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Technological Change and Skill Formation in the Bank Sector

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Abstract — This paper focuses on the shifts in the educational structure in the banking sector caused by technological developments. A cross-section analysis of 100 local banks shows that the diffusion of office automation has significant positive effects on both the skill level and the share of vocationally skilled workers. The results also show that the automated banks use recruitment policies more intensively than less automated banks in adjusting the skill structure.

1. INTRODUCTION

AS TECHNOLOGICAL innovations are introduced in the banking sector at a fast rate, one might expect continuous changes in the demand of new skills. We can distinguish quantitative and qualitative effects in the demand for these new skills. The quantitative effects reflect changes in the amount of labor demanded (for instance the number of automation workers), whereas the qualitative effects correspond to changes in the skills needed within occupational groups. In this paper we will focus on these qualitative aspects.

In this paper we analyse the effects of technological developments on the skill structure of the workforce in the banking sector in the Netherlands in the 1980s, focussing on the question whether upgrading or downgrading tendencies can be identified. Moreover, we analyse how the skill level of the workforce is adjusted: by means of a recruitment policy or through an active training policy aimed at improving the skill level of the present workforce.

The structure of this paper is as follows. In the following section we deal with the hypotheses of our model. In section 3 we present our theoretical model, which we call the *transformation model*. In section 4 we discuss the data used and present the empirical specifications and outcomes. We verify which policy is used most intensively in adjusting the workforce to the new skills required: the recruitment policy or the schooling policy. In section 5, based on the empirical outcomes we present the predictions of the model. This paper will be concluded with a short summary and conclusions.

2. UPGRADING OR DOWNGRADING

There are several factors which might cause changes in the educational structure of the workforce. First and foremost we have the impact of technological developments on both the occupational structure and the educational structure.

Second, the way management chooses to implement new technology and the way they organize newly emerging work processes can have a serious impact on the new skill structure. On this point technological determinists hold the view that technological development itself determines the way work processes are organized. Contrary to this view is the view that the management has a high degree of freedom in the way the new labor process is organized.

Third, changes in the occupational and educational structure might be caused by the combined impact of intensified competition in the bank sector, a tendency towards product differentiation and a policy aimed at higher quality standards in order to meet the higher quality demanded by customers.

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Because these three factors are strongly related to each other it is often difficult to unravel the overall effects.

Finally, the increasing average level of education of the labor supply in general probably leads to "bumping-down processes" at the occupational ladder: the substitution of lower by higher skilled workers as a surplus of educated workers enables employers to raise their skill requirements. However, these bumping-down processes will not be the subject of our study. The fact that our analyses are entirely cross-sectioned enables us to abstract from the continuously increasing supply of higher educated workers. This increasing skill level of labor supply often hampers time-series analysis of the relation between technological development and skill requirements.[1]

In this section we will put forward the main theoretical positions in the debate on the effects of technological developments on educational structure. In our model we want to embody several hypotheses with regard to these effects. First, we want to test the following hypotheses:

— differences in the educational structure of occupations of various local banks are determined by differences in technology, against:
— differences in the educational structure of occupations of various local banks are not determined by differences in technology.

According to the first hypothesis we expect that the introduction of desk terminals both in the back office (BO) and in the front office (FO), have a significant impact on the educational requirements of the workforce as they involve major changes in production technology. The second hypothesis assumes that the educational structure of occupations is rather sticky and largely determined by labor market conditions in the past; the skill structure does not differ significantly between local banks and in as far as differences exist, the skill structure does not consistently differ according to differences in technology levels between the local banks.

However, we cannot test both hypotheses in a strict sense, because we cannot abstract from the role of management. Suppose differences in the educational structure of occupations between local banks are determined by differences in technology but the management of local banks reacts in different ways. Then there will be no consistent pattern in the way the educational structures of occupations are adjusted. Therefore, the only thing we can do is test the role of management and the impact of technology simultaneously. To do this we further differentiate the above hypothesis where the role of management and the educational effects of the implementation of new technology are formulated in the three following scenarios:

— differences in educational structures of occupations of various local banks are determined by differences in technology, and management policy does not play a significant adverse role by itself, against:
— differences in educational structure of occupations of various local banks are not only determined by differences in technology, but also management policies play significant and different roles in adjusting educational structures, or
— differences in educational structures of occupations of various local banks are not determined by differences in technology.

We will test the first hypothesis against the other two. This means that if we have to reject the first hypothesis, we do not know which of the other two are valid.

So far, the hypothesis with respect to the educational structure only reflects the statement "Technology does matter", but it does not indicate the direction of change.

However, in the literature there is no consensus in which way and to what extent technological developments change occupational and skill structures. Although it is generally accepted that new technologies, particularly the more frequent use of computers in the office, have significant impacts on the composition of the workforce and skill requirements, the effects expected are not unambiguous. Generally speaking there are three positions in this debate.[2] First, the *upgrading* view expects an increase in the share of the upper tier occupations (executives, managers and professionals) in the occupational structure and an increasing share of employees with a higher general or vocational training. This is due to the fact that the automation processes are believed to demand more skills, greater responsibility, the ability to operate in a changing environment, the handling of more abstract tasks, etc.

Second, the *downgrading* argument emphasizes that technological developments cause simplifications of tasks, for example for a large part of the work force there is a tendency for more repetitive, straightforward tasks caused by the implementation of automation equipment. Although the downgrading proponents recognize that management plays a crucial role in the way the newly emerging work processes are organized, they believe that in general a deskilling of jobs will occur.

