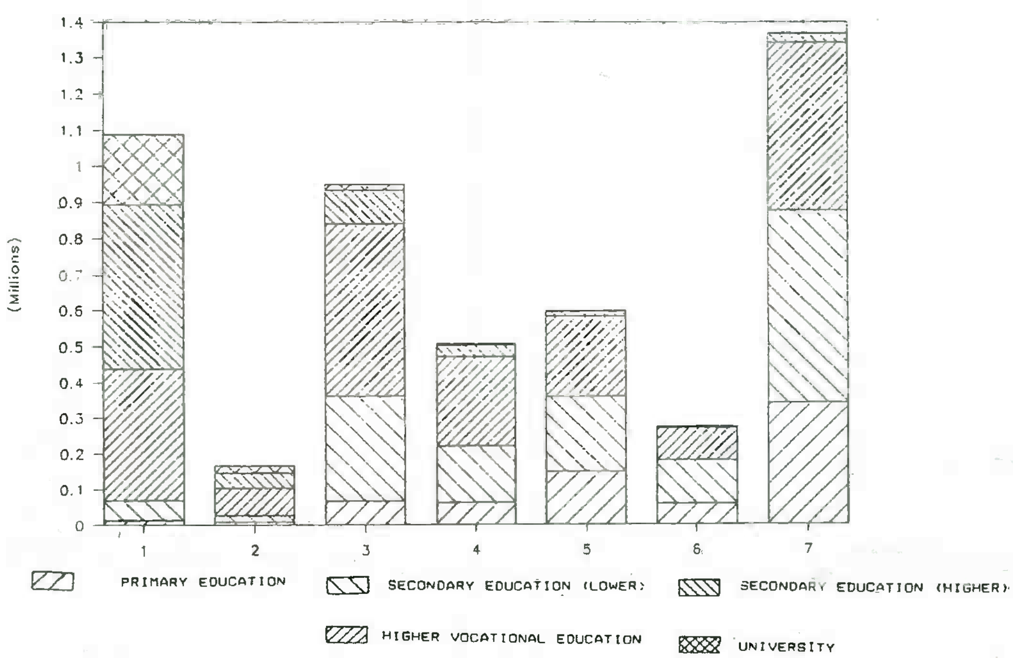


Figure IIb. Educational background of persons employed within seven occupational categories in 1985



The figures IIa and IIb show the changing occupational and educational structure of employment but do not show us the way industries have expanded or shrunk. It could be possible that the changing occupational and educational structure is mainly caused by a changing industrial structure. In the next section attention is paid to shifts in the industrial structure and the occupational and educational structure within branches of industry.

Moreover looking at numbers of persons employed, like is done above, it seems also necessary to take into account the reduction of working hours that took place during 1979-1985. The reason for an increase in the number of persons employed in a certain industry and therefore an increase in the occupations that are represented in this industry could probably be traced back to the reduction of working hours. For this reason we used the results of a study in which the average working time of occupations within industries was estimated by making use of data about the average working time of the working population in occupations and data about the working time of the working population in branches of industry. The estimation was carried out by a so called RAS-procedure (Groot and Heijke, 1989). The number of hours worked are sorted in eight categories and the number of persons within these eight categories are estimated for every occupation within a branch of industry. We define:

EP(b,o,t) : employed persons in branch of industry b, occupation o at time t (directly from the Labour-Force Censuses);
EP^{*}(b,o,h,t) : number of employed persons in branch of industry b, occupation o, class of working hours h at time t, estimated by the RAS-procedure;
MH(h) : average number of hours of the class of hours h.

The variable h indicates the eight categories of working hours distinguished (so h = 1, 2 .. 8), where each category represents a class of working hours (e.g. category 1 is the working hours category that ranges from 0 working hours to 16 working hours, etc.). We calculated the number of employed persons adjusted for the share of part-time work, which gives us employment in person-years, defined as AEP, by transforming the employed persons of the Labour-Force Censuses:

$$AEP(b,o,t) := \frac{\sum_h EP^{*}(b,o,h,t) * MH(h)}{\sum_h EP^{*}(b,o,h,t) * 40} * EP(b,o,t) \qquad (1)$$

The first term right of the equality symbol represents the average number of working hours of occupation o within industry b. The denominator of this term contains the normal working time of occupation o and industry b, which is here assumed to be 40 hours a week. By multiplying the first term by the number of persons employed in occupation o and industry b, which is the second term, the adjusted number of employed persons is found.

One conclusion of the study of Groot and Heijke mentioned above is that the shares of part-time work as measured by average working time per week are more determined by occupation than by industry. In figure III the employed persons and adjusted number of employed persons within the seven main occupations in 1979 and 1985 are compared. The correction for working hours is bigger in 1985 than in 1979 and seems to have the least impact on administrative, managerial workers and agricultural occupations (category 2 and 6). The relative small difference between adjusted and unadjusted numbers of employed persons in the agricultural industry is also found in figure IV; for the three main branches of industry the agricultural industry shows the least differences by the adjustments made.

Figure III. Employed persons and employed persons adjusted for the share of part-time work within seven occupational categories in 1979 and 1985

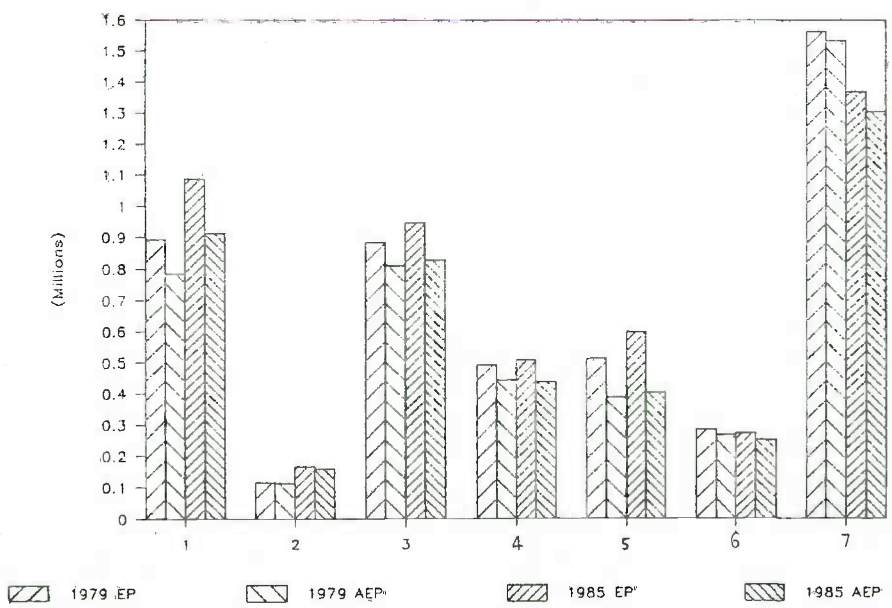
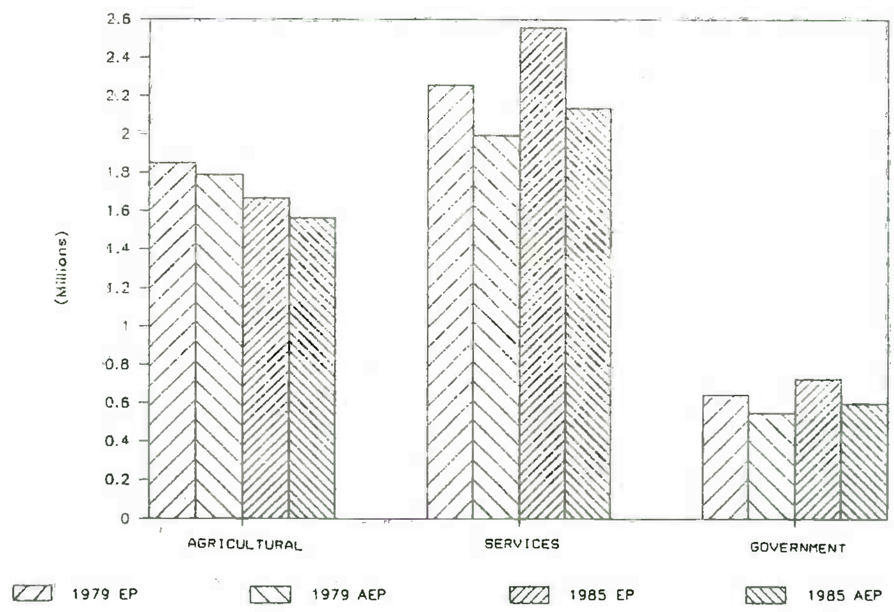


Figure IV. Employed persons and employed persons adjusted for the share of part-time work within three branches of industry in 1979 and 1985



We assume that the adjustments for working hours of the number of employed persons with a certain educational background is fully determined by the occupation within a branch of industry they have. We therefore calculate the adjusted number of employed persons with certain educational backgrounds by multiplying those numbers with the average number of working hours of the occupation they have and industry they were working, so[2]

$$AEP(b,o,e,t) := \frac{\Sigma_h \; EP^*(b,o,h,t) * MH(h)}{\Sigma_h \; EP^*(b,o,h,t) * 40} * EP(b,o,e,t) \qquad (2)$$

with

EP(b,o,e,t) : number of employed persons within industry b, occupation o, education e at time t;

AEP(b,o,e,t) : adjusted number of employed persons within industry b, with occupation o and education e at time t.

2. For the estimation method we use in chapter 3 there is no difference between taking account of the employed people or the adjusted employed people when calculating the endogenous variable of the educational model. This is because of the fact that nominator and denominator are adjusted by the same factor. Only the estimated covariance matrix is touched by the adjustments made here for part-time work.

2.2. Shift and share analyses

Every branch of industry has its own occupational and educational structure. In some branches certain occupations will be well represented. The agricultural industry for example obviously possesses most of the agricultural occupations. So a relative decrease of employment in the agricultural industry structure will automatically cause a relative decrease in the agricultural occupations. This effect is called the *industry structure effect*. Given this industry structure the occupational structure within branches of industry can also change, for example if the computerization of industries implies increasing demand of automation experts substituting clerical occupations. This effect is called the *occupational structure effect*. Finally, it is possible that within certain occupations the educational level increases due to the abundant supply of higher educated persons. This shift effect is called the *educational structure effect*. We here analyze these three effects for the seven occupations and five educational levels mentioned in section 2.1. Besides the three structure effects we distinguish an interaction effect[3].

Table 3 shows the results of this shift and share analysis for the occupational structure of the seven occupations within the 21 distinguished industries. All numbers of persons are adjusted for restrictions in working hours (see (1))[4].

From 1979 until 1985 an occupational shift took place towards the "professional", "administrative", "clerical" and "service" occupations at the expense of the "agricultural" and "industry" occupations (see column "Net shift"). The decline of the agricultural and production occupations is mainly, by 83% and 70% respectively, due to industry shifts but is also caused by the occupational shift within these industries (column "Occupational shift effect").

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3. Other labour market studies using shift-share analyses are e.g. Singelmann and Browning (1980), NEI (1986), Grip (1987) and Teulings (1990).

4. For a complete description of the shift and share analysis used, see annex B.1.

Table 3. Changes in the occupational structure and its components, 1979-1985

	Components of net shift				Components of net shift (percentages)		
	Net shift	Industry shift effect	Occupation shift effect	Interaction effect	Industry shift effect	Occupation shift effect	Inter. effect
Profess.	138237	98379	40676	-818	71.2	29.4	-0.6
Administ.	46867	-815	53341	-5659	-1.7	113.8	-12.1
Clerical	24045	22148	520	1377	92.1	2.2	5.7
Sales	-937	-11012	11815	-1740	1175.2	-1260.9	185.7
Services	19748	51732	-28583	-3401	262.0	-144.7	-17.2
Agricult.	-14466	-11952	-3130	616	82.6	21.6	-4.3
Product.	-213495	-148482	-74640	9627	69.6	35.0	-4.5

Explanation column titles :

Net shift : Change in occupational structure because of industry and occupational shifts;
Industry shift effect : Change in occupational structure because of industry changes;
Occupational shift effect : Change in occupational structure because of occupational structure changes within industries;
Interaction shift effect : Changes in occupational structure as a consequence of changes in both occupational and industrial shifts that are not directly attributable to one of both effects.

Except the "administrative" occupations, all other occupational category shifts are for at least 70% due to industrial shifts. The interaction effects with these occupations are negligible, which implies that occupational and industrial effects by themselves have large effects on changes in the occupational structure. The occupational category "administrative" has obviously gained most by the changing occupational structure within industries. In view of the total expansion the negative interaction effect did not play a big role.

Table 4 contains the results of the shift and share analysis of the educational shifts within industries and occupations. The first column contains the educational shifts within industry-occupation-combinations. Comparing the educational structure of 1979 and 1985, we see that the shift towards the higher level educations is mainly due to the changing structure of educations *within* industries and occupations. Interaction effects are hardly noticeable. The results of a shift and share analysis applied to the educational structure within occupations (so neglecting the industrial structure) and the results of a shift and share analysis applied to the educational structure within industries (so neglecting the occupational structure) do not differ much from these results. The differences that are found (especially at the extended primary and secondary education) are possibly ascribable to changing occupations within industries that were mainly held by persons with these educations.

Table 4. Changes in educational structure and its components, 1979-1985

	Components of net shift				Components of net shift (percentages)		
	Net shift	Ind.-oc. shift effect	Education shift effect	Interaction effect	Ind.-oc. shift effect	Education shift	Inter. effect
Primary	-366346	-74007	-313808	21469	20.2	85.7	-5.9
Secon. lower	-145690	-60057	-73703	-11930	41.2	50.6	8.2
Secon. higher	318632	37338	294847	-13553	11.7	92.5	-4.3
Higher	138283	66425	70494	1364	48.0	51.0	1.0
University	55121	30098	22063	2960	54.6	40.0	5.4

The results above are not remarkable. It is obvious that the occupational structure is much more influenced by industry shifts than the educational structure, which is probably much more effected by the labour supply and the degree of scarcity on the labour market.

