A double hurdle approach for company further training behaviour and an empirical test of this using data from the IAB establishment panel[*]

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In this paper the further training behaviour of firms is explained using a double hurdle approach: the first hurdle is that the further training of employees is worthwhile for the firms in general, the second hurdle is that demand for further training arises. The empirical test is conducted using data from the IAB establishment panel: by combining the balanced panel for three waves into a cross-section it is possible to determine the effect of extending the observation period for the provision of further training (probit estimates) and the intensity of further training (quasi-likelihood estimates). The results confirm the double hurdle approach: variables for capital intensity, innovation orientation and the employee structure have a significant impact on whether further training is generally worthwhile for the firms, and investment in data processing and in the field of communication as well as organisational changes are significant motivations for providing further training.

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1 Problem

Against the background of rapid technological and organisational change and the demographic trend, company further training has gained considerable importance from the viewpoint of employers (and employees). It therefore comes as a surprise that some 60 % of all western German firms do not provide their employees with further training. If firms are asked to give their reasons for not providing further training, only 19 % of them report that they do not support further training in principle; 16 % say that they only did not provide further training in the first six months of the year but that they do support further training in principle; 12 % state that they only did not release their staff for further training for reasons of time, and 57 % state that the skill level of their workforce is currently sufficient (Table A1 in the appendix).[1] This suggests that the *length of the observation period* is of importance in questions regarding *firms' further training behaviour.*

In the light of this consideration we start out from the hypothesis that if a longer observation period were taken as a basis, the share of firms providing further training would increase and their further training intensity would decline. The *theoretical background* for this is a *double hurdle model* as developed by Cragg for decisions to purchase durable goods: "Two hurdles have to be overcome before positive values of y_t are observed. First, a positive amount has to be desired. Second, favorable circumstances have to arise for the positive desire to be carried out" (Cragg 1971: 831). We apply a model of this type to the *further training behaviour of firms.* Here the *first hurdle* is that a firm generally classifies provision of further training as being worthwhile, and the *second hurdle* is that the firm actually provides further training in concrete terms because the skill level of its workforce is no longer sufficient or the firm wishes to prevent this occurring.

In order to test the applicability of the model *empirically* we first calculate the further training provision and the intensity of further training for the 2001 wave of the IAB establishment panel and estimate what determinants they depend on. Then we combine the results of the three survey waves of the establishment panel[2] between 2000 and 2005, i.e. we

make a cross-section out of the balanced panel and obtain in this way an observation period of six years for which we calculate the same dependent variables and estimate their determinants.

Our paper continues as follows: in *part two* we substantiate our hypothesis using a double hurdle approach, which also takes into account previous empirical findings concerning the determinants of company further training. In *part three* we examine whether it is possible to depict firms' further training behaviour better by extending the observation period. For this we estimate the provision of further training using a probit approach and the further training intensity using a quasi-likelihood approach following Papke/Wooldridge (1996) for the short and the longer observation periods. Finally in *part four* we discuss the differences between our procedure and that of panel models as regards the issue being investigated, summarise the findings and refer to further possible applications of combining several waves of a longitudinal section to make a cross-section.

2 Theoretical background and previous empirical findings

2.1 A double hurdle approach for company further training behaviour

The point of departure is earlier work on the importance of the length of the survey interval for purchasing decisions of households; for instance, with a short observation period a household not purchasing alcoholic beverages may mean that the members of the household do not drink alcohol in general or that they are using alcoholic drinks that they bought previously (cf. Tobin 1958). Cragg (1971) explained this using a *double hurdle model:* the first hurdle that generally stands in the way of purchasing certain goods can be of social, psychological or ethnic nature, whilst the second hurdle involves the price being too high or the existence of supplies. If the observation period, and thus the period in which a purchase can be made, is extended, then the second hurdle becomes lower because special offers for the good become more likely and/or the supplies are exhausted. Such a model can be applied to the *further training behaviour of firms.*

The *first hurdle* is that a firm classifies *provision of further training* as being worthwhile *in general* because the associated *costs* (K_U) are permanently not higher than the *revenues* (E_U^t) expected in the future

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[1] Result from the IAB establishment panel for 2003. The question regarding the reasons for not providing further training was only asked in 2003 and not in 2001.

[2] In the IAB establishment panel questions about further training behaviour are only asked every two years, so no data on further training are available for 2000, 2002 and 2004. For this reason we assume that the results of the survey apply for a period of two years in each case.

as a result of the training measure (cf. Neubäumer 2006):

$$K_U \leq E_U^r = P_U \cdot E_U = P_U \cdot (E_U^+ - w_U^+) \qquad \text{(GL.1)}$$

where E_U^+ = cash value of the (gross) revenues obtainable in addition in the various periods as a result of further training

w_U^+ = cash value of the qualification-related wage differential

P_U = likelihood of the potential net revenues $(E_U^+ - w_U^+)$ being realised.

Revenues resulting from further training are to be put down to the fact that better qualified employees make it possible to reduce production costs and transaction costs and/or to achieve higher sales revenues. These revenues differ greatly depending on the characteristics of the firms.

Thus firms with *high capital intensity* can raise their revenues more considerably by means of additional human capital because in their case a small relative increase in an employee's productivity already leads to a clearly higher absolute additional revenue.[3] Accordingly we start out from the hypothesis that firms with high capital intensity are more frequently involved in further training and demonstrate a higher intensity of further training.

What is also important for the revenues gained from further training is the extent to which the firms compete via the quality and the degree of novelty of the goods and services they offer. For new production processes and/or new products can be introduced more smoothly and quickly with a skilled workforce. It is therefore to be assumed that variables which indicate a firm's *high level of innovation orientation*, such as modern production equipment and a firm's own research and development, have a positive effect on further training activities. (Since both firms' capital intensity and their innovation orientation depend on the industry, provision of further training and the intensity of further training are likely to be influenced equally by *industry affiliation*.[4] Furthermore the industry reflects other determinants of further training behaviour, such as collectively agreed

regulations on further training, "innovation pressure" and the degree of specialisation.)

The *organisation structure* is another factor that influences the extent to which training is used and the way in which it is used. In the case of certain forms of participatory organisation, such as teamwork, flat hierarchies and employees in the lower levels of the hierarchy having their own areas of responsibility and possibilities of participation, the skills required of the employees and thus also the possibilities of utilising further training are especially high (cf. Aoki 1990). These forms of organisation require broad skills, an understanding of relationships within the firm, and social competence. Against this background, firms with participatory organisation forms can be expected to be more active as regards further training.

Finally, the revenues gained from further training depend on the *employee structure*. Statistically it is possible to detect a relationship between trainability, and thus success in learning, and the prior education and training, so firms with a large share of employees who have a vocational qualification or in particular a university degree expect higher revenues as a result of further training measures. What is also of importance here is they rate a higher qualification level as a "signal" for greater willingness to perform. In the case of older workers, women and/or part-time employees, the firms often assume a shorter payback period for the investment in further training, with the result that less further training activity can be expected in firms with a large share of these employee groups.