Third, the final position in the debate suggests that the effects of technological change or changes in the labor process are *mixed and offsetting*. "Alternately, the effects depend on the level of automation-upgrading in the early stages, downgrading at later stages — or depend on the organizational milieu, the way management chooses to implement change . . . The outcome is little net change in the skill requirements of work or offsetting trends in the composition of the occupational structure as some sectors and jobs experience upgrading and others downgrading . . ." (Spenner, 1985, p. 128).

In this paper we will use the empirical evidence of our case study to evaluate the above three positions in the debate. We do expect, however, that local banks with relatively modern production techniques on average will have more higher educated employees as well as a higher share of employees with a vocational education. The theoretical foundation for this expectation is stressed by several authors: ". . . it has been argued that workers with more education are more adept at critically evaluating new information, and therefore respond to technical change more readily. This 'allocative efficiency' of schooling hypothesis suggests that innovative firms in high-technology industries are more likely to use highly educated and technically skilled workers" (Lillard and Tan, 1986, p. 2) and ". . . educated persons . . . can distinguish more quickly between the systematic and random elements of productivity responses. When a new product or process has recently been introduced, there is more remaining to be learned about the technology, and there is a greater premium on the superior 'signal-extraction' capability of educated labor" (Welch, 1970, p. 47). Obviously this hypothesis should be tested.

3. THE TRANSFORMATION MODEL

Our transformation model tries to explain shifts in the demand of skills *within* the various occupational groups caused by up- or downgrading processes. A main problem is the very limited time period for which data on the educational structure are available. By confining our approach to a cross-section analysis we can avoid this problem. Moreover, in a cross-section approach the (demand-induced) effects of technological development on educational structure can be better distinguished from the (supply) effect of the continuously increasing educational levels of new labor force entrants. Other problems involve the role of management and the multidimensional aspect of education.

Following Osterman (1986) we distinguish four occupational groups, listed in Scheme 1 below.[3]

Scheme 1. Occupational groups and types of education in the transformation model

Occupational groups
Clerical production workers
Clerical coordination workers
Commercial
Management

Branches and level of study
General — low
— high
Economic and other education — low
— high

Clerical production workers consist of data typists, desk clerks and cashiers. Clerical coordination workers consist of secretaries and administrative personnel. Commercial employees consist of advisors, automation workers, scientists and experts. Finally we have management and the board as a separate occupational group.

We will limit our analyses to these four occupational groups and to four educational variables (we distinguish between two different branches of studies, general education and vocational education and measure each of its average educational level and its share). In total we therefore have 16 dependent variables: the educational level and the share of each educational category (branch of study) in each occupational group. This is summarized in Scheme 1.

We adopt a very straightforward approach by estimating the following equation:

$$y_{ijk} = \alpha_{ij} + \beta_{1ij}\, x_{1k} + \ldots + \beta_{nij}\, x_{nk} + \epsilon_{ijk}, \quad (1)$$

with

Y_{ijk}: share or level of educational category i in employment of occupation j at local bank k;

$y_{ijk} = \ln (Y_{ijk})$;

x_{sk}: value of explanatory variable ($s = 1, \ldots, n$) for bank k;
$x_{sk} = \ln(X_{sk})$;
ϵ: error term.

We take logarithms on both sides of the equation in order to be able to interpret the coefficients β_{ij} as elasticities.[4] Most research on the impact of technology on the occupational and skill structure uses technology indicators like R&D expenditures and the number of patents to measure the state of technology indirectly (e.g. Bekkering *et al.*, 1988). We know, however, the state of technology of a local bank rather precisely: Expenditures on specific computer equipment like bank terminals used in the back office (BO) or front office (FO) and expenditures on other computer equipment (cash dispensers, network equipment). These expenditures are reflected in the technical coefficients, which measure the state of technology much more directly. Another difference between our model and most other models linking educational structure and technology, which will become clearer in section 4, is that we not only test *if* technology matters, but we also quantify *how* the change in the educational structure is brought about (recruitment effects vs schooling effects).

In our model we use the following independent variables:

(1) *TC*: technical coefficients based on the depreciation costs of the amount of investments in computer equipment between 1979 and 1987;
(2) *YBO*: the availability of back office desk terminals (in years);
(3) *YFO*: the availability of front office desk terminals (in years);
(4) *PAUT*: the share of automation workers at the local bank (as an indicator of the degree of automation);
(5) *SIZE*: the size of the local banks (number of employees);
(6) *TYPE*: the typology of the local bank, which classifies banks as rural or urban.

The first four variables are the technology variables representing the technological developments within the banks. With respect to the technical coefficient we distinguish between three main bank products: payments, savings and finance. Since clerical workers deal both with payments and savings, the technical coefficient for these occupations is based on a weighted average of the technical coefficients of the depreciation costs of investments for these two products with the labor spent on each product as weights. Analogously, the technical coefficient for commercial personnel and management are based on a weighted average of the technical coefficients for all three products.

The introduction of back office and front office terminals means a major shift in production technology for each local bank. Therefore, besides the variable representing the technical coefficient, we included two other technology variables: the number of years that (only) back office terminals are available (*YBO*) and the number of years that back office terminals plus the number of years that front office terminals are available if front office terminals are available in 1987 (*YFO*). This means that the variable *YBO* gives the pure effect of back office automation and *YFO* a combined effect of back and front office automation.

As these variables are measured at local bank level, it is implicitly assumed that each local bank reacts in the same way to changes in bank technology. To weaken this assumption we introduce two more variables which allow local banks to react differently to changes in technology: *SIZE* and *TYPE*. These variables are meant to correct for scale effects and the socio-economic surrounding of the local banks.[5]

4. EMPIRICAL SPECIFICATIONS AND OUTCOMES

In this section we present the empirical results of our analysis. First, in section 4.1 we give a global description of the data and the variables used. Next, in 4.2 we present the empirical results of the transformation model linking educational structure with variables which measures the state of technology. The mechanisms of adjusting the educational structure will be considered in more detail in sections 4.3 and 4.4. Section 4.3 explores the relationship between technology and adjustment of the educational structure by means of educational policies. Section 4.4 concentrates on the relationship between technology and adjustment of the educational structure by means of recruitment policies. Section 4.5 gives an overview of the results.