For the sake of completeness these shift and share analyses were also applied to the 83 occupations and 58 educations (listed in annex A2 and A3). The results are in annexes B.1 and B.2. These shift and share analyses at a lower level of aggregation lead largely to the same conclusions as the analysis at the higher level of aggregation, so the occupational and educational shifts are more due to industrial shifts and shifts of the educational structure within industries and occupations respectively.

In annex B.1 however the divergence of the explanation of the changing occupational structure within an occupational category immediately catches the eye. For example the four most changing occupations in the occupational category "professional" are explained by different effects; the employed persons in occupation 5, "medical", occupation 10 "teachers" and occupation 16 "professional, technical" expanded as a consequence of industrial shifts, whereas occupation 6 "statisticians" increased as a result of occupational shifts within industries. The same can be observed within the service workers category (category 5). In addition the figures show that the occupational category "production" (category 7) for almost all thirty occupations that are distinguished had a very bad time during 1979-1985.

Annex B.4 shows big changes within the "technical", "social" and "economic-clerical" educations at nearly all levels. The technical educations at the extended primary and secondary levels (education 4 and 14) declined considerable, whereas these educations at the higher levels (education 30-31 and 48-49) expanded strongly. These shifts were not mainly caused by an industrial or educational effect within industry-occupation-combinations. The "social" educations at the higher levels (education 39 and 55) and the "economic-administrative" educations (education 19, 36-37, 52-53) owe their growth to educational changes.

From these results might be concluded that it does not seem acceptable to neglect changes in industrial, occupational and educational structures. The most relevant result for us is however the fact that the assumption of a constant occupational and educational structure within industries and industry-occupation-combinations respectively is objectionable (columns "industry shift effect" and "ind.-oc. shift effect" in table 3 and table 4 respectively); so it seems important to find explanations for the changing occupational and educational structures.

In the next section we describe a method to explain the occupational and educational structure within industries and industry-occupation-combinations. This method should improve the forecasts of the occupational and educational shifts during 1979-1985 compared to the constant shift methods.

3. THE MODEL

3.1. The economic model

In this chapter the economic models of both the explanation of the occupational and educational shifts are described. Further a formal description of both models and the estimation method used is shortly discussed.

The manpower requirements models relate employment of a certain occupation or education to industrial employment. In the fixed manpower requirements model these shares are assumed to be constant in time, so that substitution among different types of labour is not possible. This method was also used in chapter 2 (table 3 and 4, column 2). In the study of Freeman (1980) the fixed manpower requirements model for different types of occupations during 1960-1970 are discussed, while the study of Freeman (1986) discusses the model for different types of education. Because this model neglects the possibility of substitution between types of labour, Freeman also uses different explanatory models. In Freeman (1980) the wage structure corresponding to the occupations is taken into account and as a result the fixed coefficient model is not rejected because of the relative moderate variation of the wage structure. In Freeman (1986) it is emphasized that the fixed method can play an important role even if the negligence of substitution possibilities seems not realistic.

Like Dekker et al. (1988), Beekman et al. (1989) and Van Opstal (1988) we want to explain the manpower coefficients by assuming a relationship between these coefficients and some relevant economic variables. Van Opstal uses as dependent variable in his econometric modelling the employment of educational categories within industrial employment and thereby skips the occupational level of analysis. Contrarily, we first relate employment of an occupational category to industrial employment and then relate the employment of an educational category to the employment of a industry-occupation-combination. We define:

AEP(o,e,t) : number of employed persons with occupation o, education e at time t;
AEP(b,t) : number of employed persons within industry b at time t;
$p_t(e|b,o)$: fraction of employed persons with education e within industry b, occupation o at time t;
$p_t(o|b)$: fraction of employed persons with occupation o within industry b at time t.

Then the following identity holds:

$$AEP(o,e,t) = \Sigma_b\ p_t(o|b)\ p_t(e|b,o)\ AEP(b,t) \tag{3}$$

The fixed manpower requirements model assumes $p_t(o|b)$ and $p_t(e|b,t)$ to be independent of time. Here we assume these coefficients to depend on economic factors. We distinguish the occupational fraction from the educational fraction, thereby assuming that the occupational and industrial structure represent the demand side of the labour market whereas the educational structure of industries and occupations is a result of the matching process of labour supply and labour demand (see De Grip et al., 1989).

The variables used for explaining the fractions of occupations are defined as:

$p_{t-2}(o|b)$: the fraction of occupation o within industry b at time t-2;
INVVA(b,t) : the investments related to value added in industry b at time t;
DCU(b,t) : the degree of capacity utilization of industry b at time t.

The variables used for explaining the fractions of educations are defined as:

$p_{t-2}(e|b,o)$: the fraction of education e within industry b and occupation o at time t;
INVVA(b,t) : see above;
DCU(b,t) ; see above;
PLF(e,t) : potential labour force of education e at time t.

As the dependence of the current occupational and educational structures from the past structures should not be neglected, this dependence is taken into account. Resulting from the fact that we work with bi-annual data, the fractions of two years ago are considered. By taking account of these past fractions the other variables in the model should explain the shifts per occupation and education from time t-2 to t.

Above mentioned parts of both models are firstly explained by a variable representing technological progress per industry (variable INVVA(b,t)). This variable is measured as[5]:

$$INVVA(b,t) := [\sum_{j=-9}^{0} INV(b,t+j)]/[\sum_{j=-9}^{0} VA(b,t+j)] \qquad (4)$$

where

INV(b,t) : investments in industry b at time t;
VA(b,t) : value added in industry b at time t.

The second variable used for explaining the shifts per occupation and education during time t-2 until t is the degree of capacity utilization that represents cyclical effects in the employment structure. This variable is constructed as

$$DCU(b,t) =: VA(b,t)/[1/5 \sum_{j=-2}^{2} VA(b,t+j)] \qquad (5)$$

It is assumed that the changing investments and degrees of capacity utilization both influence the occupational and educational structure and that this influence is different between occupations and educations. It seems reasonable to assume that some occupations or educations take advantage of the changing technological developments at the expense of other occupations or educations. If lower skilled persons are substituted by higher skilled persons one is speaking of *upgrading*, the opposite case is *downgrading*. Developments like upgrading or downgrading might in this way be examined. The two variables mentioned are both industrial-specific, so might be seen as determined by the demand side of the labour market.

By explaining the educational fractions the supply side of the labour market is taken into account by means of the variable PLF. The supply of persons with certain educational qualifications may cause shifts within the educational structure. From the data we used it was after all obvious that during 1979-1985 a considerable expansion of higher educated employed persons took place which could be a reflection of the high growth rate of

5. This variable slightly differs from the variable used in Dekker et al. (1988) and Beekman et al. (1989) as we here specified the variable over a period of 10 in stead of 5 years, taking account of longer diffusion lags of technical progress.

relative labour supply of higher educated persons[6].

Summarizing, the fractions of occupations within industries and the fractions of educations within branch-occupation-combinations are here assumed to depend on the one hand on demand side industrial-, occupational- and on the other hand on educational-specific supply-side variables.

3.2. The econometric model and estimation method

In equation (3) the occupational and educational fractions are found. The occupational fractions are assumed to be a transformation (f_o) of the past fraction and industrial variables (x_{bt}), so[7]

$$p_t(o|b) = f_o(p_{t-2}(o|b), x_{bt}) \tag{6}$$

The educational fractions are assumed to be a transformation (f_e) of the past fraction, the educational (x_{et}) and industrial variables, so

$$p_t(e|b,o) = f_e(p_{t-2}(e|b,o), x_{bt}, x_{et}) \tag{7}$$

Because these relations are assumed to be the same, we define

$$p_t(i|g) = f_i(p_{t-2}(i|g), x_{it}, x_{gt}) \tag{8}$$

where i and g represent occupation o and branch b (i=o and g=b) or education e and the combination of branch b and occupation o (i=e and g=(b,o)). We will use this equation while considering the estimation method, and refer to i and g as the category of labour and the branch respectively.

The estimation method used is the multinomial logit method. This method assumes the fraction of a category of labour i within a branch to be logistically distributed, which means that the function f_i in (8) is the logistical density function. The probability that category i occurs within branch g is therefore assumed to be :

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6. The variables INVVA, DCU and PLF were also used in Dekker (1988) and Beekman (1989).

7. For convenience's sake we assume here that there is only one industrial-specific variable.

$$p_t(i|g) = \frac{\exp[\ \alpha \ln(p_{t-2}(i|g)) + x_{gt}^T\beta_i + x_{it}^T\tau_i + e_{igt}]}{\sum_k \exp[\ \alpha \ln(p_{t-2}(k|g)) + x_{gt}^T\beta_k + x_{kt}^T\tau_k + e_{kgt}]} \qquad (9)$$

Because equation (9) does neither consider the employment distribution within branches nor individual jobs with individual characteristics, the equation only represents average variables. The term e_{igt} is therefore added to the specification as a specification error. The parameters α, β_i and τ_i are the parameters of interest that are to be estimated. The parameters β_i and τ_i represent the individual influence of the variables x_{gt} and x_{it} on the labour category i.

By choosing a reference group of labour, say labour i^*, dividing by $p_t(i^*|g)$ and taking natural logarithms, equation (9) gives

$$\ln(p_t(i|g)/p_t(i^*|g)) = \alpha \ln(p_{t-2}(i|g)/p_{t-2}(i^*|g)) + x_{gt}^T (\beta_i - \beta_i*) + x_{it}^T\tau_i - x_{i^*t}^T\tau_i* + e_{igt} - e_{i^*gt} \qquad (10)$$

Because of this resulting equation the lagged variable is logarithmically specified in equation (9). When estimating equation (10) there is one parameter estimation for $\beta_i - \beta_i*$. That is why mostly β_i* is assumed to be zero.

Instead of the theoretical probabilities $p_t(i|g)$ the frequencies $f_t(i|g)$ are observed, so equation (10) might be rewritten as

$$\ln(f_t(i|g)/f_t(i^*|g)) = \alpha \ln(f_{t-2}(i|g)/f_{t-2}(i^*|g)) + x_{gt}^T \beta_i + x_{it}^T\tau_i - x_{i^*t}^T\tau_i* + e_{igt} - e_{i^*gt} + w_{igt} \qquad (11)$$

where

$$w_{igt} = \ln(f_t(i|g)/f_t(i^*|g)) - \ln(p_t(i|g)/p_t(i^*|g)) \qquad (12)$$

The total disturbance consists of two errors, namely the specification error $e_{igt} - e_{i^*gt}$ and the measurement error w_{igt}.

Equation (11) can be estimated by Modified Multinomial Logit (MML). This method takes into account both the specification and measurement error. In fact this method boils down to executing the Generalized Least Squares method twice. First the measurement error is taken into account (called Standard Multinomial Logit = SML) and in a second stage the specification error is taken into account (MML) by making use of the results of the first estimation. The MML-method was introduced for the multinomial case by Parks (1980). The estimation method was used for the estimation of the manpower coefficients by Van Opstal (1988). We used this method for the estimation of our models that will be considered in the next section. There are however some differences between our models and the model of Van Opstal. These differences are due to the fact that we made use of highly disaggregated occupational and educational categories (namely 83 occupations and 58 educations). Because not all occupations distinguished occurred during 1979-1985 within all 21 branches and of course not all educations occurred within all occurring branch-occupation-combinations (and some of them still do not exist), we encountered problems when estimating the models by Modified Multinomial Logit. In the next section we therefore present first the results of the models at a more aggregated level (7 occupational categories and 5 educational levels). These models are estimated by both the SML- and the MML-method. The models with the highly disaggregated occupations and educations are estimated by the SML-method and next by a method that differs in some aspects from the MML-method but still takes account of the specification error. The ins and outs of the problems we encountered and the estimation procedure of the MML-method are discussed in more detail in annex C.

4. ESTIMATION RESULTS

4.1. The explanation of the occupational shifts within branches of industry during 1979-1985

The results of the occupational and educational models that explain the share of 83 occupations and 58 educations respectively are presented in annex D. The much smaller problems in which only seven occupations with five educational levels distinguished are fully presented in this chapter. All estimation results coupled with the problems encountered during the estimation procedures are discussed here.

For being complete we recall the econometric model of the occupational structure within branches of industry that was introduced in the preceding chapter (see also annex C) :

$$\ln(f_t(o|b)/f_t(o^*|b)) = \alpha \ln(f_{t-2}(o|b)/f_{t-2}(o^*|b)) + \sum_{i=1}^{O} \beta_{1i} \text{ INVVA}(b,t) +$$

$$\sum_{i=1}^{O} \beta_{2i} \text{ DCU}(b,t) + \delta_{obt} \qquad (13)$$

$f_t(o|b)$: fraction of employed persons observed with occupation o within industry b at time t;
INVVA(b,t) : the investments related to value added in industry b at time t;
DCU(b,t) : the degree of capacity utilization of industry b at time t;
δ_{obt} : error term containing both the measurement and specification error;
$\alpha, \beta_{1i}, \beta_{2i}$: parameters to be estimated;
o : occupation (o = 1,2 .. O);
o^* : reference occupation;
b : branch of industry (b = 1,2 .. 21);
t : time index (t = 1981,1983,1985).

If only seven occupations are distinguished (see table 1), the index variable o ranges from 1 to 7. A problem encountered when estimating this model concerns the lagged endogenous variable. As not every occupational group is represented within every branch of industry, fewer than the maximum number of observations (21 industries times 7 occupations times 3 years) are observed and thus explained. The non-existence of an occupational group during the sample period causes zero observations of the lagged endogenous variable which is impossible because of the ln-transformation. We solved this problem by substituting the zero observations of the lagged variable by a dummy value of one employed person, so assuming one employed person working within this (within that year not occurring) occupation. This is of course an artificial solution but does not seem to contribute much to the estimation results because only a few times an observation of the lagged variable is missing. This solution to the missing past observations is followed in both the occupational and educational model[8].