It also follows from equation 1 that in the general decision regarding investment in further training it is of importance how much of the *revenues* that can be gained in this way the firms (have to) pass on to their employees in the form of *higher wages* and – closely linked with this – how *likely* it is that the employees who have received further training *remain with the firm*. This depends not only on the extent to which the human capital obtained through further training is *firm-specific*,[5] but also on how competitive a firm's jobs are, and it can be linked in particular to the wage level, the working conditions

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[3] High capital intensity can result not only from investment in real capital but also from investment in immaterial values such as in research and development, market research and the development of brands. Cf. Neubäumer/Kohaut 2002.
[4] The industry is of importance empirically as an indicator of capital intensity and innovation orientation, if capital intensity and innovation orientation can not be captured fully by the other explanatory variables.

[5] Acemoglu/Pischke 1999a, 1999b put it down to different market imperfections that there are so-called "compensatory wage differentials", i.e. the fact that when gaining general human capital by means of initial and further vocational training, the associated increases in revenue are not passed on fully in the wage. They take up numerous arguments cited in the literature for the fact that firms also participate in the funding of general human capital. Cf. for example the surveys in Alewell 1998 and Neubäumer 2006.

and employment security (or labour turnover). Firms with a generally higher wage level and more employment security do not need to pay such high skill-related wage differentials after a further training measure in order to "retain" their employees. Accordingly, we assume that indicators of a generally high wage level and permanent employment relationships (as well as attractive working conditions) have a positive effect on investment in further training.

It is not possible to state definitely from a theoretical point of view what effect *codetermination* and *cooperative labour relations* have on firms' decisions regarding further training. The reason for this is that firstly works councils work towards higher wage premiums to remunerate further training, and secondly they contribute to lower labour-specific transaction costs and to lower labour turnover.[6] Therefore it is not possible to make a statement as to whether codetermination leads to less or more further training activity.

The *second hurdle* is that the firm *definitely provides further training* because the employees' skill levels are no longer sufficient or the firm wishes to prevent this happening. The reason for this can be that the last further training measures took place some time ago or that occasions for further training, such as the introduction of new products and/or production processes or changes in the organisation and information systems, have occurred or are planned. When the observation period is longer this second hurdle is lower, so *more* of the firms that are *interested in further training in general* can be observed.

We assume that this is of importance in particular for small firms and put it down to cost considerations and to the fact that reasons for further training arise more irregularly in small firms:

Further training leads not only to variable costs that depend on the number of participants but also to *fixed costs*, e.g. for collecting information about suitable further training measures and for organising the participation in training. (Niederalt 2004 argues along similar lines for in-company vocational training.) For this reason further training is only worthwhile from a certain *minimum number of participants*. Such scale effects occur in particular for internal further training (cf. Pannenberg 1995), which otherwise has clear cost advantages over external

further training measures, however. If further training is conducted at longer intervals in small firms, then with a short observation period it depends (more strongly) on chance whether a firm that is generally willing to provide further training is classified as a firm that does not provide further training.

In addition to this there is the fact that "demand for further training" arises as a result of the introduction of new products and production processes and as a result of changes in the firm's organisation and information systems. Thus, for example, the introduction of units being responsible for their own costs or results or of teamwork requires better knowledge and more social competence. Such reasons for further training occur irregularly and lead to irregular further training, especially in small firms, which, unlike medium-sized and large enterprises, do not have different departments with different product lines, production processes and organisation forms. We assume that when product and process innovations occur and when participatory organisation forms are introduced both the provision of further training and the intensity of further training increase. However, only some such motivations for further training can be linked to observable characteristics and therefore be used to explain further training behaviour. Furthermore it is generally not possible to state a clear relationship between the time when the reason for training occurred and the time when the training measure was conducted. Thus, for example, a production innovation can lead to (more) further training already in the run-up to the introduction, in the same year and/or in subsequent years.

As far as the size of the enterprise is concerned, we expect that if the observation period is extended more small firms that are active in further training will be observed, i.e. their provision of further training increases (more) clearly and their further training intensity declines.

2.2 Previous empirical evidence

The further training behaviour of firms in Germany has so far been examined empirically using two data sets, the Hannover Panel, which only covers firms in the manufacturing industry and thus no service firms, and the IAB establishment panel.

With the *Hannover Panel* it can be observed first for a three-year period that 42 % of the firms constantly provide further training and 25 % never do so, whilst 33 % provide their employees with further training

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[6] Cf. the "exit and voice approach" of Freeman/Medoff 1979 and Freeman/Lazear 1995 as well as Frick/Sadowski 1995, Frick 1997 and Jirjahn 1998.

on an irregular basis (cf. Gerlach/Jirjahn 1998). This is a point in favour of using our double hurdle approach and extending the observation period.

The probit estimates of the provision of further training and the tobit estimates of the intensity of further training confirm the hypotheses we put forward in the theoretical part (cf. Gerlach/Jirjahn 1998 and 2001[7]). Thus a high level of innovation orientation and participatory employment forms, as well as a large share of skilled employees, attractive jobs and a works council have a positive effect on the provision of further training and the intensity of further training, and a large share of part-time employees has a negative effect. Of the reasons for providing further training, only product innovations prove to be significant and not the introduction of new production processes.[8]

With regard to *firm size* it emerges that it only has a positive effect on the provision of further training, i.e. the probability of a small firm providing further training for its employees is lower. This confirms our assumption that (in a short period) reasons for further training occur in fewer small firms or that cost considerations mean that further training is better provided at longer intervals. However, in the tobit estimates, firm size proves to be positively significant for the intensity of further training. We put this down to the fact that the intensity of further training is measured by the expenditure on further training per employee and that this quantity is considerably lower in small firms (in particular due to the lower wages of employees who have undergone further training and of the people conducting the training) and therefore overcompensates for the larger share of employees who have undergone further training.

In the *IAB establishment panel* the descriptive analysis shows that small firms provide further training

considerably less frequently but then provide a larger proportion of their employees with further training at the same time (cf. Düll/Bellmann 1998, Bellmann/Düll/Leber 2001, Neubäumer/Kohaut/ Seidenspinner 2006[9]). Here the intensity of further training is measured in terms of the ratio of employees with further training to all employees. In the various probit estimates *firm size* is significant with a positive sign for the provision of further training and in the various tobit estimates it is significant with a negative sign in only some cases for the intensity of further training.

In addition to this, various variables for capital intensity and innovation capacity, employee structure and codetermination as well as the attractiveness of the jobs again prove to be significant for further training activity; the hypotheses that we put forward are largely confirmed.[10] Finally the significance of *characteristics that occur only once or only temporarily*, such as shortages of skilled labour, investment in communication technology and EDP, organisational change and shifting responsibility down the company hierarchy, suggest that some firms only provide their employees with further training when there is a definite reason (cf. Düll/Bellmann 1998, Bellmann/Düll/Leber 2001, Hübler 2003, Neubäumer/Kohaut/Seidenspinner 2006).

On the whole the empirical findings obtained so far confirm our double hurdle approach in the sense that firms' further training behaviour is characterised on the one hand by longer-term largely unchanged structural characteristics such as capital intensity and innovation orientation, employment forms, employee structure, attractiveness of the jobs and industrial relations, but on the other hand short-term reasons for further training occur such as investment in the fields of EDP and communication, product innovations, shortages of skilled labour and organisational changes.