4.1 The Data

In analysing the occupational and educational structure we use a very detailed data set for one of the eight big payments banks in the Netherlands. Our case study bank shows a detailed insight of the employees' occupational and educational status. The transformation model tries to model the effect of information technology on the educational structure within four occupational groups, therefore the data we use consists of two parts: data with respect to technology and data with respect to education. First we know exactly the amount and type of investments in information technology for the period 1980–1987 for about 100 local banks. Second, we know the educational and occupational status of all employees for these same local banks in 1987.[6]

More than 60% of total investments were for back and front office automation. Also more than 75% of all investments in computer equipment came after 1984. For most local banks office automation and distributed data processing is a rather recent phenomenon. Crucial in this respect is whether the shifts in skill requirements become apparent within such a short time period.

4.2 Adjustment of the Educational Structure

First we try to relate the educational structure (measured by level and share variables) of each occupation with the state of technology at each local bank according to the following equation:[7]

$$Y = e^{\alpha}\ TC^{\beta}\ YBO^{\tau}\ YFO^{\theta}\ SIZE^{\theta}\ e^{\epsilon}. \qquad (2)$$

As this equation has been discussed in section 3, we omit the indices i,j and k in the formula.

We estimated all regressions by WLS in order to reduce the influence of measurement errors.[8] Moreover, we wanted to give large local banks a proportionally larger influence in the determination of the regression coefficients. So we used a procedure in which the relative importance of each observation varies with the number of employees at each local bank divided by the average number of employees at all local banks. We do this to compensate for the fact that the dependent variable in the analysis is expressed as a share or level from which no information about the size of the local bank can be inferred.

The equation has been estimated in a cross-section analysis of 100 local banks in 1987. The results are presented in Table 1. From the table one sees that the technical coefficient is positively significant for both the share and the educational level of vocational education for all occupations except for the management and board. Clerical production and coordination workers at banks that were first to automate their offices on average have either a higher level or a higher share of vocational education. For all occupations except management, both back office and front office automation raise the level of general education as well as the share of vocational education.

On the other hand, for most occupations the average level of vocational education shows a negative relationship with the variables which represent front and back office automation. It seems that leading banks with regard to information technology do have a higher share of workers with a vocational education instead of general education, but on average the level of vocational education is lower and the level of general education is higher for these banks. However, this can be the result of a process in which workers with a lower or intermediate general education are substituted by workers with a lower or intermediate vocational education. In that case the average level of general education increases (although the share of general education will decrease) and the level of vocational education decreases. However, we have to keep in mind that the average level of vocational education (measured by the number of years enrolled in school) is about 3 years higher than the average level of general education.[9] So the counter-intuitive result from Table 1 — a lower level of vocational education for workers in technology-leading banks — does not mean that the overall educational level for those banks is lower. On the contrary, because of the much higher share of workers with a vocational education, the average educational level of the employees of these banks will be higher. As a consequence the hypothesis that "technology does matter" in explaining the educational structure can be said to be accepted.

Next we want to explore in what way the local banks operating at the forefront established the different educational structure needed. In general, two policy options can be distinguished. The organization can use a schooling policy and/or a recruitment policy to adjust its educational structure. In 4.3 we verify the impact of the schooling policy and in 4.4 the impact of the recruitment policy.

Table 1. Relationship between technology and education (regular courses included)*

	TC	*YBO*	*YFO*	*SIZE*
Educational level of personnel with a general education				
Clerical production workers	−5.7	7.1	4.1	−4.5
	(1.9)	(2.9)	(5.8)	(2.7)
Clerical coordination workers	14.5	15.0	2.6	3.2
	(3.2)	(4.1)	(2.7)	(1.4)
Commercial employees	−5.6	5.5	4.5	−6.9
	(0.8)	(0.9)	(2.4)	(1.7)
Management	0.5	−15.9	6.0	4.4
	(0.0)	(1.2)	(1.6)	(0.6)
All	−3.4	6.1	2.9	−1.0
	(1.4)	(3.2)	(5.6)	(0.8)
Educational level of personnel with a vocational education				
Clerical production workers	3.1	−5.9	−3.1	0.1
	(1.4)	(3.6)	(6.3)	(0.1)
Clerical coordination workers	7.5	−5.5	−2.7	1.9
	(2.7)	(2.5)	(4.8)	(1.4)
Commercial employees	5.6	−1.3	−1.6	2.8
	(3.3)	(1.0)	(4.4)	(3.4)
Management	−12.0	−1.8	1.5	−0.6
	(5.0)	(0.9)	(3.3)	(0.6)
All	3.8	−4.3	−1.8	0.7
	(2.8)	(4.0)	(6.3)	(1.0)
Share of workers with a vocational education				
Clerical production workers	61.6	48.9	15.9	−18.2
	(3.7)	(3.8)	(4.2)	(2.1)
Clerical coordination workers	−17.9	32.8	14.2	−16.4
	(1.3)	(2.9)	(5.1)	(2.4)
Commercial employees	86.7	47.5	51.7	−10.4
	(4.4)	(3.1)	(12.4)	(1.1)
Management	−50.1	32.6	59.1	−42.6
	(2.6)	(1.9)	(16.6)	(5.1)
All	64.8	45.5	32.2	−19.4
	(5.1)	(4.5)	(11.7)	(3.0)

*Coefficients $\times 10^{-2}$; *t*-values between parentheses.