Table 5. Estimation results of the occupational model (7 occupations)

STANDARD MULTINOMIAL LOGIT			MODIFIED MULTINOMIAL LOGIT		
	B	SD		B	SD
LENDO	0.9858	0.0004	LENDO	0.9745	0.0089
INVVA1	0.0163	0.0075	INVVA1	-0.0254	0.2688
INVVA2	-0.235	0.0174	INVVA2	-0.0625	0.3523
INVVA4	0.4097	0.0263	INVVA4	-0.2259	0.6443
INVVA5	0.2019	0.0101	INVVA5	0.1918	0.3991
INVVA6	0.6653	0.0493	INVVA6	2.3688	2.1793
INVVA7	0.1412	0.0082	INVVA7	0.2783	0.2338
DCU1	0.0171	0.0015	DCU1	-0.0005	0.0483
DCU2	0.1245	0.0025	DCU2	0.0811	0.064
DCU4	-0.0135	0.0023	DCU4	-0.002	0.1159
DCU5	-0.0455	0.0016	DCU5	-0.1427	0.0727
DCU6	-0.0939	0.0056	DCU6	-1.2718	0.4144
DCU7	-0.0366	0.0015	DCU7	-0.0613	0.0424

R^2-ADJ = 0.9894[a] | R^2-ADJ = 0.9817[a]

Number of observations = 366
Reference category is occupation 3, "clerical and related workers".

a The adjusted R-squares are calculated by adjusting Buse's R-squares (see Buse,1973) for the degrees of freedom.

Table 5 gives the estimation results of the occupational model; the columns (B) give the parameter estimates and the standard errors (SD) respectively. The first columns contain the results when only the measurement error is taken into account. The coefficients belonging to the variable INVVA of equation (13) are here denoted as INVVA1, INVVA2, INVVA4 until INVA7 according to the seven occupational groups distinguished. The same holds for the variable DCU. Occupation 3 is missing in the table because this

8. Of course this problem gets more important if more disaggregated data are used. The least (adjusted) number of working people in a industry-occupation-education-combination of the whole sample (the number of existing number of combinations from 1979 to 1985 of the 21 branches of industry, 83 occupations and 58 educations = 36,730) is thirty persons. So the contribution of creating several combinations by assuming one working person instead of zero does not seem too serious.

occupation ("clerical and related workers") is here chosen to be the reference category (so in equation (13) the coefficients β_{13} and β_{23} are supposed to be zero). The coefficient of the lagged endogenous variable (LENDO) indicates the importance of the past occupational structure but is also significantly different from 1 (using a critical t-value of 1.96). All other coefficients differ significantly from zero, so according to these results the other variables can not be ignored.

When estimating this model with Modified Multinomial Logit however (see the last columns of table 5) only two coefficients are significantly different from zero. These results resemble the results of Parks (1980) and Van Opstal (1988) by the considerable increase of the standard errors. Parks already concluded that the differences of the standard errors between estimating by SML and MML become larger in case the specification error more dominates the measurement error. Here the specification error indeed seems to play a very big role. However, the industrial-specific variables DCU is not negligible. This can be concluded from table 6, that contains the F-statistics belonging to the overall significance of both variables within the (general) model (13).

Table 6. F-statistics for the exclusion of variables INVVA and DCU (7 occupations)[a]

Excluded variable	F-statistic	Number of restrictions	Critical value (5%)
INVVA	0.79	6	2.1
DCU	2.20*	6	2.1

a The F-statistics are calculated using the formula (12) of Buse (1979).
* Significant F-statistics at the 5%-level.

Because the relevance of changing investments to the occupational structure seems reasonable, the partial effects of the industrial-specific variables are given (separately from the reference category) in table 7. These are calculated by taking the derivatives of the probabilities with respect to these variables (see (13)), that is

$$\delta p_t(o|b)/\delta x_j(b,t) = p_t(o|b)\ (\beta_{jo} - \sum_{i=1}^{O} p_t(o|b)\ \beta_{ji}) \qquad (14)$$

where

$j = 1$ or $j = 2$

x_j = INVVA if $j = 1$
x_j = DCU if $j = 2$.

The values calculated in table 7 are the average values of (4.2) over the industries and years.

Table 7. Derivatives of the probabilities with respect to the industrial-specific exogenous variables

Occupational category	INVVA	DCU
1. Professional	-0.024	0.007
2. Administrative	-0.010	0.006
4. Sales	-0.016	0.002
5. Services	0.005	-0.006
6. Agricultural	0.034	-0.019
7. Production	0.039	-0.003

These results contradict in a way our expectations concerning these explanatory variables. If investments expand an increase of the higher qualified employed persons is usually expected. According to these results the higher qualified occupations, that are the first mentioned occupations, are negatively effected by an investments increase whereas the lower qualified occupations (occupational groups 6 and 7) benefit from these developments. Remarkably, the degree of capacity utilization shows the opposite signs. However, none of these partial derivative estimates are significant (at the 5% level).

Annex D.1 contains the results of the occupational model (13) when 83 occupations are distinguished (so index o within (13) ranges from 1 to 83). Again the results of Standard Multinomial Logit are presented in the first columns. Contrarily to the "small" occupational model above, this model is not estimated by the Modified Multinomial Logit method that was presented in the preceding chapter. Because of the fact that we distinguish so many occupations, the number of occurring occupations within the 21 branches of industry varies strongly. The estimation of the covariance matrix of the specification error (see annex C (C.1) and (C.2)) therefore did not lead to a semi-positive definite matrix. That is why we assume matrix Σ to be diagonal instead of full symmetric. The estimation procedure is however further proceeded as the Modified Multinomial Logit method. The estimation results of this method are indicated as MML (-) in annex D.1. The reference used, that is occupation 28 "clerical and related workers", is an occupational group that occurs in every branch of industry.

The results again show a big difference between the standard deviations of both estimation steps. The parameter estimations between both estimation methods also seem very different but can be justified by the insignificance of the individual estimates (most (MML-)parameter estimates are not significant). The lagged endogenous variable plays the biggest role. Even the MML-estimate indicates that the current occupational structure is highly dependent (more than 60%) on the past occupational structure and is highly significant. Comparing the lagged variable estimate with the estimate in table 4.1 we see that when distinguishing more occupational groups the lagged variable obviously seems to become less important, perhaps in favor of the other explanatory variables. The individual effects of the investments and degree of capacity utilization are mostly not significant but the overall significance of both variables counts. Table 8 contains the F-statistics belonging to the occupational model with 83 occupations.

Table 8. F-statistics for the exclusion of variables INVVA and DCU (83 occupations)[a]

Excluded variable	F-statistic	Number of restrictions	Critical value (5%)
INVVA	2.24*	82	1.29
DCU	106.12*	82	1.29

a The F-statistics are calculated using the formula (12) of Buse (1979).
* Significant F-statistics at the 5%-level.

Contrarily to the "small" occupational model both industrial-specific variables are significant. This overall significance of both variables is possibly due to the fact that the individual effects of the investments and degree of capacity utilization on occupational groups differ (or compensate each other) within the seven occupational categories distinguished in the "small" model. The estimation of the individual effects therefore seems sensible[9].

4.2. <u>The explanation of the educational shifts within both branches of industry and occupational groups during 1979-1985</u>

The model explaining the educational structure within branches of industry and occupations is as follows :

$$\ln(f_t(e|b,o)/f_t(e^*|b,o)) = \mu \ln(f_{t-2}(e|b,o)/f_{t-2}(e^*|b,o)) + \sum_{i=1}^{E} \tau_{1i} \text{ INVVA}(b,t) + \sum_{i=1}^{E} \tau_{2i} \text{ DCU}(b,t) + \sum_{i=1}^{E} \tau_{3i} \ln(\text{PLF}(e,t)/\text{PLF}(e^*,t)) + \epsilon_{ebot} \quad (15)$$

$f_t(e\|b,o)$	:	fraction of employed persons observed with education e within industry b and occupation o at time t;
INVVA(b,t)	:	the investments related to value added in industry b at time t;
DCU(b,t)	:	the degree of capacity utilization of industry b at time t;
PLF(e,t)	:	the potential labour force of education e at time t;
ϵ_{ebot}	:	error term containing both the measurement and specification error;
$\mu,\tau_{1i},\tau_{2i},\tau_{3i}$	:	parameters to be estimated;
e	:	education e (e = 1,2 .. E);
e^*	:	reference education;
o	:	occupation (o = 1,2 .. 83);
b	:	branch of industry (b = 1,2 .. 21);
t	:	time index (t = 1981,1983,1985).

In the model that distinguishes five educational levels the variable PLF is based on the Labour-Force Censuses (see Central Bureau of Statistics (CBS,1985)). If 58 educations are distinguished the variable is calculated by means of table 14 of the so called SKILL-estimates of the Central

9. We also calculated the F-statistics belonging to the SML-estimates. These statistics also showed the higher significance of the industrial-specific variable estimates when more occupational groups were distinguished. So the conclusions here concerning the overall significance of both industrial specific variables do not seem to depend on the different application of the second estimation step, that is the application of the Multinomial Logit (MML versus MML(-)).

Planning Bureau (see Spronk, 1985)[10].

The estimation results of the model with five educational levels are found in table 9. The reference education is chosen to be the lowest educational level.

Table 9. Estimation results of the educational model (5 educations)

STANDARD MULTINOMIAL LOGIT			MODIFIED MULTINOMIAL LOGIT		
	B	SD		B	SD
LENDO	0.8763	0.0005	LENDO	0.6203	0.0146
INVVA3	-0.0768	0.01	INVVA3	0.4232	0.5506
INVVA4	-0.2431	0.0096	INVVA4	0.2721	0.5864
INVVA5	0.2417	0.0123	INVVA5	0.5709	0.6681
INVVA6	0.1449	0.0151	INVVA6	1.3936	0.8311
DCU3	-0.6852	0.0137	DCU3	-1.1295	0.9441
DCU4	0.2458	0.0091	DCU4	0.3297	0.6907
DCU5	-0.343	0.0092	DCU5	-1.0778	0.5416
DCU6	-0.1281	0.012	DCU6	-0.6478	0.6881
PLF3	0.6714	0.0109	PLF3	1.1965	0.7499
PLF4	0.0352	0.007	PLF4	0.2298	0.5306
PLF5	1.4294	0.0237	PLF5	3.2363	1.4058
PLF6	2.5177	0.0955	PLF6	4.293	5.5357
R^2-ADJ = 0.9115[a]			R^2-ADJ = 0.7557[a]		

Number of observations = 1428
Reference category is occupational level 2 "primary education".

a The adjusted R-squares are calculated by Buse's R-squares (see Buse,1973) adjusted for the degrees of freedom.

The value of the highly significant parameter estimate of the lagged endogenous variable indicates the rigidity of the educational structure. Beside, the influence of the potential labour force is in line with our expectations. The supply of highly educated persons (educational level 5 and 6) effects the educational structure mostly whereas the medium educational level (level 4) seems to have the least impact on the educational structure. According to these results the investments and degree of capacity utilization show again individually non significant estimates. Table 10 gives the statistics belonging to the overall significance of these variables. According to these results the influence of the variables degree of capacity utilization and the potential labour force should not be neglected.

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10. The Central Planning Bureau however distinguishes less than 58 educations so that some educations of the 58 educations are assumed to be affected by the same educational groups.

Table 10. F-statistics for the exclusion of variables INVVA, DCU and PLF (5 educations)[a]

Excluded variable	F-statistic	Number of restrictions	Critical value (5%)
INVVA	1.19	4	2.37
DCU	4.44*	4	2.37
PLF	3.02*	4	2.37

a The F-statistics are calculated using the formula (12) of Buse (1979).
* Significant F-statistics at the 5%-level.

Table 11 contains the partial derivatives of the probabilities with respect to the explanatory variables. According to these results an increase of the investments effects negatively the secondary educational higher level whereas the degree of capacity utilization effects positively this level. All other levels experience the opposite effects. This secondary educational level is also the only level that does not take any advantage of an increasing labour supply of persons with the same educational level.

Table 11. Derivatives of the probabilities with respect to the industrial-specific exogenous variables and the labour supply variable

Educational category	INVVA	DCU	PLF
3. Secondary education lower	0.028	-0.217	0.099
4. Secondary education higher	-0.036	0.267	-0.319
5. Higher vocational ed.	0.018	-0.102	0.259
6. University	0.057	-0.017	0.170

Annex D.2 contains the results of the occupational model, in which 58 occupations are distinguished (so e ranges from 1 to 58). From all estimated models this model is mostly effected by the substitution of dummy values for missing lagged endogenous observations (see the first note of this chapter). Because of the high disaggregation within both industries and (highly disaggregated) occupations it is not possible to find an education that occurs within every existing industry-occupation-combination (at each point in time). That is why we have chosen two educations that serve as reference categories. These are the general educational groups 1 "elementary education" and 11 "general secondary education". The category of both educations that is mostly observed overall years within a industry-occupation-combination is chosen to be the reference education. If the reference education was not occurring in the past again a dummy value of one employed person was taken instead of zero persons (see also the remark about dummy values in part 4.1).

The estimation results in annex D.2 show the highly significant dependence of the past structure. Estimated coefficients of both industrial-specific variables diverge largely within the educational levels distinguished. Shifts within the educational structure explained by the investments and degree of capacity utilization are however individually not significant according to the MML-estimation results. Contrarily the estimated coefficients of the labour supply variable does not diverge that much over all educations distinguished. As a consequence this variable does not show the different influences of the labour supply on the educational levels, which could have been expected according to the estimation results of table 9. Probably the estimation results of the more disaggregated model are largely influenced by the educational groups within the educational levels that are well represented within the sample.