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[7] In the first publication three waves of the Hannover Panel (1991 to 1993) were pooled and in the second publication four waves were pooled (1996 to 1999) ("unbalanced panel"). In each case a pooled probit estimate and a random effects probit estimate of further training provision were conducted as well as a tobit estimate of the intensity of further training only for 1993 to 1996. For this the provision of further training is measured by the funding of further training and the intensity of further training by the expenditure on further training per employee.

[8] In Gerlach/Jirjahn innovation orientation is measured in terms of state-of-the-art plant and the medium-term development of R&D, participatory employment forms are measured in terms of teamwork and quality circles, the employee structure is measured in terms of the proportions of university graduates, skilled workers, commercial staff, trainees and part-time employees, the attractiveness of the jobs and codetermination are measured by the existence of collective agreements, profit-sharing plans for employees and the existence of a works council, and reasons for further training are measured by the introduction of new products and new production processes. In some cases different variables prove to be significant in the probit and tobit estimates.

[9] Provision of further training is measured by the promotion of further training (releasing employees to undergo further training respectively paying the further training costs). For reasons of comparison, in the studies by Düll/Bellmann 1998 and Bellmann/ Düll/Leber 2001 only results for western Germany are given.

[10] Depending on the publication and the issue being investigated, different variables are included in the various probit and tobit estimates. These variables are not listed here in full. Capital intensity is measured in terms of the total investment per employee and in terms of variables for investment in intangible assets, e.g. in market research; innovation orientation is measured in terms of the modernness of the plant and equipment, the employee structure in terms of the proportions of skilled employees, trainees, commercial staff and women, and the attractiveness of the jobs and codetermination in terms of the existence of collective agreements and a works council or staff council.

3 Methodical procedure and our own empirical findings

3.1 The data set

Our empirical analysis is based on the *IAB establishment panel* and therefore on a representative sample of almost 10,000 western German firms. The basis for the sampling is the establishment file of the Federal Employment Agency, so the population includes all firms with at least one employee covered by social security (cf. Bellmann 2002, Bellmann/Kohaut/Lahner 2002). Strata are formed according to 17 industries and 10 firm-size classes, and the selection probabilities are approximately in proportion with the employee shares. The IAB establishment panel data have been collected once a year since 1993 in western Germany and since 1996 in eastern Germany.[11]

The *survey units* are *establishments*, i.e. local units in which goods and services are produced. They are interviewed by Infratest München on behalf of the IAB. The annual survey programme covers structural characteristics of the establishments (industry, firm size, investments) and questions about the development and structure of the workforce and about the business development (turnover, profitability, capacity utilisation). In addition to this there are various special focus subjects in individual years. For example in 2001, 2003 and 2005 the firms were asked additional questions about their *further training behaviour*.

3.2 Extending the observation period

When extending the observation period we start out from the assumption that we were able to ask the firms (and that they had reliable documentation of) whether they had provided further training in the last six years and how many employees were involved. In order to approximate this assumption, in our study we take into account *only* establishments that were in the 2001, 2003 and 2005 waves of the IAB establishment panel and gave details regarding their further training provision in the different years and regarding the number of employees who under-

went further training in the different years.[12] For them we form the variable for the provision of further training in the entire observation period (y_{Bi})

$$y_{Bi} = \begin{cases} 0 \text{ if all } y_{Bit} = 0 & (t = 1 \text{ to } 3) \\ 1 \text{ if at least one } y_{Bit} =] & (t = 1 \text{ to } 3) \end{cases}$$

where y_{Bit} = dummy for provision of further training in period t

and the variable for the average further training intensity in the entire observation period (y_{Ii})

$$y_{Ii} = \left(\sum_{t=1}^{3} \frac{w_{it}}{b_{it}} \right) : 3 \qquad (t = 1 \text{ bis } 3)$$

where w_{it}, b_{it} = the number of employees who underwent further training and the number of employees of firm i in period t.

One limit of this assumption is that firms were only asked about their further training behaviour at two-year intervals, i.e. details about further training are only available for three years of the six-year period. To simplify the matter we assume that the firms have always given information about their further training behaviour in the last two years, knowing full well that we can not capture all of the firms which only provide further training temporarily.

This conversion of the balanced panel into a cross-section (and thus not taking into account the longitudinal variance) is to be seen against the background of our double hurdle model of further training behaviour, which has to be tested empirically:

- Firms' *general willingness to provide further training* (and thus the overcoming of the first hurdle) depends on a number of *structural characteristics* which barely change over time (or for which larger changes are taken into account).

- The firms which provide further training at irregular intervals (because they do not always over-

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[11] We do not include eastern German firms in our analysis since due to the transformation process the determinants of company further training differ strongly between the states of former East and West Germany.

[12] The firms were able to report both participants in further training and cases of further training; the latter were converted into further training participants.
Details about firms' expenditure on further training (as in the Hannover Panel) are not available in the IAB establishment panel. This is to be seen in the light of the fact that the costs of further training for the firms are very difficult to record reliably in practice: many establishments (firms) do not determine their further training costs explicitly and some of the firms do not add the costs related to the absence of the employees while they undergo training, whilst others include these costs in their further training costs. Cf. Grünewald/Moraal/Schönfeld 2003.

Table 1

Comparison of further training provision and further training intensity in 2001, 2003, 2005 and 2000 to 2005 according to firm-size classes

Firms with ... employees	Further training				Further training intensity							
	provision				All firms				Firms providing further training			
	2001	2003	2005	2000 to 2005	2001	2003	2005	2000 to 2005	2001	2003	2005	2000 to 2005
1 to 9	0.30	0.33	0.32	0.49	0.14	0.17	0.16	0.16	0.28	0.35	0.33	0.26
10 to 49	0.58	0.56	0.57	0.76	0.17	0.21	0.21	0.20	0.23	0.27	0.28	0.23
50 to 49	0.70	0.69	0.71	0.87	0.15	0.23	0.22	0.20	0.17	0.26	0.25	0.20
100 to 499	0.89	0.87	0.92	0.97	0.18	0.25	0.19	0.20	0.19	0.26	0.19	0.20
500 and more	0.98	0.98	0.94	1.00	0.22	0.29	0.26	0.23	0.22	0.29	0.26	0.25
Total	0.39	0.41	0.41	0.58	0.15	0.18	0.18	0.17	0.26	0.32	0.31	0.28

come the second hurdle) are not fully observed, especially when the observation period is short, with the result that the provision of further training is shown as too low (and the further training intensity of firms providing further training is shown as too high).

– It is not only the case that reasons for further training occur irregularly, but also that it is not possible to state a clear temporal relationship between the occurrence of the corresponding variables and (more) further training measures. This, too, is more noticeable with a (too) short observation period.

Finally with a balanced panel converted into a cross-section the problem of *panel mortality* occurs to the same extent: of about 9,850 establishments that belonged to the establishment panel for western Germany in 2001 only about 3,800 replied in both 2003 and 2005, i.e. less than 40 %. The panel mortality scarcely differs in the different firm-size classes, however (Table A2 in the appendix).