4.3 Adjusting the Educational Structure by Means of a Schooling Policy

As we can see in Table A1 in the Appendix, differences exist between the educational structure regarding formal schooling only and the educational structure regarding both formal schooling and regular courses followed. Regular courses are here defined as courses lasting for a longer time period and, therefore, probably change the educational status of employees. If we include these regular courses in our analysis the share of workers with a general education only drops from 65 to 30%. In order to measure the adjustment in educational structure by means of post-formal schooling and to establish the relationship between this adjustment and the state of technology at each local bank, we take the shift in educational structure brought about by regular courses as the dependent variable. Hence, we specify the following relation:

$$\Delta y_{ijk} = e^{\alpha}\, TC^{\beta}\, YBO^{\tau}\, YFO^{\delta}\, SIZE^{\theta}\, e^{\epsilon}. \quad (3)$$

where Δy_{ijk} represents the mutation in share or level of education i in occupation j at local bank k brought about by regular courses.

The hypothesis we test here is as follows: the shift in the educational structure brought about by regular courses will be greater if the local bank is at the forefront of technology; that is, we test whether the educational effort of these innovating banks is greater than the efforts of the lagging banks. In Table 2 the outcomes of these tests are presented.

Table 2. Relationship between technology and shifts in educational structure by means of regular courses*

	TC	*YBO*	*YFO*	*SIZE*
Mutation in share of workers with a vocational education				
Clerical production workers	1.44	−0.44	−0.51	−0.06
	(5.8)	(2.3)	(9.1)	(0.4)
Clerical coordination workers	0.35	−0.32	−0.52	0.05
	(1.8)	(2.0)	(13.4)	(0.5)
Commercial employees	−0.07	−0.53	−0.31	0.02
	(0.7)	(6.8)	(14.4)	(0.4)
Management	−0.14	−0.33	−0.20	−0.12
	(1.1)	(3.1)	(8.8)	(2.1)
All	0.89	−0.46	−0.40	−0.04
	(7.2)	(4.7)	(14.1)	(0.7)
Mutation in educational level of workers with a vocational education				
Clerical production workers	2.86	−1.54	−1.36	−0.26
	(5.2)	(3.7)	(11.0)	(0.9)
Clerical coordination workers	1.73	−1.12	−1.11	−0.05
	(3.2)	(2.6)	(10.4)	(0.2)
Commercial employees	0.23	−0.74	−0.81	0.64
	(0.7)	(2.9)	(11.8)	(4.1)
Management	−0.53	−0.52	−0.37	0.04
	(2.3)	(2.7)	(8.7)	(0.4)
All	2.42	−1.19	−0.98	0.22
	(7.2)	(4.5)	(13.7)	(0.1)

* Regular courses which raise the level of general education do not exist.

Here the equation is also estimated over a cross-section of 100 local banks.

From this table we can see that information technology can have opposite effects on educational structure. On the one hand, we mostly see positive relationships between the technical coefficients and both level and share of vocational education, and on the other hand, almost all variables which represent back and front office automation show negative relationships with these variables. The opposite signs may partly reflect the difference in nature of the technical coefficient vs the variables which represent back and front office automation. The technical coefficient variable is mainly based on depreciation costs of investments in information technology over the last 4 years only, whereas the back and front variables measure office automation from 1980 onwards. A positive sign for the technical coefficient, therefore, means that local banks with larger investments in information technology in the recent past show a greater schooling effort.

If we assume that the combined negative effect of the back and front office automation variables is stronger than the positive effect of the technical coefficient, then the total effects can be interpreted as follows: the negative relationship between the variables representing the length of the period that front and back office automation is present at the bank and the share of vocational education means that the shift in the share of vocational education brought about by post-formal schooling is greater for those banks which lag behind. Local banks which lag behind in technology have a relatively high share of workers with a general education only — as shown in Table 1. For these banks there will be large scope for post-initial schooling of their workers in order to supply the necessary branch and job-specific vocational skills. However, in Table 1 we saw that leading banks already have a higher share of workers with a vocational background, so even if they participate in post-formal schooling courses, it will not change their educational status unless it raises their level of vocational education. For workers with general education only, a regular course will not only change their educational status with respect to the branch of study, it will also change their educational level. This last phenomenon also seems to be the case: the mutation in the average level of vocational education brought about by regular courses is smaller for those banks with a long tradition of information technology, but higher if banks invested in information technology quite recently.

4.4 Adjusting the Educational Structure by Means of a Recruitment Policy

Finally, we want to verify if local banks operating at the forefront can be characterized by a different recruitment policy, i.e. higher conditions of entry. We can see in Table A2 in the Appendix that the personnel who started working after 1980, on average, had a much higher educational level and a greater share of vocational education. Here we test if information technology leaders have even higher entry requirements than other banks (given the fact that for all local banks the entry requirements have been increased). To test this hypothesis, analogous to Eqn (2), we try to explain the differences in educational structure of the group employees recruited after 1980, out of the state of technology at each local bank. Table 3 summarizes the results of this analysis.