Table 12. F-statistics for the exclusion of variables INVVA, DCU and PLF (58 educations)[a]

Excluded variable	F-statistic	Number of restrictions	Critical value (5%)
INVVA	3.34*	56	1.34
DCU	21.42*	56	1.34
PLF	24.02*	52	1.35

a The F-statistics are calculated using the formula (12) of Buse (1979).
* Significant F-statistics at the 5%-level.

The F-statistics of this model are given in table 12. The three explanatory variables are according to these results overall significant, so that the explanatory contribution of these variables to the educational structure should not be neglected.

4.3. A comparison of the Fixed Coefficient results with the Multinomial Logit results

In this chapter the occupational and educational shares of persons employed within branches of industry and both branches of industry and occupations respectively are explained by economic explanatory variables. Here we compare these results with the results of the fixed coefficient method. In annex B the results of a shift and share analysis of the occupational model (with seven occupations) are given in table B.1. Column 4 contains the results of the fixed coefficient method in which the occupational structure of 1979 is imposed upon the total numbers of employed persons within the 21 branches of industry in 1985. By means of the estimation results of the SML- and the MML-method we calculated the estimated numbers of employed persons within the seven occupations. These estimated numbers and the numbers of the fixed coefficient method are compared with the real numbers of employed persons in 1985. We calculated the average absolute deviation of the estimated numbers from the real numbers per occupation in 1985 with respect to the total numbers of persons employed in 1985, that is

$$\frac{1}{O} \sum_{o=1}^{O} \frac{|AEP^*(o,1985)-AEP(o,1985)|}{AEP(1985)} \qquad (4.4)$$

where

O : total number of occupations;
AEP(o,1985) : number of employed persons with occupation o in 1985;
$AEP^*(o,1985)$: estimated number of employed persons with occupation o in 1985;
AEP(1985) : total number of employed persons in 1985 (= $\sum_o$ AEP(o,1985)).

Table 13 gives the calculated criterions (4.4) for all estimation results and all models (where the criterion in (4.4) is summed over educations instead of occupations within the educational models).

Table 13. Comparing the estimation results of the Fixed Coefficient Method (FCM) with the Multinomial Logit results (SML and MML)

	FCM	SML	MML/MML(-)[a]
Occupational model (7 occupations)	0.0066	0.0034	0.0051
Educational model (5 educational levels)	0.0352	0.0011	0.0118
Occupational model (83 occupations)	0.0010	0.0006	0.0037
Educational model (58 educations)	0.0039	0.0013	0.0038

[a] The more aggregated models were estimated with MML(-).

The first row in table 13 shows the results of the highly aggregated occupational model. We see that the SML-result is much better than the FCM-result, that is the FCM-result shows an average deviation which is twice the

SML-result. Although the MML-result is still better than the FCM-result, the difference between both results is much smaller. Here all models show better SML- than FCM-results. However, according to this criterion results are not improved by taking account of the specification errors; the MML-results are worse than the SML-results and the MML-result even exceeds the FCM-result within the highly disaggregated occupational model. However, within this occupational model the fixed coefficient method seems rather good with respect to the other three models. Unfortunately according to these results we still can not draw any definite conclusions about the estimation method multinomial logit compared with the fixed coefficient method. Here only one simple criterion is used and just one year, 1985, is taken into account. Because the FCM-results of the highly disaggregated models indicate much better results than the more aggregated models, these results justify the fact that the assumption of the rigidity of the occupational and educational structure seems significant so that the dependence on past structures should always be considered.

5. CONCLUSIONS

In this study the occupational structure of 83 occupations was explained by the past occupational structure and the investments and degree of capacity utilization within 21 branches of industry. The estimation results indicated the major significance of the past occupational structure but also the overall non-negligence of both industry-specific variables.

In this study also the educational structure of 58 educations within the occurring combinations of the 21 branches of industry and 83 occupations was examined. Besides the past educational structure and the industry-specific variables, investments and degree of capacity utilization, the labour supply variable "potential labour force" was used for explaining the present educational structure. Like in the occupational model, the past educational structure played a highly significant role. Moreover, the three other exogenous variables are overall significant.

However, of course some remarks of criticism have to be made. Firstly, the serious and seemingly insurmountable problem we encountered was the lacking of past observations. The results of the shift and share method (chapter 2) indicated that the past structures should be taken into account. Because we chose a specification that contained a logarithmic transformed lagged endogenous variable the problem of missing observations arose. We solved this problem by substituting the past zero observations of presently occurring occupations or educations by one employed person (with this certain occupation or education). We expect that this artificial solution to the problem does not influence the estimation results in a significant way because of the relatively small contribution of these "created" numbers.

The second problem concerns the fact that the estimation method used was not fully executed as described by Parks (the introducer of the method used). Both the occupational and educational model were estimated by Standard Multinomial Logit and should in a second stage be estimated by Modified Multinomial Logit. Both the measurement and the specification error would then be taken into account respectively. We did not succeed in executing the Modified Multinomial Logit method because of the fact that the covariance matrix of the specification error was found to be indefinite. We therefore estimated this matrix by assuming it to be diagonal so we extended the Standard Multinomial Method but modified the Modified Multinomial Method.

A third problem was encountered when estimating the educational structure within branches of industry and occupations. Because we here wanted to use the Multinomial Logit Method again there had to be an education to serve as a reference category. It was impossible to find an educational category that occurred within all branches of industry and occupations, so again adjustments had to be made by replacing a lacking past reference education by a dummy value of one employed person.

Beside these above critical remarks on the estimation procedure, improvements could be made with regards to the exogenous variables used. The lagged endogenous variable seems to fit well and seems to dominate the other explanatory variables. Possibly occupational specific variables like the average wages of each occupational category could improve the explanatory power of these variables of the occupational model. The educational model possesses already an educational-specific variable, namely the potential labour force, but the differentiation of this variable could also be better extended according to the 58 educations distinguished.

In comparison with the preceding studies of Dekker et al. (1988) and Beekman et al (1989) within the Research Centre for Education and Labour Market this study differs mainly in the estimation method used. Dekker et al. explained the occupational structure within branches of industry by means of Weighted Least Squares, where Beekman et al. used the same estimation method when explaining the educational structure within both industries and occupations. Both studies explained observed fractions of working persons that were not related to a reference category. Therefore estimated fractions had to be adjusted afterwards to maintain the logical consistency that all fractions (occupations within industries and educations within both industries and occupations) add up to one. Logical consistency is maintained in this study by means of the reference category used. Also because of this logical consistency a specific structure of the covariance matrix was taken into account. Another difference between this study and both studies mentioned above is that in this study past structures were used as explanatory variables. According to the theory and also according to our estimation results these lagged structures seem to play an important role, although the role of the other explanatory variables that ought to explain the structure shifts should of course not be neglected. The coefficient estimates of the other explanatory variables are of course determined by the (relatively high) coefficient estimate of the lagged endogenous variable. Probably the long term coefficient estimates, that could be calculated by assuming the endogenous and the lagged endogenous variable to be the same, will indicate the importance of these variables.

Like most previous studies, this study could be improved by more and better data. The Labour-Force Censuses we used only contain four years. Because of the econometric specification chosen, only the occupational and educational structure of three years (1981, 1983 and 1985) could be considered. The relative importance of the time aspect of the lagged endogenous variable within the specification certainly asks for a longer time-period of analysis. If the occupational and educational structures at more points of time are analyzed, and possibly more fluctuations over this longer time period are found, the other exogenous variables used could probably account for more explanatory power. Moreover, of course more recent data are more interesting for analyzing latest developments of the occupational and educational structures.

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ANNEX A: Branches of industry, occupational and educational groups

ANNEX A.1.: Branches of industry codes and corresponding names

INDEX	AGRICULTURE & MANUFACTURING INDUSTRY	CODE
1	Agriculture, fishing, forestry	01-03
2	Manufacture of foodstuffs, beverages, tobacco products	20-21
3	Manufacture of textiles, wearing apparel, footwear and other leather products	22-24
4	Manufacture of wood and building materials and glass products	25,32
5	Manufacture of paper and printing and publishing industries	26-27
6	Petroleum, chemical industry and manufacture of rubber and plastic products	28-31
7	Basic metal industries	33
8	Manufacture of metal products, mechanical and instrument engineering	34,35,38,39
9	Electrical engineering	36
10	Manufacture of transport equipment	37
11	Mining and quarrying	11,12,19
12	Electricity, gas and water	40
13	Construction	51,52
	TERIARY & QUATERNARY SERVICES	
14	Trade (wholesale and retail)	61,62,65,66
15	Sea- and airtransport	73,75
16	Transport, storage and communication	71,72,74,76,77
17	Banking and insurances	81,82
18	Other private services and ownership of dwellings	67,68,83-85,98,99
19	Medical and veterinary services	93
20	Other public services	91,94-97
	GOVERNMENT	
21	Public administration and education	90,92

ANNEX A.2.: Occupational codes and corresponding names

INDEX	CODE	OCCUPATION
1	01	Physical scientists and related technicians.
2	02/03	Architects, engineers and related techniciens.
3	04	Aircraft and ships' officers.
4	05	Life scientists and related technicians.
5	06/07	Medical, dental, veterinary and related workers.
6	08	Statisticians, mathematicians, systems analysts and related technicians.
7	09	Economists.
8	11	Accountants.
9	12	Jurists.
10	13	Teachers.
11	14	Workers in religion.
12	15	Authors, journalists and related writers.
13	16	Sculptors, painters, photographers and related creative artists.
14	17	Composers and performing artists.
15	18	Athletes, sportsmen and related workers.
16	19	Professional, technical and related workers N.E.C.
17	20	Legislative officials and government administrators.
18	21	Managing and higher executive functions exclusive of public administration.
19	30	Clerical supervisors.
20	31	Government executive officials.
21	32	Stenographers, typists and card- and tape-punching machine operators.
22	33	Bookkeepers, cashiers and related workers.
23	34	Computing machine operators.
24	35	Transport and communications supervisors.
25	36	Transport conductors.
26	37	Mail distribution clerks.
27	38	Telephone and telegraph operators.
28	39	Clerical and related workers N.E.C.
29	40	Managers (wholesale).
30	41	Managers (retail trade).
31	42	Working proprietors (wholesale).
32	43/44	Shopkeepers; street vendors.
33	45	Sales supervisors and buyers.
34	46	Technical salesmen, commercial travellers and manufacturers' agents.
35	47	Insurance, real estate, securities and business services, salesmen, and auctioneers.
36	48	Salesmen, shop assistants and related workers.
37	49	Sales workers N.E.C.
38	50	Managers (catering and lodging services).
39	51	Working proprietors (catering and lodging services).
40	52	Housekeeping and related service supervisors.
41	53	Cooks, waiters, bartenders and related workers.
42	54	Maids and related housekeeping workers N.E.C.
43	55	Building caretakers, charworkers, cleaners and related workers.
44	56	Launderers, dry-cleaners and pressers.
45	57	Hairdressers, barbers, beauticians related workers.
46	58	Protective service workers.
47	59	Service workers N.E.C.

48	60/68	Farm managers and supervisors.
49	61	Farmers.
50	62	Agricultural and animal husbandry workers.
51	63	Forestry workers.
52	64	Fishermen, hunters and related workers.
53	70	Production supervisors and general foremen.
54	71	Miners, quarrymen, well drillers and related workers.
55	72	Metal processors.
56	73	Wood peparation workers and paper makers.
57	74	Chemical processers and related workers.
58	75	Spinners, weavers, knitters, dyers and related workers.
59	76	Tanners, fellmongers and pelt dressers.
60	77	Food and beverage processers.
61	78	Tobacco preparers and tobacco-product makers.
62	79	Tailors, dressmakers, sewers, upholsterers and related workers.
63	80	Shoemakers, and leather goods makers.
64	81	Cabinetmakers, woodworkers and related workers.
65	82	Stone cutters and carvers.
66	83	Blacksmiths, toolmakers, and machine tool operators.
67	84	Machinery fitters, machine assemblers and precision-instrument makers (except electrical).
68	85	Electrical fitters and related electric and electronics workers.
69	86	Broadcasting station and sound equipment operators and cinema projectionists.
70	87	Plumbers, welders, sheet metal and structural metal preparers and erectors.
71	88	Jewellery and precious metal workers.
72	89	Glass formers, potters and related workers.
73	90	Rubber and plastics product makers.
74	91	Paper and paperboard products makers.
75	92	Printers and related workers.
76	93	Painters.
77	94	Production and related workers N.E.C.
78	95	Bricklayers, carpenters and other construction workers.
79	96	Stationary engine and related equipment operators.
80	97	Material handling and related equipment operators, dockers and freight handler.
81	98	Transport equipment operators.
82	99	Labourers N.E.C.
83	xx	Professional soldiers

ANNEX A.3.: Educational codes and corresponding names

IND	CODE	EDUCATION
Educational level 2:		Primary education
1	000,111,201	Elementary education
Educational level 3:		Secondary education (lower level)
2	301	General secondary education, lower level
3	321-329	Junior agricultural education
4	331-339	Junior technical education
5	341-349	Junior transport, communication and traffic education
6	351-359	Junior medical and paramedical education
7	361-366	Lower business education, Secondary school for tradesmen (lower level), Practical training for clerks and salesmen at the school for domestic science and technique
8	381-386	School for domestic science and technique exclusive of training for clerks and salesmen, establishment certificate for café holders
9	391-394	Business security and surveillance training
10	other	Other disciples at educational level 3
Educational level 4:		Secondary education (higher level)
11	401	General secondary education, intermediate and higher levels
12	406	Training for driving instructor, sports coach
13	421-429	Senior agricultural education
14	431-439	Senior school for laboratory science and senior technical training
15	441-449	Senior education in transportation, communication and traffic science
16	451	Training of nurses and medical receptionists at the secondary school for medical and other services, higher level
17	452	Secondary school for medical laboratory science, higher level
18	454	Training for ward orderlies, etc.
19	453,461-464	Training for medical clerks, senior retail school and intermediate business education, etc.
20	466	Intermediate business education, department of management studies
21	471	Social work and welfare work (secondary school for medical and other services)
22	481,484-486	External care, services as taught at the secondary school for medical and other services or the INTAS, fashion drawing, etc
23	483	Secondary hotel and catering school, hairdresser's school
24	491-494	Training of municipal and state police, fire brigade
25	other	Other disciplines at educational level 4