3.3 Description and explanatory variables

Table 1 shows the effects that extending the observation period has on the provision of further training and the intensity of further training, which we expected: whereas in the period 2000 to 2005 58 % of the firms provided their employees with further training, it averaged only 40 % in the individual years, i.e extending the observation period the firms' provision of further training increased by 45 %. This effect is stronger still in the case of very small establishments: the proportion of firms providing further training grew by 58 %. This indicates

that firms' fundamental provision of further training is underestimated when the observation period is (too) short. On the other hand the intensity of further training for the firms that do provide further training is overestimated in this way: it averages 30 % in the individual years (32 % for very small establishments) and falls to 28 % (26 %) when the observation period is extended. At the same time the provision of further training by firms that provide further training no longer varies so considerably between the firm-size classes.

In our estimates of the provision of further training and the intensity of further training for the short and the long observation periods we assume that the further training behaviour is influenced by four groups of variables:[13] capital intensity and innovation orientation; firm size, proportions which characterise the firms' employee structure; variables that stand for the attractiveness of the jobs and for codetermination; and variables that characterise reasons for further training. With the first three groups we assume that they are *longer-term structural characteristics* which hardly change over time (qualitative characteristics) or which vary around a certain level over time only by coincidence or for reasons associated with the business cycle (quantitative characteristics), whilst in the case of the fourth group of characteristics we assume that they reflect irregularly occurring reasons for further training as well as structural changes. This procedure is a result of our double hurdle approach.[14]

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[13] An overview of the delimitation of the explanatory variables and the variables to be explained is provided by Table A3 in the appendix.
[14] Cf. Neubäumer/Kohaut/Seidenspinner 2006 for a similar procedure. There the selection of the first three groups of variables is explained in more detail.

Table 2

Comparison of the means and proportions of the explanatory variables for firms which do not provide further training, firms which provide further training at irregular intervals and those providing further training regularly

	firms not providing further training (n = 717)	firms providing further training at irreg. intervals (1 or 2 times) (n = 1,075)	firms providing further training regularly (3 times) (n = 1,995)
Covariates	**(weighted) means/proportions[1]**		
Total investment per employee	171	781	1,422
Modern technological state of the plant	0.55	0.69	0.70
Involvement in R & D	0.02	0.06	0.11
Firm size	4.0	6.7	14.6
Employee structure			
– Unskilled and semi-skilled workers	0.18	0.13	0.10
– Skilled non-manual employees	0.25	0.38	0.53
– Women	0.44	0.47	0.53
– Part-time employees	0.28	0.27	0.26
Works council	0.02	0.09	0.23
Collective agreement	0.35	0.50	0.62
Payment above collectively agreed wage scale	0.12	0.22	0.30
Labour turnover	0.05	0.06	0.04
Investment in comm. technology and EDP	0.44	0.65	0.82
Organisational changes	0.16	0.31	0.52
Shift in responsibility down the hierarchy	0.04	0.09	0.23
Introduction of teamwork	0.01	0.04	0.12
Introduction of determination of own results/costs	0.02	0.02	0.09
Improvement of technological state of the plant (2005 over 2001)	0.19	0.18	0.20
Development of the number of employees between 2001 and 2005	−0.27	−0.17	−0.24

1 Weighted using panel factors.

Table 2 shows that firms which provide further training at irregular intervals – which are usually assigned to the firms not providing further training when the observation period is short – differ clearly in their structural characteristics from the firms that do not provide further training: they are larger, invest more and have more modern plant and equipment, they employ fewer unskilled and semi-skilled workers and more skilled non-manual employees, and are more likely to have a works council and collective agreements and pay above the collectively agreed wage scale. However, they differ in virtually the same structural characteristics from firms that provide further training regularly (apart from the almost equal technological state of their plant and equipment and a high labour turnover). Reasons for further training, such as investment in communication technology and EDP or various changes in the organisation system, occur more seldom in firms that provide further training at irregular intervals (and even more so in firms that do not provide further training).

As three attributes are available for many variables (for 2001, 2003 and 2005), the delimitation of the explanatory variables requires prior consideration and pre-testing with regard to contents.

For each of the *quantitative characteristics* we calculate the *mean* from the values for the *three years.*

This is important above all in the case of variables which fluctuate strongly over time, such as investment, for which constancy can be achieved in this way (in contrast the proportions that characterise the employee structure remain virtually constant). For the number of employees, in addition to the attribute for 2001, we also use a variable for the development between 2001 and 2005 because a large increase (or reduction) in the workforce is likely to have an impact on the further training behaviour.[15]

A number of qualitative (structural) characteristics do not change over time; this can be seen from the fact that for most of the firms the dummy variables have the same value of 0 or 1. For industry affiliation and the existence of a works council we accordingly used the dummy variable for 2001 and 2003 respectively.[16] For the technological state of the plant, for which changes occur in the firms' estimations, we use both the dummy variable for 2001 and a further dummy variable for an improvement in the technological state, which can be regarded as a proxy variable for process innovations. In the case of the existence of collective agreements and payment above the collectively agreed wage scale, additional evaluations found that almost all cases of a change in the dummy occur temporarily. Accordingly we set a dummy value of 1 for these variables if there is a collective agreement or payment above the collectively agreed wage scale in at least two of the three surveys.

Finally the variables of involvement in R&D, organisational changes, a shift of responsibility down the hierarchy, introduction of teamwork and the introduction of units having to determine their own results and costs are only available for 2001. They can only be used to explain further training if the observation period is extended (or the appropriate cross-section used) and then lead to an information gain.

3.4 Estimation procedure and results of the estimate

As a *reference model* (model 1) we first estimate the provision of further training in 2001 using a probit approach and the intensity of further training in 2001 using a quasi-likelihood approach following Papke/Woodridge (1996)[17] subject to the different explanatory variables for 2001. Then we extend the survey interval and estimate what determines whether a firm provided further training at least once in the years 2001, 2003 and 2005 and which factors determined the firm's average intensity of further training in these three years. For this we use analogue variables like those in the reference model but defined for the longer survey interval (model 2a) or we use another two additional variables that capture changes in the survey interval (extended model 2b).

In our (robust) *probit estimates* virtually the *same variables* prove to be *significant* for both the short and the longer observation periods for firms generally classifying further training as worthwhile: investment in real capital, modern plant and equipment, involvement in R&D and firm size (each with a positive sign), as well as the proportion of skilled non-manual employees (with a positive sign) and the proportion of unskilled and semi-skilled employees (with a negative sign) (Table 3). This confirms our hypotheses that capital intensity, innovation orientation and the size of the firms as well as the skill level of their workforces are of importance for overcoming the first hurdle.

For the shorter observation period this also applies for the existence of collective agreements, payment above the collectively agreed wage scale, labour turnover and the existence of a works council, i.e. for variables that characterise the attractiveness of the jobs and the type of industrial relations. For the longer observation period, however, only the existence of collective agreements proves to be significant. This suggests that payment above collectively agreed wage scales, labour turnover and the existence of a works council are of no (or only slight) importance for further training in the case of (small) firms which less frequently overcome the second hurdle by means of concrete reasons for further training.[18]

Of the reasons for overcoming the second hurdle for further training, only investment in communication

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[15] If there is a considerable change in the average number of employees for all of the firms together, the change in the number of employees in a firm is calculated as follows: $\frac{B_{i05} - B_{i01}}{B_{i05}}$.