From this table we can see that:

(1) there exists a positive relationship between front and back office automation and the level of general education of the clerical employees;

(2) a strong positive relationship is observed between front office automation and the share of vocational education, and to a lesser extent the level of general education for all workers. This

Table 3. Relationship between technology and educational structure of personnel who started working after 1980*

	TC	*YBO*	*YFO*	*SIZE*
Educational level of personnel with a general education				
Clerical production workers	0.2	8.5	5.4	−7.2
	(0.0)	(2.6)	(9.0)	(0.8)
Clerical coordination workers	18.9	15.4	4.4	7.0
	(1.5)	(1.6)	(3.0)	(0.5)
Commercial employees	−12.4	−3.2	1.4	−36.0
	(0.6)	(0.2)	(0.6)	(1.5)
Management	n.a.	n.a.	n.a.	n.a.
All	−2.1	8.2	4.0	0.8
	(0.5)	(2.8)	(8.1)	(0.2)
Educational level of personnel with a vocational education				
Clerical production workers	0.5	−6.0	−2.2	2.5
	(0.4)	(2.5)	(5.0)	(0.1)
Clerical coordination workers	−5.3	−9.9	−2.7	0.7
	(0.9)	(2.4)	(4.2)	(0.1)
Commercial employees	3.1	2.1	0.4	8.1
	(0.6)	(0.5)	(0.7)	(1.6)
Management	−12.7	−2.9	2.8	−0.5
	(1.1)	(0.1)	(2.6)	(0.1)
All	1.3	−5.4	−1.5	2.6
	(0.5)	(3.0)	(4.8)	(0.9)
Share of workers with a vocational education				
Clerical production workers	65.8	46.5	11.6	65.8
	(2.0)	(2.3)	(3.1)	(1.1)
Clerical coordination workers	10.4	35.3	12.6	−3.4
	(0.2)	(1.0)	(2.3)	(0.1)
Commercial employees	95.0	45.4	43.2	25.0
	(2.5)	(1.5)	(10.8)	(0.7)
Management	−55.0	−17.5	22.0	−37.3
	(1.1)	(0.2)	(4.8)	(1.3)
All	88.3	44.7	20.5	−12.4
	(4.2)	(3.2)	(8.6)	(0.6)

n.a. = not available (insufficient number of observations).
*Coefficients $\times 10^{-2}$.

means that local banks which were among the first to implement office automation also had a recruitment policy characterized by relatively high entry requirements. In the first half of the 1980s, a period in which major shifts in production technology occurred, leading banks mostly recruited employees with a vocational background. Other banks recruited fewer employees with a vocational education, but the workers on average had a higher level of vocational education. This effect is strongest for both groups of clerical workers;

(3) commercial employees show the least pronounced effects. Only with respect to the share of vocational education does the state of technology seem to increase entry requirements.

The fact that the state of technology does not always lead to significant adjustments in the skill level of the new entrants in the organization does not mean that adjustment processes in the educational structure by means of recruitment are slow. We see in Table A2 in the Appendix that the personnel who started working after 1980, on average, had a much higher educational level and a greater share of vocational education, in spite of the fact that the new entrants have a lower function level, on average, and did have less opportunity to raise their educational status by post-formal schooling than workers with longer tenures. Here, we tested if leading local banks have even higher entry conditions than other banks, given the fact that all local banks have increased their entry requirements throughout the years.

5. PREDICTIONS OF THE MODEL

In this section we want to show the model at work. Although the model is basically a cross-section — the estimates are based on cross-sectional differences in educational and technological structures among local banks in 1987 — it can make predictions for others years as well. We use the term predictions instead of forecasts, because forecasts are exclusively related to the future. The term "prediction" therefore reflects nothing else than outcomes of the model, based on certain assumptions, either for the past or for the future. Actually, we make predictions for the time span running from 1980 (in which year the back office automation started) to 1995. We are able to compare the outcomes of the model simulations with the values actually observed for the period 1984–1987 only. With respect to all the variables which measure the state of technology, we know the course of development between 1980 and 1987.

The prediction for 1980–1987 is based on the following assumptions:

(1) the variables *YBO* and *YFO* are supposed to be zero in 1980, simply because in 1980 back office automation started;

(2) the technical coefficient for each local bank in 1987 is rescaled with the actually observed average growth rate in the period 1980–1987.[10]

The prediction for 1987–1995 is based on the following assumptions:

(1) the variable *YBO* is equal to zero because every bank is supposed to have made a step towards front office automation. This assumption is quite realistic: in 1987 only the smaller local banks had not yet adopted the front office automation techniques;

(2) the average growth rate for the technical coefficient for payments in the period 1987–1995 is assumed to be much higher than the actual observed growth rate in the period 1980–1987. This reflects the expert opinion that the large scale introduction of cash dispensers (cashomats) will increase the amount of capital input per unit of output (payments). For savings we assume sustained high growth in the amount of capital per unit of output.

These assumptions are summarized in Table 4.

Figures 1–3 present the predictions of the model with respect to the level of general education, the level of vocational education and the share of vocational education, respectively, for the period 1980–1995. The figures graphically illustrate the type of relationships listed in Table 1. They describe total effects of technological developments. We have to keep in mind that these projections are based on cross-sectional estimates, in which, according to the assumptions above, in the future the

Table 4. Actually observed and expected average growth rates of technical coefficients of computer equipment