Educational level 5: Higher vocational education

26	506	Training college for primary and pre-primary school teachers, Secondary-school teacher training, new style
27	511	Training for interpreters and translators
28	516	Training for pastoral work, etc.
29	521-529	Agricultural college
30	531	Laboratory college
31	536-539	Technical college
32	541-549	Transport, communication and traffic college
33	551	Nursing college, physiotherapy college
34	552	College for medical laboratory science
35	554	Dietetics college, etc.
36	561	Business science college, exclusive of administrative and fiscal studies
37	562	Courses for ergonomists and management science at the Higher Technical School, etc.
38	566	Business science college, legal and administrative studies
39	571	College of social studies, Library studies
40	583	Hotel College
41	586	Art Academy, Academy of Dramatic Art
42	591-594	Police College, RMA, Naval Academy
43	other	Other disciplines at educational level 5

Educational level 6: University education

44	606	Teacher training (highest level)
45	611	Language and literature
46	616	Theology
47	621-629	Agricultural and domestic sciences
48	631	Mathematics and physics
49	636-639	Technical sciences
50	651	Medical sciences
51	652	Pharmacy
52	661	Economics and business administration (B.A.)
53	662	Econometrics, actuary and management (B.Sc.)
54	666	Law
55	671	Socio-cultural sciences
56	686	Fine arts
57	691-694	Military Academy
58	other	Other disciplines at educational level 6

ANNEX B: Shift and share analysis

ANNEX B.1.: Changes in the occupational structure and its components, 1979-1985

Table B.1. Changes in the occupational structure and its components, 1979-1985

	1	2	3	4	5
Profess.	783080	914660	776423	874802	817099
Administ.	113663	159564	112697	111882	166038
Clerical	809384	826548	802503	824651	803023
Sales	442821	438119	439056	428044	450871
Services	386447	402910	383162	434894	354579
Agricult.	267484	250744	265210	253258	262080
Product.	1531391	1304877	1518372	1369890	1443732
Total	4334270	4297422	4297423	4297421	4297422

	6	7	8	9	10	11	12
Profess.	138237	98379	40676	-818	71.17	29.42	-0.59
Administ.	46867	-815	53341	-5659	-1.74	113.81	-12.07
Clerical	24045	22148	520	1377	92.11	2.16	5.73
Sales	-937	-11012	11815	-1740	1175.24	-1260.94	185.7
Services	19748	51732	-28583	-3401	261.96	-144.74	-17.22
Agricult.	-14466	-11952	-3130	616	82.62	21.64	-4.26
Product.	-213495	-148482	-74640	9627	69.55	34.96	-4.51

Column 1 : Adjusted number of employed persons in 1979;
Column 2 : Adjusted number of employed persons in 1985;
Column 3 : Adjusted number of employed persons in 1985 if the occupational structure of 1979 is applied to the total adjusted number of employed persons in 1985;
Column 4 : Adjusted number of employed persons in 1985 if the occupational within industries of 1979 is applied to the adjusted number of employed persons within industries in 1985;
Column 5 : Adjusted number of employed persons in 1985 if the industrial structure effect of 1979 is applied to the total number of employed persons in 1985 with the occupational structure of 1985;
Column 6 : Change in occupational structure because of industry and occupational shifts, called the net shift (= column 2 - column 3);
Column 7 : Change in occupational structure because of industry changes, called the industry shift effect (= column 4 - column 3);
Column 8 : Change in occupational structure because of occupational structure changes within industries, called the occupational shift effect (= column 5- column 3);
Column 9 : Changes in occupational structure as a consequence of changes in both occupational and industrial shifts that are not directly attributable to one of both effect, called the interaction effect (= column 6 - column 7- column 8);
Column 10 : Share of the industrial shift in the total shift (= column 7 divided by column 6);
Column 11 : Share of the occupational shift in the total shift (= column 8 divided by column 6);
Column 12 : Share of the interaction shift in the total shift (= column 9 divided by column 6).

The columns 10 until 12 previously mentioned are here given for 83 occupations within 21 industries (see annexes A.2 and A.1).

Table B.2. Percent changes in the occupational structure and its components, 1979-1985

Occ.	Industry shift effect	Occ. shift effect	Inter. effect	Occ.	Industry shift effect	Occ. shift effect	Inter. effect
1	297.91	-98.96	-98.96	42	691.24	-628.68	37.44
2	-44.14	32.71	111.43	43	71.72	47.49	-19.21
3	86.80	13.64	-0.44	44	-137.98	178.79	59.19
4	50.39	38.41	11.20	45	-1070.97	1095.16	75.81
5	82.73	13.13	4.14	46	47.86	48.66	3.48
6	5.52	88.69	5.79	47	-685.34	672.28	113.06
7	19.64	84.47	-4.11	48	-2.14	110.8	-8.66
8	207.52	-101.00	-6.52	49	65.93	36.09	-2.02
9	16.10	75.18	8.72	50	64.56	43.44	-7.99
10	82.77	14.43	2.80	51	35.04	80.47	-15.51
11	178.37	-58.37	-20.00	52	-12.15	116.05	-3.90
12	5.88	87.04	7.07	53	-213.98	314.24	-0.27
13	-213.67	225.95	87.72	54	-68.77	144.52	24.25
14	232.91	-110.71	-22.20	55	20.16	-0.79	80.63
15	-568.90	570.23	98.66	56	27.12	73.55	-0.68
16	75.46	26.37	-1.83	57	266.23	-125.58	-40.65
17	-89.61	168.12	21.50	58	59.44	50.97	-10.4
18	-2.50	114.29	-11.78	59	790.91	-624.24	-66.67
19	-55.64	137.71	17.93	60	85.20	11.10	3.70
20	-42.15	130.77	11.39	61	58.76	46.19	-4.95
21	92.26	9.83	-2.09	62	100.71	-21.74	21.03
22	24.11	60.83	15.07	63	127.47	-72.16	44.69
23	-59.24	155.10	4.14	64	55.88	54.04	-9.92
24	6.62	103.59	-10.21	65	-173.58	374.53	-100.94
25	15.22	85.75	-0.97	66	30.50	86.83	-17.33
26	-9.48	105.31	4.17	67	35.48	70.52	-6.00
27	-40.75	121.96	18.79	68	-234.57	423.43	-88.86
28	97.63	-12.94	15.31	69	12.62	70.73	16.65
29	-4.14	107.12	-2.98	70	51.37	42.85	5.78
30	-12.82	115.49	-2.67	71	-38.46	84.62	53.85
31	-862.86	937.14	25.71	72	136.70	-72.04	35.34
32	21.25	81.72	-2.97	73	416.49	-288.92	-27.57
33	34.67	61.85	3.48	74	-30.96	129.56	1.40
34	-111.10	261.02	-49.92	75	99.33	-19.24	19.92
35	18.52	81.43	0.05	76	78.27	24.49	-2.76
36	145.53	-71.42	25.90	77	41.13	62.59	-3.72
37	-3.97	101.87	2.10	78	80.74	27.17	-7.91
38	-37.93	117.89	20.03	79	27.43	103.44	-30.87
39	-218.19	288.08	30.11	80	253.11	-100.28	-52.84
40	49.64	36.38	13.98	81	40.42	67.46	-7.88
41	492.62	-349.86	-42.75	82	41.29	72.76	-14.04
				83	-122.89	204.02	18.87

ANNEX B.2.: Changes in the educational structure and its components, 1979-1985

Table B.3. Changes in educational structure and its components, 1979-1985

	1	2	3	4	5
Primary	967962	593387	959733	885726	645925
Secondary l.	1368124	1210803	1356493	1296436	1282790
Secondary h.	1421682	1728228	1409596	1446934	1704443
Higher	423422	558105	419822	486247	490316
University	153080	206900	151779	181877	173842
Total*	4334270	4297423	4297423	4297220	4297316

	6	7	8	9	10	11	12
Primary	-366346	-74007	-313808	21469	20.2	85.66	-5.86
Secondary l.	-145690	-60057	-73703	-11930	41.22	50.59	8.19
Secondary h.	318632	37338	294847	-13553	11.72	92.54	-4.25
Higher	138283	66425	70494	1364	48.04	50.98	0.99
University	55121	30098	22063	2960	54.6	40.03	5.37

* The sums of the columns 4 and 5 do not equal the sum of column 3 because of the occurrence of industry-occupation-combinations that do not exist in 1979 but do exist in 1985.

The columns 10 until 12 previously mentioned (see annex B.1) are here given for 58 educations within 83 occupations and 21 industries (see annexes A.1 until A.3).

Table B.4. Percent changes in the educational structure and its components, 1979-1985

Edu.	Ind-occ. shift effect	Edu. shift effect	Inter. effect	Edu.	Ind-occ. shift effect	Edu. shift effect	Inter. effect
1	11.72	84.70	3.57	30	15.94	69.96	14.09
2	-212.77	140.63	172.14	31	1.45	56.03	42.52
3	25.94	63.97	10.10	32	322.31	-259.30	36.98
4	57.65	20.42	21.93	33	30.51	51.57	17.92
5	-0.24	107.31	-7.07	34	22.22	63.01	14.78
6	-36.39	102.08	34.31	35	32.86	56.70	10.44
7	4.34	102.63	-6.97	36	4.77	72.64	22.59
8	-70.54	98.59	71.95	37	1.85	71.16	27.00
9	4.41	80.07	15.52	38	21.42	92.06	-13.48
10	1.49	105.60	-7.09	39	32.19	53.53	14.28
11	19.73	68.88	11.39	40	50.10	60.24	-10.34
12	123.03	54.77	-77.8	41	120.27	55.66	-75.93
13	-13.42	116.80	-3.38	42	531.71	467.07	-898.78
14	-283.44	416.68	-33.24	43	-40.53	134.56	5.97
15	10.50	94.89	-5.39	44	30.03	52.84	17.13
16	100.04	10.31	-10.35	45	24.53	53.70	21.77
17	14.93	37.25	47.82	46	53.49	56.51	-10.00
18	40.05	49.2	10.75	47	17.45	58.59	23.96
19	0.66	89.45	9.89	48	122.82	-85.55	62.73
20	178.68	57.97	-136.65	49	21.80	62.21	15.99
21	43.71	50.81	5.48	50	96.60	-4.95	8.35
22	34.15	77.21	-11.37	51	-44.04	170.64	-26.61
23	47.87	116.13	-64.00	52	24.52	31.29	44.20
24	24.65	74.78	0.56	53	0.52	81.56	17.92
25	-7.11	102.57	4.54	54	16.60	34.57	48.83
26	77.70	11.68	10.62	55	16.62	66.88	16.50
27	40.15	1.72	58.13	56	-302.00	378.00	24.00
28	422.16	-111.34	-210.82	57	17.09	118.80	-35.90
29	8.86	25.42	65.72	58	-29.28	132.63	-3.35

ANNEX C: Estimation of the Multinomial Logit model[11]

For describing the estimation method we recall equation (11) (where we assume τ_i^* to be zero)

$$\ln(f_t(i|g)/f_t(0|g)) = \alpha \ln(f_{t-2}(i|g)/f_{t-2}(0|g)) + x_{gt}^T \beta_i + x_{it}^T\tau_i + e_{igt} - e_{0gt} + w_{igt}$$

and define :

$i = 1,2 \,..\, I$

$g = 1,2 \,..\, G$

$t = 2,3 \,..\, T$ [12]

0 : reference labour category

$$y = \begin{bmatrix} y_{12} \\ y_{22} \\ \cdot \\ y_{G-1,T} \\ y_{GT} \end{bmatrix} \quad \text{where} \quad y_{gt} = \begin{bmatrix} \ln(f_t(1|g)/f_t(0|g)) \\ \ln(f_t(2|g)/f_t(0|g)) \\ \cdot \\ \ln(f_t(I|g)/f_t(0|g)) \end{bmatrix}$$

$$X = \begin{bmatrix} y_{11} & X_{12} & x_2 \\ y_{21} & X_{22} & x_2 \\ \cdot & \cdot & \cdot \\ y_{G-1,T-1} & X_{G-1,T} & x_T \\ y_{G,T-1} & X_{GT} & x_T \end{bmatrix}$$

where X_{gt} equals the IxI-diagonal matrix with on the diagonal the elements x_{gt}

$$\text{and} \quad x_t = \begin{bmatrix} x_{1t} & & 0 \\ \cdot & \cdot & \cdot \\ \cdot & & \cdot \\ 0 & & x_{It} \end{bmatrix}$$

---

11. See also Parks (1980) or Van Opstal (1988) for a complete description of Modified Multinomial Logit.

12. Because we use a lagged dependent variable the index time ranges from 2 to T.

$\beta = (\alpha, \beta_1 \ldots \beta_I, \tau_1 \ldots \tau_I)^T$

$$v_{gt} = \begin{bmatrix} v_{1gt} \\ v_{2gt} \\ \cdot \\ v_{Igt} \end{bmatrix} \qquad e_{gt} = \begin{bmatrix} e_{1gt} - e_{0gt} \\ e_{2gt} - e_{0gt} \\ \cdot \\ e_{Igt} - e_{0gt} \end{bmatrix} \qquad w_{gt} = \begin{bmatrix} w_{1gt} \\ w_{2gt} \\ \cdot \\ w_{Igt} \end{bmatrix} \quad \text{where} \quad v_{igt} = e_{igt} - e_{0gt} + w_{igt}$$

Further we define the block-diagonal covariance matrix

$$V = \begin{bmatrix} W_{12}+\Sigma & & & 0 \\ \cdot & W_{22}+\Sigma & & \cdot \\ \cdot & & \cdot & \cdot \\ \cdot & & W_{G-1,T}+\Sigma & \cdot \\ 0 & & & W_{GT}+\Sigma \end{bmatrix} \tag{C.1}$$

The covariance matrix of the specification error is given by

$$\begin{aligned} E((e_{gt}-e_{0t})\,(e_{g't'}-e_{0t'})^T\,) &= \Sigma \qquad \text{if } g = g' \text{ and } t = t' \\ &= 0 \qquad \text{else} \end{aligned} \tag{C.2}$$

and the covariance matrices of the measurement errors are

$$\begin{aligned} E(w_{gt}\, w_{g't'}{}^T) &= W_{gt} \qquad \text{if } g = g' \text{ and } t = t' \\ &= 0 \qquad \text{else.} \end{aligned} \tag{C.3}$$

The (k,1)-coefficient of the covariance matrix W_{gt} can be proven to be

$$w_{gt}{}^{kl} = 1/N_{gt}\,(d_{kl}\,(1/p_t(i|g) + (1/p_t(0|g))$$

where

N_{gt} = number of employed people within industry g at time t and

$d_{kl} = 1$ if $k = 1$
$d_{kl} = 0$ else.