[16] Values for the existence of a works council are only available for all of the firms for 2003.

[17] The suitability of tobit estimates when the variables to be explained have a value between 0 and 1, which used to be conducted frequently, is meanwhile being questioned by a number of authors, who have suggested using other methods. Cf. Ronning 1992, Papke/Woolridge 1996, Wagner 2001, Kieschnik/McCallough 1999.

[18] However, fewer variables for industrial relations are significant, too, if the probit estimates are conducted for the two other (individual) years 2003 and 2005 (Table A4 in the appendix). This suggests a not very stable correlation between the provision of further training and the attractiveness of the jobs and the type of industrial relations. According to Jirjahn 2003 this could also be attributable to the fact that a works council and the existence of collective agreements have to act in combination.

Table 3

Comparison of different probit estimates of the determinants of firms' further training provision[1] in 2001 and 2000 to 2005

| Covariates | Estimate for the short survey period 2001 | | | Estimate for the longer survey period 2000 to 2005 | | | | | |
| | (model 1) | | | comparable variables to 2001 (model 2a) | | | with additional variables (model 2b) | | |
	Co-efficient	Stand. dev. (robust)	P > |z|[2]	Co-efficient	Stand. dev. (robust)	P > |z|[2]	Co-efficient	Stand. dev. (robust)	P > |z|[2]
Total investment per employee[3]	.0250193	.0094056	0.008**	.0348665	.0131208	0.008**	.0336110	.0131921	0.011*
Modern plant[4]	.1756653	.0589582	0.003**	.1972228	.0689654	0.004**	.2673632	.0888418	0.003**
Involvement in R & D[4]	.2616020	.0975704	0.007**	.4623855	.1513416	0.002**	.4674173	.1524420	0.002**
Firm size[3]	.3594962	.0268802	0.000**	.5163769	.0385206	0.000**	.5157458	.0386795	0.000**
Unskilled and semi-skilled workers[3]	−.6027070	.1380020	0.000**	−1.164368	.1996593	0.000**	−1.1667690	.2001282	0.000**
Skilled non-manual employees[3]	.5717890	.1184814	0.000**	.9502127	.1796616	0.000**	.9411333	.1803354	0.000**
Women[3]	.1677942	.1296583	0.196	−.0192541	.1626092	0.906	−.0169388	.1632940	0.917
Part-time employees[3]	−.2480135	.1378542	0.072+	−.1060327	.1813485	0.559	−.1065400	.1815676	0.557
Works council[5]	.1431515	.0792289	0.071+	.1479081	.1179315	0.210	.1533997	.1180579	0.194
Collective agreement[6]	.2049237	.0647642	0.002**	.2693210	.0804686	0.001**	.2731672	.0806586	0.001**
Payment above collectively agreed wage scale[6]	.1697270	.0630920	0.007**	.0705929	.0925093	0.445	.0672609	.0925329	0.467
Labour turnover[3]	−.5482337	.2467270	0.026*	−.0414280	.0795818	0.603	−.0038903	.0777868	0.960
Investment in communication technology and EDP[4]	.2508964	.0763561	0.001**	.2443967	.0911734	0.007**	.2413864	.0913432	0.008**
Organisational changes[4]	.3684118	.0690339	0.000**	.3103438	.0868506	0.000**	.3185538	.0870093	0.000**
Shift in responsibility down the hierarchy[4]	.0958174	.0960028	0.318	.0873666	.1322742	0.509	.0838521	.1324007	0.527
Introduction of teamwork[4]	.1123399	.1266249	0.375	−.0232556	.1767616	0.895	−.0305109	.1772764	0.863
Intro. of determination of own results/costs[4]	.0029725	.1290681	0.982	−.1343189	.1994647	0.501	−.1376142	.1995065	0.490
Improvement in modernness of the plant[4]							.1313055	.1058920	0.215
Change in firm size between 2001 and 2005							.0066074	.0024429	0.007**
Industry dummies	yes			yes			yes		
Constants	−1.83949	.1268339	0.000**	−1.531145	.1397243	0.000**	−1.590222	.1456541	0.000**
	n = 3,353 Wald χ²(29) = 982.89 Prob. > χ² = 0.0000 Pseudo-R² = 0.3525			n = 3,189 Wald χ²(29) = 674.12 Prob. > χ² = 0.0000 Pseudo-R² = 0.4099			n = 3,189 Wald χ²(31) = 675.14 Prob. > χ² = 0.0000 Pseudo-R² = 0.4107		

1 Dependent variable: 1 = provision of further training in 2001 (model 1) and provision at least once in 2001, 2003 or 2005 (model 2 a,b);
   0 = no provision.
2 Levels of significance: ** P < 0.01; * P < 0.05; + P < 0.1.
3 Values for 2001 (model 1) or average values for 2000 to 2005 (model 2a, b).   4 Dummy for 2001.   5 Dummy for 2003.
6 Dummy for 2001 (model 1) or dummy = 1 if the dummy has a value of 1 in at least two of the three survey waves (model 2a, b).
Source: IAB establishment panel 2001, 2003, 2005.

technology and EDP and general changes in the organisation structure are significant (each with a positive sign), whilst the introduction of various forms of participatory employment shows no significant impact. Finally, of the structural changes in the extended model only an increase in the size of the workforce proves to be significant (with a positive

sign), but not the improvement of the technological state of the plant and equipment.

The results in the (robust) *quasi-likelihood estimates* are similar: when the observation period is extended, the same structural variables (with the exception of firm size) for capital intensity and innova-

Table 4

Comparison of different quasi-likelihood estimates according to Papke/Wooldridge of the determinants of firms' further training intensity[1] in 2001 and 2000 to 2005