	1980–1987	1987–1995
Payments, accounts	2.8%	6.8%
Savings	6.0%	7.0%

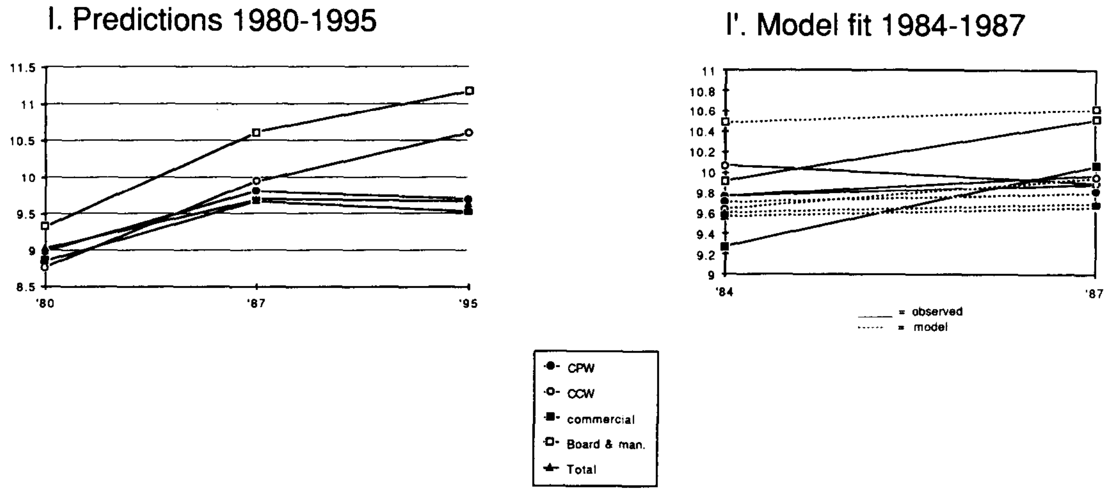

Figure 1. General Education (years).

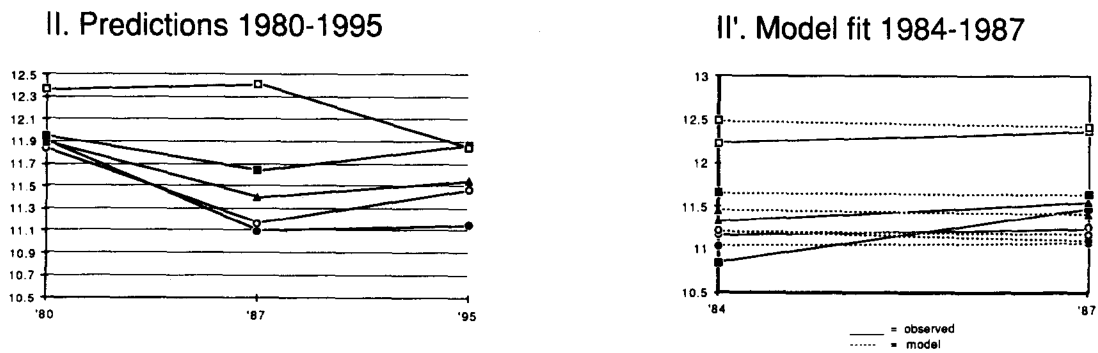

Figure 2. Vocational education (years).

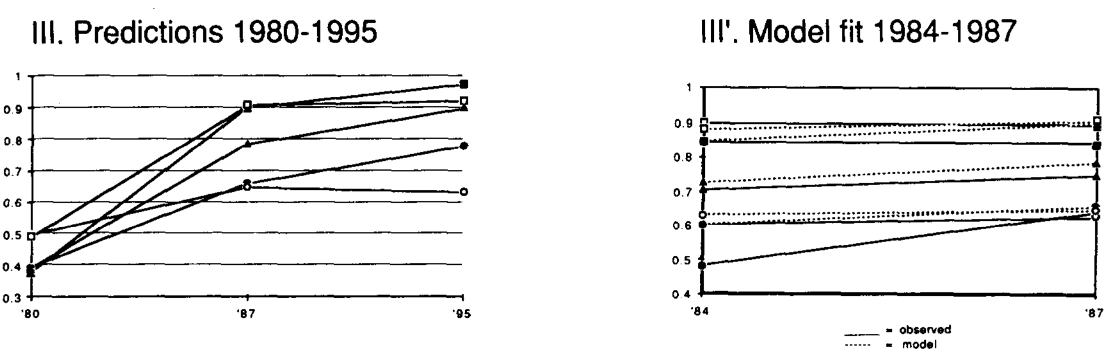

Figure 3. Vocational education (shares).

influence of technical coefficients becomes relatively more important in comparison with the back and front office automation variables. The abbreviated names for the occupations in the figures correspond with the classification of occupational groups listed in Scheme 1 in section 2. Despite the breaks, most occupations show similar developments: the share of vocational education and the level of general education increased over the whole period, while the level of vocational education first decreased and then increased after 1987. Figures 1′–3′, on the other hand, show the actually observed values of these variables for the period 1984–1987, which enables us to evaluate the performance of the model. It seems that both the height (intercept) and the direction of change (slope) of the level of general education and the share of vocational education is predicted rather well for the period 1984–1987. The only anomaly in the prediction is the predicted small decrease in the level of vocational education against an actually observed increase for most occupations.

The breaks occurring in 1987 reflect the differences in assumptions made for the periods 1980–1987 and 1987–1995. These differences are:

(1) a change in growth rates (see Table 4 above);[11]
(2) the absence of effects of the back office automation. Although these effects died out in 1987 — either because most back office automation took place before 1984 or because the model specification enforces a decreasing effect of the explanatory variables (see Appendix B) — it partly determines the slope of the curve between 1980 and 1987.

Besides the two points mentioned above, these changes in slope also result from the opposite signs of the technology variables in explaining the educational structure (see Table 1). Before 1987 the influence of the back office and front office variables are dominant, thereafter the technical coefficient becomes relatively more important.

One should keep in mind, however, that these projections are only meant to show more explicitly the kind of relationships found and the basic characteristics of the model. Whether the predicted increase in the level of both general and vocational education and the increase in the share of vocational education will actually occur, also depends on the educational characteristics of the future labor supply and the educational effort of the bank organization itself.