Then equation (11) equals

$$y = X\beta + v \qquad \text{where} \qquad v \sim N(0,V) \tag{C.4}$$

Estimation of the Modified Multinomial Model consist of applying Generalized Least Squares to equation twice (C.4) in the following way:

(1) The coefficients of the W_{gt}'s are estimated by replacing the theoretical probabilities $p_t(i|g)$ by the observed frequencies $f_t(i|g)$. Then the Standard Multinomial Logit estimator β_{SML} is calculated as

$$\beta_{SML} = (X^T \hat{W}^{-1} X)^{-1} X^T \hat{W}^{-1} y \qquad \text{(C.5)}$$

where $\hat{W}$ represents the estimated covariance matrix of the measurement error. We define the SML-residuals as

$$u = y - X\beta_{SML}$$

$$u = (u_{12}, u_{22} \cdot\cdot u_{GT})^T \quad , u_{gt} = (u_{1gt}, u_{2gt} \cdots u_{Igt})^T$$

(2) The SML-residuals are used to estimate the elements of covariance matrix Σ. We calculate :

$$v^{kl} = 1/R^{kl} \sum_{t=2}^{T} \sum_{g=1}^{G} u_{kgt} u_{lgt} \qquad \text{(C.6)}$$

Here only branches in which the labour category i exists are taken into account, so that R^{kl} equals the number of block-matrices within equation (C.1) that contain both categories of labour k and l.

(3) A consistent estimate of covariance matrix Σ, denoted as $\hat{\Sigma}$ with elements e^{kl}, is then found by

$$e^{kl} = v^{kl} - (1/R^{kl}) \sum_{t=2}^{T} \sum_{g=1}^{G} w_{gt} \qquad \text{(C.7)}$$

This estimated matrix $\hat{\Sigma}$, that should be semi-positive definite, is added to the estimated covariance matrices $\hat{W}_{gt}$ in (C.1), so a new (positive definite) estimator of V, $\hat{V}$, is found.

(4) Finally the Modified Multinomial Logit estimator, β_{MML}, is calculated by

$$\beta_{MML} = (X' \hat{V}^{-1} X)^{-1} X' \hat{V}^{-1} y . \qquad \text{(C.8)}$$

If only the measurement error is taken into account and the specification error should not be neglected (that is Σ does not equal zero), the standard errors of the estimates will be biased downward. This follows from the fact that:

$$Var(\beta_{SML}) = (X'W^{-1}X)^{-1} X'W^{-1}VW^{-1}X (X'W^{-1}X)^{-1} > Var(\beta_{MML}) = (X'W^{-1}X)^{-1}.$$

We estimated the occupational and educational model by executing the first step, that is calculating β_{SML}. We did however not succeed in calculating a semi-positive definite matrix Σ (see C.7). This problem arose because of the fact that not every category of labour occurs within every branch (so the number of existing categories within branches, R^{kl}, did not equal the maximum number of branches and points in time, being (T-1) x G). For this reason we assumed Σ within (C.2) to be diagonal instead of full-symmetric when estimating the occupational and educational models that distinguish 83 occupations and 58 educations.

ANNEX D: The estimation results of the Multinomial Logit Method

ANNEX D.1 The occupational model

STANDARD MULTINOMIAL LOGIT

	B	SD
LENDO	0.842	0.0003
INVVA1	-0.0265	0.0322
INVVA2	-0.8156	0.0147
INVVA3	0.3276	0.0347
INVVA4	-1.0818	0.0331
INVVA5	-1.4304	0.0307
INVVA6	-0.7408	0.0265
INVVA7	0.2478	0.044
INVVA8	-2.1216	0.0684
INVVA9	-0.7175	0.0342
INVVA10	1.3897	0.0264
INVVA11	-1.0369	0.172
INVVA12	-0.8346	0.0486
INVVA13	-0.6521	0.0582
INVVA14	-2.5881	0.1092
INVVA15	-2.6425	0.1255
INVVA16	-0.282	0.0184
INVVA17	-5.311	0.1777
INVVA18	-0.897	0.0196
INVVA19	-1.2326	0.0414
INVVA20	2.6357	0.0782
INVVA21	-0.496	0.0167
INVVA22	-0.7831	0.0134
INVVA23	0.2413	0.0522
INVVA24	-0.0623	0.0305
INVVA25	-1.8862	0.337
INVVA26	0.5833	0.0414
INVVA27	-0.2647	0.0428
INVVA29	9.4235	1.4708
INVVA30	3.913	0.3324
INVVA31	35.9036	1.5182
INVVA32	33.5713	1.3097
INVVA33	-1.703	0.051
INVVA34	-1.2298	0.0642
INVVA35	-1.2265	0.052
INVVA36	-0.852	0.0477
INVVA37	9.919	0.3101
INVVA38	-0.1412	0.0534
INVVA39	26.1123	0.7973
INVVA40	2.0384	0.0678
INVVA41	-1.73	0.0236
INVVA42	-0.8693	0.0301
INVVA43	-0.4944	0.0195
INVVA44	0.6156	0.2552
INVVA45	3.1519	0.2706
INVVA46	0.3869	0.0267
INVVA47	-2.0438	0.0461
INVVA48	2.5412	0.182

MODIFIED MULTINOMIAL LOGIT (-)

	B	SD
LENDO	0.6176	0.0094
INVVA1	-0.8097	1.2444
INVVA2	0.0562	0.4337
INVVA3	1.0428	2.282
INVVA4	-3.2783	2.1963
INVVA5	-1.239	1.5044
INVVA6	-0.1659	0.7416
INVVA7	1.4533	1.1773
INVVA8	-1.0967	1.8183
INVVA9	0.2559	1.7266
INVVA10	0.5719	1.3149
INVVA11	-4.8894	2.7884
INVVA12	0.2525	1.1675
INVVA13	-1.3342	1.5594
INVVA14	-3.1917	3.0522
INVVA15	-1.7544	2.1598
INVVA16	-0.5731	0.8817
INVVA17	-0.431	4.2388
INVVA18	-0.9125	0.393
INVVA19	-0.4376	1.773
INVVA20	3.1265	2.2977
INVVA21	-0.6205	0.8256
INVVA22	-0.1304	0.4132
INVVA23	-0.5325	1.3293
INVVA24	1.1035	1.1393
INVVA25	1.2494	4.2406
INVVA26	1.0166	1.3072
INVVA27	0.2116	0.8329
INVVA29	9.6503	19.3639
INVVA30	2.9322	3.4683
INVVA31	29.6085	16.9993
INVVA32	73.845	15.3234
INVVA33	-1.2413	1.052
INVVA34	-2.5272	1.6891
INVVA35	-1.6232	1.3905
INVVA36	-2.6165	1.4003
INVVA37	6.8501	3.7875
INVVA38	-0.2502	1.681
INVVA39	17.8255	3.2483
INVVA40	2.7978	1.7719
INVVA41	-0.4923	0.6915
INVVA42	0.1141	1.5004
INVVA43	-1.5539	0.882
INVVA44	3.4266	2.9359
INVVA45	-4.2828	3.2031
INVVA46	0.8569	0.9624
INVVA47	-0.7808	1.1304
INVVA48	2.0986	2.5891

INVVA49	-0.4781	0.5217
INVVA50	2.555	0.0528
INVVA51	3.9102	0.1739
INVVA52	2.6466	0.4335
INVVA53	-0.1333	0.0243
INVVA54	3.3606	0.3014
INVVA55	7.055	0.1311
INVVA56	10.4599	0.2929
INVVA57	2.8877	0.0779
INVVA58	-1.9462	0.1521
INVVA59	12.4823	1.2026
INVVA60	4.2207	0.0737
INVVA61	-2.4368	5.2452
INVVA62	-0.383	0.0935
INVVA63	6.406	0.2213
INVVA64	5.7323	0.1609
INVVA65	-48.901	1.5335
INVVA66	-2.4302	0.073
INVVA67	-0.469	0.0183
INVVA68	-0.3314	0.0196
INVVA69	-0.0404	0.1966
INVVA70	-0.9927	0.0241
INVVA71	-13.6103	0.7842
INVVA72	0.8562	0.187
INVVA73	1.629	0.1201
INVVA74	8.6694	0.6589
INVVA75	0.0887	0.0576
INVVA76	-0.6976	0.0673
INVVA77	0.2099	0.0897
INVVA78	-1.8915	0.031
INVVA79	0.6084	0.0463
INVVA80	0.0148	0.0176
INVVA81	0.2852	0.0188
INVVA82	-1.4919	0.0379
INVVA83	-6.7962	0.1701
DCU1	-0.2717	0.006
DCU2	0.0081	0.0025
DCU3	-0.226	0.0127
DCU4	-0.0231	0.0055
DCU5	0.3546	0.0029
DCU6	-0.04	0.0041
DCU7	-0.3064	0.0071
DCU8	-0.0806	0.0059
DCU9	-0.0284	0.0068
DCU10	-0.2516	0.0074
DCU11	-0.0938	0.0105
DCU12	-0.086	0.007
DCU13	-0.2021	0.0052
DCU14	-0.0491	0.0084
DCU15	-0.1308	0.0101
DCU16	-0.0188	0.0034
DCU17	1.0948	0.0518
DCU18	0.0633	0.0027
DCU19	-0.0033	0.0092
DCU20	-1.0352	0.0228
DCU21	-0.0712	0.0028
DCU22	0.0819	0.0023
DCU23	-0.3944	0.0077

INVVA49	21.3501	10.4462
INVVA50	-3.0422	1.4484
INVVA51	3.4215	2.7343
INVVA52	6.1385	2.9789
INVVA53	-0.4552	0.8705
INVVA54	0.3748	2.6952
INVVA55	3.6639	2.5154
INVVA56	-0.3079	5.0684
INVVA57	2.8948	1.7075
INVVA58	6.31	6.1789
INVVA59	1.0015	11.5782
INVVA60	-0.9076	2.9064
INVVA61	-20.7115	39.9821
INVVA62	-2.1695	1.4154
INVVA63	0.2363	4.8112
INVVA64	-0.8599	2.7598
INVVA65	-12.7561	10.315
INVVA66	-1.5473	1.5163
INVVA67	0.1008	0.4746
INVVA68	0.7914	0.9501
INVVA69	-5.3298	2.8211
INVVA70	0.0626	0.9992
INVVA71	6.1219	12.6805
INVVA72	-0.9145	2.7914
INVVA73	7.1689	3.033
INVVA74	-0.1934	6.9717
INVVA75	0.3925	1.1217
INVVA76	-2.5677	1.6546
INVVA77	-1.3432	1.71
INVVA78	-0.4594	0.8172
INVVA79	1.1517	1.2215
INVVA80	0.5579	0.6916
INVVA81	0.2371	1.1191
INVVA82	-1.4081	0.9793
INVVA83	-0.7438	2.5361
DCU1	-0.7653	0.2023
DCU2	-0.2752	0.0782
DCU3	-0.9219	0.4675
DCU4	-0.438	0.3388
DCU5	-0.8436	0.283
DCU6	-0.6796	0.1355
DCU7	-1.2337	0.2177
DCU8	-1.2454	0.337
DCU9	-1.1167	0.3374
DCU10	-1.1215	0.2474
DCU11	-0.8154	0.4629
DCU12	-1.2437	0.2074
DCU13	-0.6431	0.2868
DCU14	-1.0336	0.434
DCU15	-1.5365	0.4596
DCU16	-0.8999	0.1618
DCU17	-1.0877	0.6933
DCU18	-0.0511	0.0704
DCU19	-1.1162	0.3342
DCU20	-2.0438	0.4966
DCU21	-0.2839	0.1484
DCU22	-0.1851	0.0743
DCU23	-0.9921	0.2441