Covariates	Estimate for the short survey period 2001 (model 1)			Estimate for the longer survey period 2000 to 2005					
				comparable variables to 2001 (model 2a)			with additional variables (model 2b)		
	Co-efficient	Stand. dev. (robust)	P > |z|[2]	Co-efficient	Stand. dev. (robust)	P > |z|[2]	Co-efficient	Stand. dev. (robust)	P > |z|[2]
Total investment per employee[3]	.0213963	.0114023	0.061+	.0377195	.0114646	0.001 **	.0343657	.0114230	0.003 **
Modern plant[4]	.1695162	.0652344	0.009 **	.1409048	.0507153	0.005 **	.3455642	.0733123	0.000 **
Involvement in R & D[4]	.3360246	.0872425	0.000 **	.2080148	.0680493	0.002 **	.2066859	.0678588	0.002 **
Firm size[3]	−.1040264	.0240221	0.000 **	−.0675458	.0193176	0.000 **	−.0664027	.0192637	0.001 **
Unskilled and semi-skilled workers[3]	−.7842202	.1660485	0.000 **	−.5137018	.1529948	0.001 **	−.5260196	.1531724	0.001 **
Skilled non-manual employees[3]	.7380839	.1336637	0.000 **	.9384409	.1179141	0.000 **	.9139396	.1179378	0.000 **
Women[3]	.3609029	.1500656	0.016 *	.3295404	.1286802	0.010 **	.3297294	.1276799	0.010 **
Part-time employees[3]	−.3591464	.1727078	0.038 *	−.2144298	.1499446	0.153	−.2006536	.1492694	0.179
Works council[5]	.2671710	.0853200	0.002 **	.0445431	.0634010	0.482	.0490220	.0634612	0.440
Collective agreement[6]	.1784174	.0752999	0.018 *	.2382917	.0631200	0.000 **	.2408351	.0628214	0.000 **
Payment above collectively agreed wage scale[6]	.2156386	.0665842	0.001 **	.0923826	.0572559	0.107	.0912590	.0570685	0.110
Labour turnover[3]	−.5205490	.3236298	0.108	−.0881187	.0392039	0.025 *	−.0842960	.0412218	0.041 *
Investment in communication technology and EDP[4]	.1294052	.0910156	0.155	.1803344	.0777099	0.020 *	.1765363	.0775723	0.023 *
Organisational changes[4]	.2750591	.0749716	0.000 **	.2744018	.0574845	0.000 **	.2853469	.0575351	0.000 **
Shift in responsibility down the hierarchy[4]	.1574359	.0732464	0.032 *	.1182577	.0590599	0.045 *	.1191009	.0587257	0.043 *
Introduction of teamwork[4]	.1455545	.0875618	0.096+	.0799277	.0689915	0.247	.0635608	.0690585	0.357
Intro. of determination of own results/costs[4]	.0137657	.0897388	0.878	.0486163	.0697285	0.486	.0487056	.0693417	0.482
Improvement in modernness of the plant[4]							.3416939	.0859521	0.000 **
Change in firm size between 2001 and 2005							.0019341	.0017687	0.274
Industry dummies	yes			yes			yes		
Constants	−2.627381	.148	0.000 **	−2.698239	.1225716	0.000 **	−2.872285	.1275683	0.000 **
	n = 3,323 LR χ²(12) = 29.20 Prob. > χ² = 0.0037			n = 3,079 LR χ²(12) = 23.10 Prob. > χ² = 0.0269			n = 3,079 LR χ²(12) = 22.70 Prob. > χ² = 0.0304		

1 Dependent variable: intensity of further training in 2001 (model 1) and average further training intensity in 2001, 2003 and 2005 (model 2 a,b).
2 Levels of significance: ** P < 0.01; * P < 0.05; + P < 0.1.
3 Values for 2001 (model 1) and average values for 2000 to 2005 (model 2a, b).   4 Dummy for 2001.   5 Dummy for 2003.
6 Dummy for 2001 (model 1) and dummy = 1 if the dummy has the value of 1 in at least two of the three survey waves (model 2a, b).
Source: IAB establishment panel 2001, 2003, 2005.

tion orientation as well as the skill level of the work-force remain significant and suggest that these variables are of importance for whether it is generally worthwhile for firms to provide a larger proportion of their staff with further training. As regards the proportion of women, it stands out that it is significant with a *positive* sign for firms' intensity of further training and therefore contradicts our hypothesis of the negative impact of a short pay back period. We put this down to the fact that particularly in

firms with a large number of women working part-time the intensity of further training is lower and that we record the proportion of part-time employees separately and it has the expected negative sign.[19] (When estimating the provision of further training the proportion of women and part-time employees had proved not to be significant.)

Differences between the results for the short and the long observation periods are found again for the variables characterising the attractiveness of the jobs and the type of industrial relations: with the longer observation period, payment above the collectively agreed wage scale and the existence of a works council are now no longer significant.[20]

Finally, of the reasons for overcoming the second hurdle for further training, not only investment in communication technology and EDP and general changes in the organisation structure but also shifts in responsibility down the hierarchy prove to be significant (with a positive sign). Of the structural changes in the extended model, the improvement of the technological state of the plant and equipment is now significant, whilst an increase in the number of employees is of no importance for a higher further training intensity. (This could be attributable to more employees with the necessary qualifications being hired.)

On the whole the empirical findings confirm our hypotheses that various structural variables (in particular of capital intensity, innovation orientation and the structure of the workforce) have an influence, in both the short and the longer observation period, on whether the provision of further training in general and a high further training intensity is worthwhile for firms, i.e. whether they overcome the first hurdle. (Only the influence of the variables characterising the attractiveness of the jobs and the type of industrial relations proves not to be stable.) The hypothesis that there are certain concrete reasons for further training which result in the second hurdle for further training activity being overcome is also confirmed. Furthermore both the descriptive results of a clearly lower rate of further training provision and a higher intensity of further training in very small firms as well as the significance of firm size

(with a positive sign) indicate for the provision of further training that reasons for further training occur less frequently in smaller firms.

4 Concluding remarks

4.1 Why an extension of the observation period and not a panel model?

This question can not simply be answered to the effect that the data are not suitable for estimates with a panel model. For instance although the further training behaviour is only observed every two years in the IAB establishment panel, we had to find a solution (assumption) for this problem when extending the observation period, too. (One could argue, at best, that three observation times are not many for a panel and that panel mortality would increase considerably if there were more observation times.) Furthermore, information on some of the variables that are relevant for company further training behaviour is only collected in one or two of the survey waves. With a panel model these variables would have to be left out of consideration or assumptions would have to be made for the variable values in the other survey waves. When extending the observation period it is instead necessary to establish how to deal with the variable values for three points in time.

What is far more important is that the two methods start out from *different questions. Panel models* take into account in particular *changes* in the variables to be explained over time, in this case the provision and intensity of further training. This becomes particularly clear with the fixed effects model.[21] All firms that either generally do not provide further training ($y_{it} = 0$ for $t = 1$ to 3) or generally do provide their employees with further training ($y_{it} = 1$ for $t = 1$ to 3) would "fall victim to" *differencing out* (cf. Ronning 1991, Greene 2000). Accordingly *only* the variables that change over time would be taken into account in the estimates. Furthermore the *same "temporal structure"* would have to be assumed for all firms. Thus, for instance, it would be assumed that the introduction of teamwork in t_2 leads to further training in the following period (t_3); it is also conceivable, however, that some of the firms pro-

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[19] It is also possible that women having better school qualifications than men and firms expecting higher "trainability" and/or motivation as a result could play a role in the positive impact of a large proportion of women on the intensity of further training.
[20] Here, too, conducting analogous quasi-likelihood estimates for the other two individual years suggests that industrial relations do not have a stable influence on the intensity of further training (Table A5 in the appendix).

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[21] In random effects models, too, *changes* are the focus of attention. However, no differencing out is necessary because it is assumed that the unobservable heterogeneity is independent of the explanatory variables and that only the values of the unobservable heterogeneity depend on each other at various points in time. Cf. for example Baltagi 2001 and Arndt 2004.

vide further training only in the run-up (t_1) or in the run-up and in the introduction period (t_1 and t_2).