6. SUMMARY AND CONCLUSIONS

In this paper we tried to quantify the effects of technological developments on the educational structure of the banking sector. The approach followed in this paper consisted of subdividing the total effect of technology on educational structure in recruitment effects and schooling effects. Table 1 shows that the technology variables (back office and front office automation and the technical coefficient) are major determinants of the educational structure in banking. All occupations show a significant relationship between at least one of these variables, on the one hand, and the educational structure, on the other. Second, when the recruitment effect and schooling effect have opposite signs, the recruitment effect is dominant. Third, the educational structure of the occupational groups of commercial employees and the management and the board seems to be somewhat less influenced by technological developments. Fourth, there is a large correspondence in the overall effects, the recruitment effects and the schooling effects for both groups of clerical workers. A large part of the total effects can be contributed to recruitment effects rather than to schooling effects. The recruitment strategy appears to be the element by which rapidly developing banks can be distinguished from local banks that experience a slower rate of technological development. This is not to say, however, that the recruitment mechanism is dominant over the schooling mechanism in adjusting the educational structure. It appears that almost all local banks use both of these policies very intensively (see Tables A1 and A2 in the Appendix). But leading local banks tend to recruit more workers with a vocational education. Therefore, the overall educational level of new entrants for leading banks will be much higher. Probably, these entrants are recruited for all kinds of functions, from lower white collar jobs concentrated in the clerical occupations to higher white collar jobs concentrated in commercial and managerial functions. Both with respect to the level of vocational education and with respect to the share of vocational education, the schooling effect is mostly contrary to the recruitment effect. Because of their strong recruitment effect, the leading banks already have a larger share of workers with a vocational education. The shift from general to vocational educational status resulting from post-formal schooling is, therefore, much greater for the banks with a relatively large share of workers with only a general education. Given the high share of workers with a vocational education, the only way the educational status of those workers can change is via regular courses which raise their level. Although the shift in the share of vocational education brought about by regular courses, for reasons listed above, is greater for banks which lag behind, the average educational level is higher for leading banks.

For most occupations the model predicts an upgrading tendency in the educational structure; therefore, we also consider a shift from general to vocational education as upgrading. The only exception is the small decrease in the level of vocational education for the board and management.

Although the predicted changes in skill levels are small, the model predicts a rather significant increase in the share of employees with a vocational education of more than 10% for the 1987–1995 time span. If we bear in mind the rather significant changes in educational structure that occurred between 1984 and 1987 through recruitment and schooling policies, we expect that the predicted change in educational structure can be easily dealt with. There are, however, as has been said before, many more determinants of educational structure than are incorporated in our model. All those other determinants, such as future conditions in the labor market, educational characteristics of new labor force entrants, competitiveness in the bank sector, the role of labor unions, etc., may influence the future skill structure in the bank sector.

NOTES

1. It is, however, still possible that supply side effects are not completely eliminated in as far as technologically progressive banks are more attractive to the pool of applicants than banks that experience a slower rate of technological development.
2. For a more elaborate discussion see Spenner (1985) and Kern and Schumann (1984).
3. For a justification of this occupational classification, see Diederen *et al.* (1989).
4. That is $\beta_{ij} = (\delta Y/Y)/(\delta X/X)$. In Appendix B it is shown that the coefficients β actually represent differences between elasticities.
5. In the analysis the variable for typology has to be dropped because of over high correlation with the technology variables (so most of the rural banks already seem to have specific computer equipment before 1984). Also the share of automation personnel had to be dropped as an explanatory variable, because of too little variation in this variable.
6. The average local bank has 49 employees, of which 19 are classified as clerical production workers, eight as clerical coordination workers, 12 as commercial employees, six belong to board or management and for four the occupation is not known. This sample can be considered as representative for the whole bank. More detailed information can be found in Diederen *et al.* (1989).
7. For a complete exposition of the model, its characteristics and the interpretation of the coefficients see Appendix B.
8. The measurement error in the share of an educational category in an occupation for each local bank is greater the smaller the local bank and the fewer the number of employees for that particular combination of education and occupation. We correct for this measurement error by using weighted least squares (WLS) regressions with the number of employees as weights.
9. This is because the number of years of general education ranges from six (primary school) to 12 (general secondary, higher level) and for vocational education from nine (lower vocational) to 15 (higher vocational or university).
10. $TC_k80 = TC_k87/(1 + g)^7$, with k = bank k, g = average growth rate of the technical coefficient between 1980 and 1987.
11. Smaller growth rates result in almost all cases in a less pronounced change in educational structure.

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APPENDIX A

Table A1. Change in educational structure

	Formal education		Regular courses included	
	1984	1987	1984	1987
Primary	5.3	4.4	4.4	3.5
General secondary (low)	37.1	32.8	19.6	14.8
General secondary (high)	24.9	28.1	11.5	10.7
Lower technical	1.6	1.4	1.2	1.0
Intermediate technical	0.6	0.7	0.4	0.5
Higher technical	1.2	1.2	0.6	0.7
Lower economical	6.2	5.7	17.0	16.1
Intermediate economical	9.4	12.4	31.5	38.9
Higher economical	3.6	4.0	8.3	9.5
Remaining lower	3.1	2.3	2.3	1.6
Remaining intermediate	5.3	4.6	2.2	1.7
Remaining higher	1.8	2.3	1.0	1.0
	100.0	100.0	100.0	100.0
Less than 12 years	53.3	46.6	44.5	37.0
12 Years	40.2	45.8	45.6	51.8
More than 12 years	6.6	7.5	9.9	11.2
	100.0	100.0	100.0	100.0

Table A2. Educational structure in 1987 for personnel who started before and after 1980