DCU24	-0.1891	0.0073	DCU24	-1.045	0.2112
DCU25	-0.0034	0.0761	DCU25	-1.2104	0.752
DCU26	-0.2212	0.0092	DCU26	-1.1525	0.2443
DCU27	-0.38	0.0079	DCU27	-1.201	0.1556
DCU29	-0.3714	0.0847	DCU29	-1.04	1.5127
DCU30	-0.2478	0.02	DCU30	-1.0024	0.691
DCU31	-2.0807	0.088	DCU31	-2.3376	1.1297
DCU32	-1.7881	0.0758	DCU32	-3.9412	0.6989
DCU33	0.0146	0.0052	DCU33	-0.7828	0.1904
DCU34	0.0396	0.0059	DCU34	-0.4916	0.2645
DCU35	-0.0526	0.0044	DCU35	-0.9882	0.2697
DCU36	0.2749	0.0039	DCU36	-0.3342	0.2591
DCU37	-1.224	0.0292	DCU37	-1.9824	0.5169
DCU38	-0.3117	0.0066	DCU38	-0.9952	0.3149
DCU39	-0.2604	0.0089	DCU39	-0.3644	0.1994
DCU40	-0.3019	0.0077	DCU40	-1.5755	0.3207
DCU41	0.0105	0.0029	DCU41	-0.8276	0.1259
DCU42	0.1371	0.0031	DCU42	-1.1153	0.2744
DCU43	0.0156	0.0035	DCU43	-0.7089	0.1606
DCU44	-0.2242	0.008	DCU44	-1.3782	0.3831
DCU45	-0.0815	0.0053	DCU45	-0.5905	0.4347
DCU46	-0.2018	0.0071	DCU46	-1.087	0.1793
DCU47	-0.1192	0.005	DCU47	-1.2131	0.2111
DCU48	-0.3959	0.0225	DCU48	-1.5257	0.4013
DCU49	0.3039	0.0669	DCU49	-1.2752	0.9516
DCU50	-0.1881	0.0061	DCU50	-0.4504	0.2855
DCU51	-0.6985	0.0213	DCU51	-1.3867	0.4536
DCU52	-0.5171	0.0556	DCU52	-2.1505	0.4579
DCU53	-0.0684	0.0035	DCU53	-0.4056	0.158
DCU54	-0.4833	0.0221	DCU54	-1.2892	0.4253
DCU55	-0.89	0.0151	DCU55	-1.2645	0.4278
DCU56	-1.2501	0.0291	DCU56	-0.7296	0.7065
DCU57	-0.5114	0.0136	DCU57	-1.4327	0.2903
DCU58	-0.0168	0.0148	DCU58	-1.6009	0.6064
DCU59	-1.1201	0.0867	DCU59	-0.9096	1.1719
DCU60	-0.3919	0.0093	DCU60	-1.1238	0.4851
DCU61	0.0291	0.7377	DCU61	2.3856	5.6157
DCU62	-0.1067	0.0082	DCU62	-0.7905	0.2464
DCU63	-0.5566	0.0144	DCU63	-1.1415	0.522
DCU64	-0.7491	0.0159	DCU64	-0.9451	0.4024
DCU65	5.034	0.1645	DCU65	1.0335	0.9108
DCU66	0.0962	0.0068	DCU66	-0.745	0.2859
DCU67	-0.0187	0.0026	DCU67	-0.3121	0.0853
DCU68	-0.011	0.0032	DCU68	-0.4602	0.1722
DCU69	-0.0982	0.0204	DCU69	-0.8486	0.4104
DCU70	0.032	0.0031	DCU70	-0.7762	0.1851
DCU71	0.6525	0.0515	DCU71	-1.8384	0.9115
DCU72	-0.2438	0.0212	DCU72	-1.0654	0.461
DCU73	-0.3686	0.0206	DCU73	-1.7892	0.4191
DCU74	-0.9169	0.065	DCU74	-1.012	0.7707
DCU75	-0.0339	0.0068	DCU75	-1.2022	0.2024
DCU76	-0.0691	0.0049	DCU76	-0.5779	0.2944
DCU77	-0.3387	0.011	DCU77	-0.788	0.2966
DCU78	0.2339	0.003	DCU78	-0.6948	0.1492
DCU79	-0.479	0.0123	DCU79	-1.6431	0.2291
DCU80	-0.0181	0.0029	DCU80	-0.3486	0.1244
DCU81	-0.0523	0.0038	DCU81	-0.4755	0.2018
DCU82	-0.0482	0.0041	DCU82	-0.92	0.1791
DCU83	1.9016	0.0507	DCU83	-0.2248	0.4267

R^2-ADJ = 0.9428 R^2-ADJ = 0.8261

Number of observations = 3260

Reference category is occupation 28 "clerical and related workers".

D.2. The educational model

STANDARD MULTINOMIAL LOGIT

	B	SD
LENDO	0.5386	0.0002
INVVA2	0.6642	0.012
INVVA3	1.5729	0.0364
INVVA4	-0.8705	0.0124
INVVA5	-0.453	0.0375
INVVA6	0.1801	0.1867
INVVA7	-0.3927	0.0205
INVVA8	-1.6414	0.0206
INVVA9	-2.4945	0.0804
INVVA10	-0.3432	0.059
INVVA12	4.8269	0.0319
INVVA13	1.5591	0.0393
INVVA14	-0.4122	0.0124
INVVA15	0.661	0.0259
INVVA16	-4.874	0.0421
INVVA17	0.8097	0.0897
INVVA18	-4.132	0.0924
INVVA19	-1.0301	0.0123
INVVA20	3.5038	0.032
INVVA21	0.8723	0.0331
INVVA22	-2.2403	0.0282
INVVA23	-3.6702	0.0521
INVVA24	5.3447	0.0324
INVVA25	0.3702	0.0549
INVVA26	6.9541	0.0202
INVVA27	-3.4256	0.0819
INVVA28	-7.1819	0.1295
INVVA29	0.3636	0.0665
INVVA30	1.8879	0.0511
INVVA31	-0.7777	0.0215
INVVA32	1.7137	0.0305
INVVA33	-1.5825	0.0543
INVVA34	0.0764	0.0754
INVVA35	1.4229	0.1596
INVVA36	0.0482	0.0228
INVVA37	1.7563	0.1338
INVVA38	1.3745	0.0447
INVVA39	-0.0847	0.0274
INVVA40	0.2968	0.121
INVVA41	-2.3177	0.0464
INVVA42	0.5772	0.0991
INVVA43	0.2722	0.0558
INVVA44	2.238	0.0686
INVVA45	1.4518	0.0533
INVVA46	-5.4062	0.0918
INVVA47	-1.122	0.0774
INVVA48	0.3822	0.038
INVVA49	-0.7206	0.03
INVVA50	-1.6324	0.0461
INVVA51	2.1848	0.158
INVVA52	-0.0762	0.0375
INVVA53	-0.4552	0.1058

MODIFIED MULTINOMIAL LOGIT (-)

	B	SD
LENDO	0.4065	0.0158
INVVA2	0.9864	1.4998
INVVA3	1.371	2.6847
INVVA4	1.0343	1.5254
INVVA5	1.2931	3.5655
INVVA6	2.9731	8.323
INVVA7	1.4261	1.9013
INVVA8	0.0488	2.3493
INVVA9	-0.615	8.5514
INVVA10	1.719	3.4887
INVVA12	3.137	3.3652
INVVA13	0.9097	2.7089
INVVA14	1.0701	1.4889
INVVA15	2.0689	2.0251
INVVA16	1.3537	3.8016
INVVA17	1.1191	4.4004
INVVA18	-1.1734	6.159
INVVA19	0.7533	1.6253
INVVA20	2.4526	3.6983
INVVA21	1.7642	3.1824
INVVA22	0.7291	2.5567
INVVA23	-0.0356	3.6723
INVVA24	2.6087	2.6929
INVVA25	1.8642	3.4538
INVVA26	0.538	2.1046
INVVA27	1.5126	5.6288
INVVA28	-0.31	14.558
INVVA29	0.5675	4.7609
INVVA30	2.3551	3.5439
INVVA31	0.7621	2.367
INVVA32	1.4021	3.2943
INVVA33	1.0926	6.6215
INVVA34	0.2051	6.4298
INVVA35	4.8136	7.8814
INVVA36	0.4417	2.4231
INVVA37	3.2927	6.9108
INVVA38	2.0645	4.287
INVVA39	1.5359	3.6597
INVVA40	2.1523	5.2722
INVVA41	2.8667	5.2126
INVVA42	0.0715	6.6871
INVVA43	1.1714	3.8342
INVVA44	3.5322	6.4316
INVVA45	3.0742	4.8356
INVVA46	4.2265	6.1451
INVVA47	0.6433	7.4898
INVVA48	1.4604	4.6145
INVVA49	-0.4766	3.5643
INVVA50	1.1359	5.5274
INVVA51	3.264	9.0841
INVVA52	0.8608	3.2901
INVVA53	2.0227	4.967

INVVA54	0.7809	0.0408
INVVA55	-0.6595	0.0308
INVVA56	-2.7476	0.1324
INVVA57	-2.3476	0.537
INVVA58	-1.2086	0.0912
DCU2	-0.1014	0.0062
DCU3	1.3471	0.0645
DCU4	0.3251	0.0086
DCU5	0.296	0.0297
DCU6	1.8537	0.1516
DCU7	1.6467	0.0255
DCU8	0.4832	0.0169
DCU9	0.6328	0.0775
DCU10	-0.4262	0.0082
DCU12	2.3514	0.0626
DCU13	0.1694	0.039
DCU14	0.1979	0.0057
DCU15	-0.2896	0.0134
DCU16	0.5828	0.0306
DCU17	0.0828	0.0439
DCU18	-0.095	0.0677
DCU19	0.2374	0.0049
DCU20	-0.6919	0.0131
DCU21	0.1081	0.0207
DCU22	0.0428	0.0209
DCU23	-0.1685	0.0425
DCU24	0.4806	0.0621
DCU25	-0.8685	0.0087
DCU26	-0.7187	0.0157
DCU27	1.3798	0.0825
DCU28	-1.7542	0.0955
DCU29	3.6501	0.0782
DCU30	-0.1574	0.0462
DCU31	0.4897	0.0144
DCU32	-0.6063	0.029
DCU33	0.2402	0.0396
DCU34	1.2186	0.0454
DCU35	1.5856	0.1652
DCU36	0.0285	0.0156
DCU37	1.0435	0.0554
DCU38	-0.0059	0.0339
DCU39	0.8433	0.0226
DCU40	1.8773	0.0863
DCU41	2.0476	0.0822
DCU42	2.3142	0.2229
DCU43	-0.6981	0.009
DCU44	-0.1172	0.0516
DCU45	1.0786	0.103
DCU46	0.2876	0.1172
DCU47	1.3444	0.1005
DCU48	0.0778	0.0471
DCU49	0.6173	0.0298
DCU50	-0.2759	0.0543
DCU51	-0.3869	0.2686
DCU52	0.9375	0.0315
DCU53	1.9066	0.071
DCU54	1.9554	0.0334
DCU55	0.3974	0.0383

INVVA54	1.8422	3.9097
INVVA55	0.9142	3.4169
INVVA56	4.0606	10.4713
INVVA57	-2.3471	10.896
INVVA58	3.2647	6.529
DCU2	0.3553	0.374
DCU3	2.6513	3.2816
DCU4	0.6719	0.4826
DCU5	-0.2935	1.59
DCU6	-0.7155	3.814
DCU7	0.9565	1.1301
DCU8	0.7263	0.9878
DCU9	1.6443	4.1267
DCU10	-1.0292	0.5529
DCU12	2.287	2.5533
DCU13	4.2272	1.7897
DCU14	1.0766	0.371
DCU15	0.164	0.6988
DCU16	2.0394	1.7685
DCU17	1.3092	1.8882
DCU18	0.3402	4.1215
DCU19	0.8903	0.346
DCU20	0.083	0.8851
DCU21	1.2079	1.078
DCU22	0.3744	1.3521
DCU23	0.4843	2.5004
DCU24	3.9315	2.7913
DCU25	-0.8642	0.5511
DCU26	1.0771	0.6971
DCU27	2.255	3.4438
DCU28	3.4808	7.464
DCU29	6.1117	3.78
DCU30	3.5158	2.163
DCU31	1.8334	0.9938
DCU32	0.9177	2.0734
DCU33	3.8057	3.8969
DCU34	2.6501	3.7615
DCU35	-0.7499	7.4293
DCU36	1.8752	0.9582
DCU37	2.0292	2.6811
DCU38	1.8337	1.9977
DCU39	2.9931	1.8233
DCU40	-0.1914	3.8882
DCU41	5.078	3.7268
DCU42	5.48	11.7974
DCU43	-0.3629	0.6158
DCU44	0.3881	2.4012
DCU45	2.8024	4.451
DCU46	4.9056	4.7473
DCU47	4.1496	5.923
DCU48	0.969	2.613
DCU49	2.0088	1.9617
DCU50	4.6367	3.5982
DCU51	5.1139	12.4337
DCU52	3.8556	1.7843
DCU53	4.5196	2.8
DCU54	4.331	2.2066
DCU55	1.8149	1.8578

DCU56	1.4686	0.3157
DCU57	-0.9256	1.6421
DCU58	-0.0081	0.0207
PLF2	0.0849	0.006
PLF3	0.6335	0.0228
PLF4	0.267	0.0085
PLF5	0.2898	0.0299
PLF6	2.1955	0.1415
PLF7	0.8032	0.0097
PLF8	0.4521	0.0153
PLF9	0.3359	0.079
PLF12	1.0145	0.0183
PLF13	0.1794	0.0129
PLF14	0.0874	0.0049
PLF15	0.1884	0.0106
PLF16	0.0755	0.0142
PLF17	0.3009	0.0204
PLF18	-0.1622	0.0316
PLF19	-0.0762	0.0044
PLF20	0.1866	0.0106
PLF21	0.3568	0.0114
PLF22	0.0272	0.0115
PLF23	-0.1025	0.023
PLF24	0.4291	0.0177
PLF26	0.1025	0.008
PLF27	0.3972	0.0256
PLF28	-0.8449	0.029
PLF29	0.8552	0.0146
PLF30	0.0502	0.0104
PLF31	0.1889	0.0051
PLF32	0.0903	0.0102
PLF33	0.0001	0.0118
PLF34	0.3816	0.0137
PLF35	0.7995	0.0475
PLF36	0.0437	0.0052
PLF37	0.5108	0.0189
PLF38	0.2155	0.0114
PLF39	0.2258	0.007
PLF40	0.675	0.0259
PLF41	0.4455	0.0197
PLF42	0.4871	0.0399
PLF44	0.2517	0.0274
PLF45	0.3586	0.0237
PLF46	-0.0851	0.0273
PLF47	0.3037	0.0174
PLF48	0.0954	0.0111
PLF49	0.1969	0.0074
PLF50	-0.1152	0.0139
PLF51	0.194	0.0678
PLF52	0.2843	0.0073
PLF53	0.4823	0.0169
PLF54	0.5868	0.008
PLF55	0.0453	0.0098
PLF56	0.4764	0.0761
PLF57	-0.1921	0.4006