When extending the *observation period*, on the other hand, further training is regarded as a *longer-term phenomenon*;[22] temporary changes such as temporary non-provision of further training or fluctuations in the intensity of further training are not of interest. Against this background the balanced panel is converted into a cross-section and a distinction is made between firms providing further training and firms not providing further training only in a period of six years. It is accordingly of interest which structural characteristics cause firms to provide further training either regularly or at certain intervals. In addition we have brought into the discussion the new factor that when a firm is generally willing to provide further training there are certain occasions and changes that provoke (additional) further training measures. When extending the observation period it is not necessary to make such strict assumptions concerning the temporal effect of the latter variables as is the case with panel models.

Both of the methods – extending the observation period and fixed effects models – "give away" certain information; this information is quite different, however, due to the different issues from which the methods start out. With the extension of the observation period, all short-term changes within this period (in particular temporary provision of further training, fluctuating further training intensity, fluctuating investment activity, fluctuating workforce size) are not included in the analysis; only variables that represent one-off "structural" changes between the beginning and the end of the observation period (e.g. an improvement in the technological state of the plant and equipment) are taken into consideration. With the fixed-effects model, only firms whose further training behaviour changes over time are included in the estimate because in this way it is possible to quantify the impact of their unobservable heterogeneity on further training.

4.2 Summary and outlook

The *length of the observation period* is of importance not only for the purchasing of durable goods by households but also for *firms' further training behav-*

iour. This can be substantiated *theoretically* using a *double hurdle model* which not only looks into the general willingness to invest in further training but also puts the sometimes irregular implementation of further training measures down to cost considerations and concrete reasons for further training.

In *empirical terms* the length of the observation period can be extended fictitiously by using the results from several survey waves of panel data sets to form variables for a longer observation period, i.e. the balanced panel is converted into a cross-section. For this study, only the firms in the IAB establishment panel which could be asked about their further training behaviour in 2001, 2003 and 2005 were taken into account. For these firms the further training provision in the period 2000 to 2005 and the average intensity of further training in the period 2000 to 2005 were calculated. First of all the descriptive analysis showed that just under half of the firms which did not provide further training in 2001 were actually involved in further training when the observation period was longer. In particular small and very small firms provide their employees with further training on an irregular basis (Table 1). Firms which do not provide further training and firms that provide further training regularly or irregularly differ considerably as regards the means and proportions of the explanatory variables (Table 2).

It emerges first of all that there are a number of variables which have an influence on whether it is generally worthwhile for the firms to provide further training, i.e. whether they overcome the first hurdle. When the observation period is extended, these structural variables remain largely unchanged. This is shown by comparing our probit estimates of further training provision and our quasi-likelihood estimates of the intensity of further training for 2001 and for 2000 to 2005. The same variables for capital intensity and innovation orientation and the same proportions for the employee structure prove to be significant in each case (Tables 3 and 4). Only the variables that characterise industrial relations – existence of a works council and payment above the collectively agreed wage scale (and labour turnover in the probit approach) – lose significance when the observation period is longer, which suggests that they do not have a stable influence on the general further training behaviour.

In addition, it is possible to establish proof of a number of concrete reasons for further training, by means of which the second hurdle for further training activities is overcome. Investment in communication technology and EDP and changes in the organisation structure are significant for firms' provi-

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[22] Gerlach/Jirjahn (1998: 323), too, refer to the continuity of company further training behaviour and conclude that it is the longer-term factors, such as production technology or the structure of the workforce, that are more likely to determine company further training activities.

sion of further training and intensity of further training in both the short and the longer observation period. (Shifts in responsibility down the hierarchy also prove to be significant for the intensity of further training in the shorter and the longer observation period.) Such reasons for further training which enable the second hurdle to be overcome occur less frequently in smaller firms, however. This can be seen firstly from the fact that the provision of further training by very small firms is clearly lower and their further training intensity is higher for 2000 to 2005 than for the average of the years 2001, 2003 and 2005. Secondly this is also suggested by the significance of firm size for the provision of further training (with a positive sign).

Extending the observation period by using the results of several waves of panel data sets is a suitable method to use for the double hurdle approaches[23] cited in the literature and for other economic issues:

– According to the double hurdle model of Blundell (1990) and Franz (1996) a supply of labour only arises when a suitable job is available (first hurdle) *and* when the individual offers labour in accordance with his or her decision rule (second hurdle).

– Dismissals for operational reasons can be observed in firms (of certain firm-size classes) only when no industry-wide collective agreements or company collective agreements stand in the way and/or when there will be no loss of reputation due to implicit contracts being broken *and* when reasons for such dismissals arise, such as a loss of market shares or a fall in sales associated with the economic cycle.

– A firm will convert a job that is covered by social security into several "€ 400 jobs" only when it not only assesses this to be worthwhile in principle but also when enough candidates with the required social competence and "trainability" apply.

– Whether or not a firm uses certain selection instruments when making personnel decisions depends not only on the fundamental decision to use such instruments but also on the firm's recruitment demand for certain job categories and on the applicant situation.

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[23] In 1992 the double hurdle approach was applied by Lambert to the occurrence of defects in manufacturing. The first hurdle is that the machine is not perfectly adjusted so defects occur in the first place. The second hurdle is determinants such as the quality of the materials or of the workers, which decide the number of defects. Lambert developed a zero-inflated Poisson model for the estimate.

References

Acemoglu, D./Pischke, J.-S. (1999a): The Structure of Wages and Investment in General Training, in: Journal of Political Economy 107, pp. 539 et sqq.

Acemoglu, D./Pischke, J.-S. (1999b): Beyond Becker: Training in Imperfect Labour Markets, in: Economic Journal 109, pp. 112 et sqq.

Alewell, D. (1997): Die Finanzierung betrieblicher Weiterbildungsinvestitionen. Ökonomische und juristische Aspekte, Wiesbaden.

Alewell, D. (1998): Warum finanzieren Arbeitgeber transferierbare Weiterbildung?, in: Zeitschrift für betriebswirtschaftliche Forschung 50, pp. 315 et sqq.

Aoki, M. (1990): The Participatory Generation of Information Rents and the Theory of the Firm, in: Aoki, M./Gustafsson, B./Williamson, O. E. (eds.): The Firm as a Nexus of Treaties, London, pp. 26 et sqq.

Arndt, Chr. (2004): Möglichkeiten und Grenzen von Panelanalysen und methodische Grundideen der Panelanalyse, in: Arndt, Chr./Strotmann, H. (eds.): Paneluntersuchungen als Instrument zur Analyse der Bestimmungsfaktoren des Strukturwandels, Tübingen, pp. 7 et sqq.

Baltagi, B. H. (2001): in: Econometric Analysis of Panel Data, second edition, Chichester/New York.

Bellmann, L. (2002): Das IAB-Betriebspanel: Konzeption und Anwendungsbereiche, in: Allgemeines Statistisches Archiv 86, pp. 177 et sqq.

Bellmann, L./Düll, M./Leber, U. (2001): Zur Entwicklung der betrieblichen Weiterbildungsaktivitäten. Eine empirische Untersuchung auf Basis des IAB-Betriebspanels, in: Reinberg, A. (ed.): Arbeitsmarktrelevante Aspekte der Bildungspolitik, Beiträge zur Arbeitsmarkt- und Berufsforschung 245, Nürnberg, pp. 97 et sqq.