Education	Formal education ≥80	Formal education <80	Courses included ≥80	Courses included <80
Primary	1.9	6.4	2.9	5.0
General secondary (low)	21.8	41.5	18.9	19.1
General secondary (high)	36.9	20.6	21.7	6.5
Lower technical	0.7	2.1	0.6	1.5
Intermediate technical	0.8	0.7	0.5	0.5
Higher technical	1.8	0.9	1.1	0.5
Lower economical	4.7	6.7	13.9	18.6
Intermediate economical	17.3	8.7	28.3	33.7
Higher economical	5.3	2.8	5.9	9.6
Remaining lower	1.9	2.5	2.0	2.3
Remaining intermediate	3.2	5.9	2.3	2.2
Remaining higher	3.5	1.4	1.9	0.6
	100.0	100.0	100.0	100.0

APPENDIX B: THE MODEL USED

The equation describing the relation between technology and educational levels is supposed to be of a multiplicative form:

$$Y = e^{\alpha}\, TC^{\beta}\, YBO^{\tau}\, YFO^{\delta}\, SIZE^{\tau}\, e^{\epsilon}, \qquad \text{(A1)}$$

with Y = educational level; ϵ = disturbance term $N(0, \sigma^2)$.

In this equation the regression coefficients can be interpreted as elasticities because

$$\beta = (\delta Y/\delta TC)/(TC/Y) \qquad \text{(A2)}$$

Another characteristic of the multiplicative specification is the implied or enforced monotone decreasing effect of all independent variables. This can be easily seen from the first and second derivatives of Eqn (A1).

$$\delta Y/\delta TC = \beta Y/TC \text{ and } \delta^2 Y/\delta TC^2 = -\beta Y/TC^2. \qquad \text{(A3)}$$

The first and second derivatives imply that the effect of the explanatory variable on the independent variable will decrease [conditional on $|\beta|<1$)] as the magnitude of the explanatory variable increases.

For an explanation of the share of vocational education (instead of level) we use a specification which is equivalent to the logit model. Because we are working with shares, a few restrictions have to be imposed on the model. First, the shares must take values between zero and one. Second, the sum of the shares must sum to one. A model which satisfies these assumptions is called a logical consistent model. Such a model, which also has the characteristics of the multiplicative model listed above, is represented in the following equations (see Leeflang (1977) for a more elaborate discussion and for alternative specifications of market share models):

Let S_j = share of type j education, then

$$S_j = e^{\alpha} X^{\beta_j} e^{\epsilon_j} / (\Sigma_j\, e^{\alpha_j} X^{\beta_j} e^{\epsilon_j}) \qquad \text{(A4)}$$

Let the denominator be equal to Z. Taking logarithms on both sides we obtain:

$$\ln S_j = \alpha_j + \beta_j \ln X + \epsilon_j - \ln Z. \qquad \text{(A5)}$$

The equation for the average share can be represented as:

$$\ln \bar{S} = \bar{\alpha} + \bar{\beta} \ln X + \bar{\epsilon} - \ln Z. \qquad \text{(A6)}$$

Taking the difference between (A5) and (A6) we get:

$$\ln S_j - \ln \bar{S} = (\alpha_j - \bar{\alpha}) + (\beta_j - \bar{\beta}) \ln X + (\epsilon_j - \bar{\epsilon}). \quad \text{(A7)}$$

So the coefficients of Eqn (A7) represent not pure elasticities, but rather the deviation from the average elasticity. Because we only have two shares, vocational vs general, it can be proven that the coefficients of (A7) represent the difference between both elasticities. The absolute magnitudes, however, cannot be derived, analogous to the logit model in which only chances relative to a reference group are estimated. That Eqn (A7) is equivalent to a logit model can be easily shown in our case with two shares:

Let p_j be the chance to belong to education j (e.g. vocational education), then the standard logit equations are:

$$p_j/(1 - p_j) = e^{\beta_j X} \quad \text{[A8(a)]}$$

and

$$p_j = 1/(1 + e^{\beta_j X}). \quad \text{[A8(b)]}$$

Our model [Eqn (A4)], in case of two shares, can be reformulated as follows:

$$S_1 = e^{\beta_1 X}/(e^{\beta_1 X} + e^{\beta_2 X}) = 1/(1 + e^{(\beta_2 - \beta_1)X}). \quad \text{(A9)}$$

As we can see the equation of the logit model [A8(b)] has the same functional form as Eqn (A9). The estimates from our model equal $(\beta_2 - \beta_1)$, while the estimates β in the logit model are always relative to the reference group.

In estimating Eqn (A7) we encountered a few problems of which the most important was the rather frequent occurrence of shares with values of zero. Because the argument of a logarithm like ln S in (A7) must be greater than zero, these observations should be excluded from the analysis. However, these observations carry the very useful information that the share of that particular type of education in that occupation is equal to zero. To solve this problem we substituted for the observations with shares equal to zero:

$$S_j = 0.25/\text{num}_{ik} \quad \text{(A10)}$$

with num_{ik} = the number of employees in occupation i at bank k.

The rationale behind this solution is that the smallest possible share in a discrete world is $1/\text{num}_{ik}$, which represents one person with that type of education out of all persons with the same occupation i at local bank k. In a non-discrete world everything above 0.5/num and below 1.5/num is, because of rounding errors, supposed to be equal to 1/num in a discrete world. Analogously, every observed share between 0 and 0.5/num (with 0.25/num as average) is, because of rounding errors, supposed to represent shares with value zero. As the number of employees in a particular occupation at a particular bank (num_{ik}) increases, it becomes less likely that the share of a particular type of education becomes zero. However, if it does, this is very useful information and our solution has the likely property that the substituted value for S_j will be very small because of the large denominator num_{ik}. By taking the logarithm of (A10) a smaller value of S_j results in a larger negative value and therefore has greater impact on the outcome of the regression coefficient.