DCU56	2.3077	14.9514
DCU57	-15.4902	62.8773
DCU58	-0.2502	1.1241
PLF2	0.2122	0.3162
PLF3	1.2533	1.1647
PLF4	0.3858	0.4363
PLF5	0.6331	1.5081
PLF6	0.2439	3.4313
PLF7	0.555	0.4307
PLF8	0.8575	0.8609
PLF9	1.7745	4.0651
PLF12	0.9867	0.7451
PLF13	1.6239	0.5986
PLF14	0.6678	0.2831
PLF15	0.8865	0.5212
PLF16	1.2562	0.8052
PLF17	0.8763	0.8849
PLF18	0.6346	1.8839
PLF19	0.6118	0.2638
PLF20	1.0045	0.6983
PLF21	1.0637	0.567
PLF22	0.45	0.7178
PLF23	0.6696	1.3224
PLF24	1.3948	0.7925
PLF26	0.7342	0.3471
PLF27	0.8291	1.0645
PLF28	1.0196	2.3225
PLF29	1.2026	0.7122
PLF30	0.8713	0.4833
PLF31	0.6599	0.3581
PLF32	0.5016	0.7124
PLF33	1.2951	1.1646
PLF34	0.9015	1.1384
PLF35	0.046	2.1023
PLF36	0.5234	0.3329
PLF37	0.6748	0.9229
PLF38	0.7638	0.705
PLF39	1.0279	0.5667
PLF40	0.2048	1.1446
PLF41	1.3132	0.896
PLF42	1.0383	2.1117
PLF44	0.273	1.2538
PLF45	0.7244	1.0293
PLF46	1.1865	1.116
PLF47	0.688	1.0318
PLF48	0.1933	0.6239
PLF49	0.4169	0.5103
PLF50	1.1431	0.9595
PLF51	1.3122	3.1854
PLF52	0.9062	0.4422
PLF53	1.0181	0.6891
PLF54	1.0854	0.5585
PLF55	0.4246	0.4971
PLF56	0.7297	3.5913
PLF57	-4.058	15.2909

R2-ADJ = R2-ADJ = 0.437

Number of observations = 25169

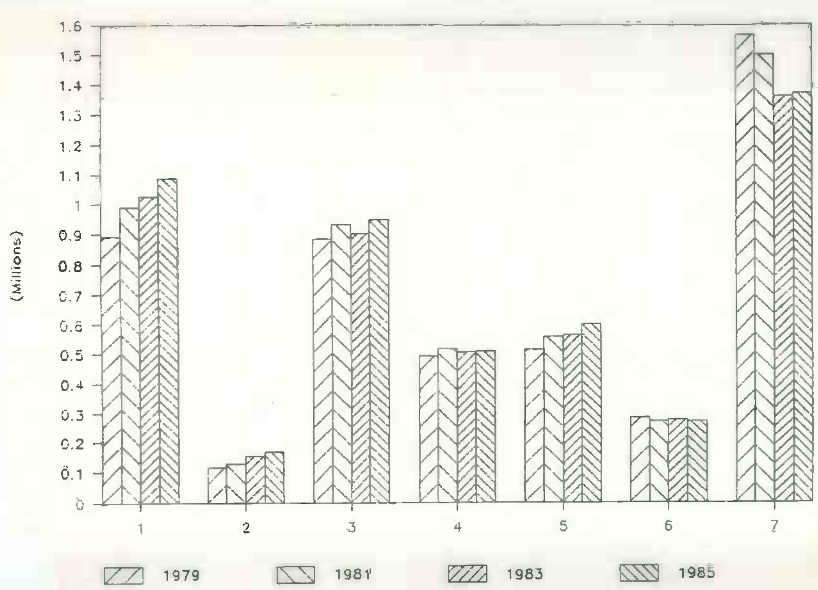
Reference categories are education 1 "elementary education" and education 11 "general secondary education, intermediate and higher levels"

Table 2. Educational levels

Category	Educational level
2	Primary education
3	Secondary education (lower level)
4	Secondary education (higher level)
5	Higher vocational education
6	University education

These categories of occupations and educations are mentioned in table 1 and 2 respectively. Employment shifts between these occupational categories from 1979 until 1985 are shown in figure I, where the seven numbers at the x-axis correspond to the seven categories mentioned in table 1. Obviously the monotonously increasing employment of the professional, technical and related workers (category 1) and the decline of the production and related workers (category 7) catch the eye.

Figure I. Working population within seven occupational categories during 1979-1985



The figures IIa and IIb illustrate the educational background of the employed population in these seven categories in 1979 and 1985. Because the seven categories are ranked from the highest to the lowest level occupations, it is not surprising that occupational category 1 contains relatively less persons with the lowest and more persons with the highest educational level than the other categories. Nevertheless, much more important here are the shifts in almost all occupations from the lower to the higher educational levels during 1979-1985.

Figure IIa. Educational background of persons employed within seven occupational categories in 1979

Figure IIb. Educational background of persons employed within seven occupational categories in 1985

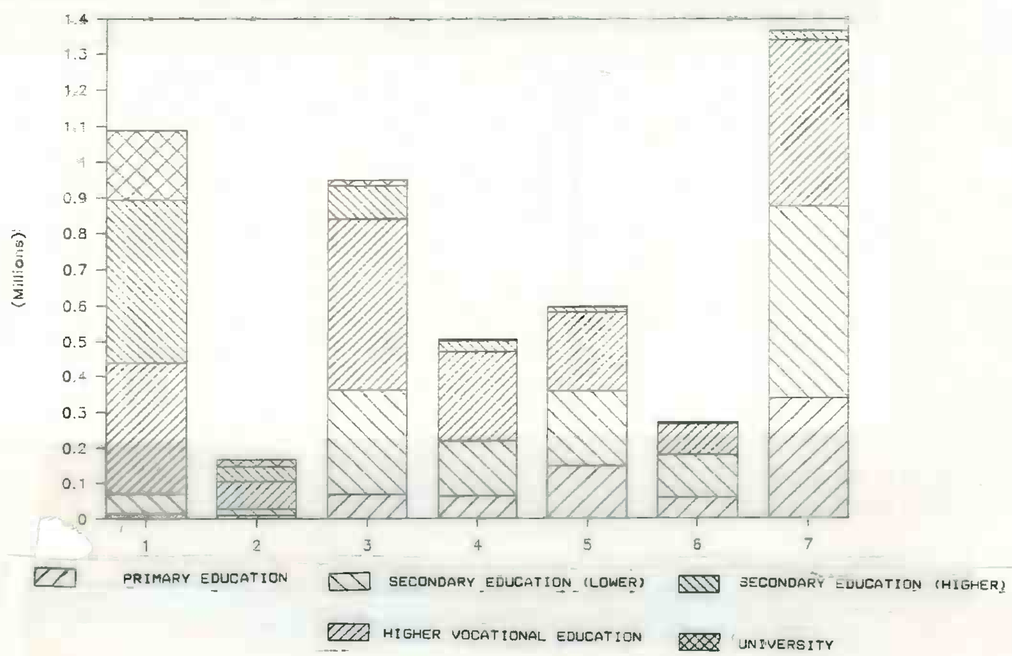
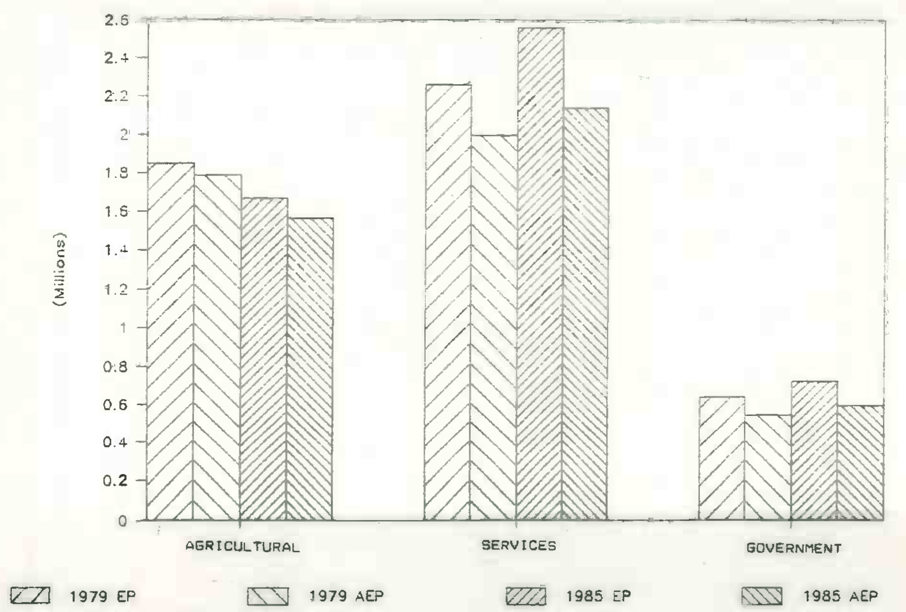


Figure IV. Employed persons and employed persons adjusted for the share of part-time work within three branches of industry in 1979 and 1985



We assume that the adjustments for working hours of the number of employed persons with a certain educational background is fully determined by the occupation within a branch of industry they have. We therefore calculate the adjusted number of employed persons with certain educational backgrounds by multiplying those numbers with the average number of working hours of the occupation they have and industry they were working, so[2]

$$AEP(b,o,e,t) := \frac{\Sigma_h\ EP^*(b,o,h,t) * MH(h)}{\Sigma_h\ EP^*(b,o,h,t) * 40} * EP(b,o,e,t) \qquad (2)$$

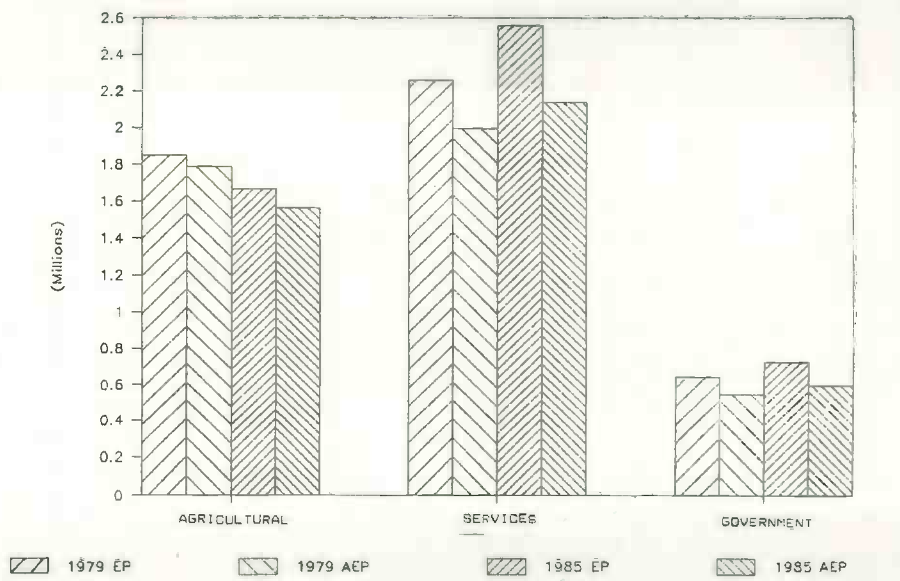
with

EP(b,o,e,t) : number of employed persons within industry b, occupation o, education e at time t;

AEP(b,o,e,t) : adjusted number of employed persons within industry b, with occupation o and education e at time t.

2. For the estimation method we use in chapter 3 there is no difference between taking account of the employed people or the adjusted employed people when calculating the endogenous variable of the educational model. This is because of the fact that nominator and denominator are adjusted by the same factor. Only the estimated covariance matrix is touched by the adjustments made here for part-time work.

Figure IV. Employed persons and employed persons adjusted for the share of part-time work within three branches of industry in 1979 and 1985



We assume that the adjustments for working hours of the number of employed persons with a certain educational background is fully determined by the occupation within a branch of industry they have. We therefore calculate the adjusted number of employed persons with certain educational backgrounds by multiplying those numbers with the average number of working hours of the occupation they have and industry they were working, so[2]

$$AEP(b,o,e,t) := \frac{\Sigma_h \, EP^*(b,o,h,t) * MH(h)}{\Sigma_h \, EP^*(b,o,h,t) * 40} * EP(b,o,e,t) \qquad (2)$$

with

EP(b,o,e,t) : number of employed persons within industry b, occupation o, education e at time t;

AEP(b,o,e,t) : adjusted number of employed persons within industry b, with occupation o and education e at time t.

2. For the estimation method we use in chapter 3 there is no difference between taking account of the employed people or the adjusted employed people when calculating the endogenous variable of the educational model. This is because of the fact that nominator and denominator are adjusted by the same factor. Only the estimated covariance matrix is touched by the adjustments made here for part-time work.

The first term right of the equality symbol represents the average number of working hours of occupation o within industry b. The denominator of this term contains the normal working time of occupation o and industry b, which is here assumed to be 40 hours a week. By multiplying the first term by the number of persons employed in occupation o and industry b, which is the second term, the adjusted number of employed persons is found.

One conclusion of the study of Groot and Heijke mentioned above is that the shares of part-time work as measured by average working time per week are more determined by occupation than by industry. In figure III the employed persons and adjusted number of employed persons within the seven main occupations in 1979 and 1985 are compared. The correction for working hours is bigger in 1985 than in 1979 and seems to have the least impact on administrative, managerial workers and agricultural occupations (category 2 and 6). The relative small difference between adjusted and unadjusted numbers of employed persons in the agricultural industry is also found in figure IV; for the three main branches of industry the agricultural industry shows the least differences by the adjustments made.

Figure III. Employed persons and employed persons adjusted for the share of part-time work within seven occupational categories in 1979 and 1985