Bellmann, L./Kohaut, S./Lahner, M. (2002): Das IAB-Betriebspanel: Ansatz und Analysepotenziale, in: Kleinhenz, G. (ed.): IAB-Kompendium Arbeitsmarkt- und Berufsforschung, BeitrAB 250, pp. 13 et sqq.

Blundell, R. (1990): Unemployment and the Labour Supply of Married Women, in: König, H. (ed.): Economics of Wage Determination, Berlin et al., pp. 273 et sqq.

Cragg, J. (1971): Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods, in: Econometrica 39, pp. 829 et sqq.

Düll, M./Bellmann, L. (1998): Betriebliche Weiterbildungsaktivitäten in West- und Ostdeutschland. Eine theoretische und empirische Analyse mit Daten des IAB-Betriebspanels 1997, in: Mitteilungen aus der Arbeitsmarkt- und Berufsforschung 31, pp. 205 et sqq.

Franz, W. (1996): Arbeitsmarktökonomik, third edition, Berlin et al.

Freeman, R. B./Lazear, E. P. (1995): An Economic Analysis of Works Councils, in: Rogers, J./Streeck, W. (eds.): Works Councils – Consultation, Representation, and Cooperation in Industrial Relations. Comparative Views on the U.S. and German Economies, London/Chicago, pp. 27 et sqq.

Freeman, R. B./Medoff, J. L. (1979): The Two Faces of Unionism, in: The Public Interest 57, pp. 69 et sqq.

Frick, B. (1997): Mitbestimmung und Personalfluktuation: Zur Wirtschaftlichkeit der bundesdeutschen Betriebsverfassung im internationalen Vergleich, München/Mering.

Frick, B./Sadowski, D. (1995): Work Councils, Unions, and Firm Performance, in: Buttler, F./Franz, W./Schettkat, R./Soskice, D. (eds.): Institutional Frameworks and Labor Market Performance, London/New York, pp. 46 et sqq.

Gerlach, K./Jirjahn, U. (1998): Determinanten betrieblicher Weiterbildungsaktivitäten. Eine empirische Untersuchung mit Daten des Hannoveraner Firmenpanels, in: Pfeiffer, F./Pohlmeier, W. (eds.): Qualifikation, Weiterbildung und Arbeitsmarkterfolg, Baden-Baden, pp. 311 et sqq.

Gerlach, K./Jirjahn, U. (2001): Employer Provided Further Training: Evidence from German Establishment Data, in: Schmollers Jahrbuch 121, pp. 139 et sqq.

Greene, W. G. (2000): Econometric Analysis, fourth international edition, Upper Saddle River (New Jersey).

Grünewald, U./Moraal, D./Schönfeld, G. (2003): Betriebliche Weiterbildung in Deutschland und Europa, Schriftenreihe des Bundesinstituts für Berufsbildung, Bonn.

Hübler, O. (2003): Zum Einfluss des Betriebsrats in mittelgroßen Unternehmen auf Investitionen, Löhne, Produktivität und Renten – Empirische Befunde, in: Goldschmidt, N. (ed.): Wunderbare Wirtschaftswelt – Die New Economy und ihre Herausforderungen, Baden-Baden, pp. 74 et sqq.

Jirjahn, U. (1998): Effizienzwirkungen von Erfolgsbeteiligung und Partizipation: eine mikroökonomische Analyse, Frankfurt/New York.

Jirjahn, U. (2003): Produktivitätswirkungen betrieblicher Mitbestimmung – Welchen Einfluss haben Betriebsgröße und Tarifbindung?, in: ZfB-Ergänzungsheft 3, pp. 63 et sqq.

Kieschnik, R./McCallough, B. (1999): Regression Analysis of Variables Observed on (0,1): With Application to Cable Penetration Data, University of Dallas Working Paper, zitiert nach Wagner (2001), p. 237.

Lambert, D. (1992): Zero-Inflated Poisson Regression with an Application to Defects in Manufacturing, in: Technometrics 34, 1, pp. 1 et sqq., zitiert nach Greene (2000), p. 978.

Neubäumer, R. (2006): Warum bilden Betriebe ihre Mitarbeiter weiter – oder auch nicht?, Ein theoretischer Ansatz zur Erklärung unterschiedlicher Weiterbildungsaktivitäten von Betrieben, in: Weiß, M. (ed.): Evidenzbasierte Bildungspolitik: Beiträge der Bildungsökonomie, Schriften des Vereins für Socialpolitik, Berlin, pp. 93 et sqq.

Neubäumer, R./Kohaut, S. (2002): Unternehmen investieren nicht nur in Sachkapital – ein theoretischer Ansatz und seine empirische Überprüfung mit dem Betriebs-Panel des IAB 1998, in: Zeitschrift für Betriebswirtschaft 72, pp. 403 et sqq.

Neubäumer, R./Kohaut, S./Seidenspinner, M. (2006): Determinanten betrieblicher Weiterbildung – ein ganzheitlicher Ansatz zur Erklärung des betrieblichen Weiterbildungsverhaltens und eine empirische Analyse für Westdeutschland, in: Schmollers Jahrbuch 126, pp. 437 et sqq.

Niederalt, M. (2004): Zur ökonomischen Analyse betrieblicher Lehrstellenangebote in der Bundesrepublik Deutschland, Dissertation, Frankfurt am Main et al.

Pannenberg, M. (1995): Weiterbildungsaktivitäten und Erwerbsbiographie, Frankfurt am Main/New York.

Papke, L. E./Woolridge, J. M. (1996): Econometric Methods for Fractional Response Variables with an Application to 401(K) Plan Participation Rates, in: Journal of Applied Econometrics 11, pp. 619 et sqq.

Pawlowsky, P. (1992): Betriebliche Qualifikationsstrategien und organisationales Lernen, in: Staehle, W./Conrad, P. (eds.): Managementforschung, second edition Berlin/New York, pp. 177 et sqq.

Ronning, G. (1991): Mikroökonometrie, Berlin.

Ronning, G. (1992): Share Equations in Econometrics: A Story of Repression, Frustration and Dead Ends, in: Statistische Hefte 33, pp. 307 et sqq.

Ronning, G. (1996): Ökonometrie, in: Börsch-Supran, A./Hagen, J. von/Welfens, P. J. J. (eds.): Springers Handbuch der Volkswirtschaftslehre, Band 1: Grundlagen, Berlin et al., pp. 77 et sqq.

Tobin, J. (1958): Estimation of Relationships for Limited Variables, in: Econometrica 26, pp. 24 et sqq.

Wagner, J. (2001): A Note on the Firm Size-Export Relationship, in: Small Business Economics 17, pp. 229 et sqq.

Woolridge, J. M. (2002): Econometric Analysis of Cross Section and Panel Data, Cambridge (Mass.).

Appendix

Table A1

Reasons for non-provision of further training by firm-size classes in 2003

Firms with ... employees	Reasons for non-provision of further training 2003[1]				
	no support of further training in principle	support of further training in principle, but none provided in first six months of the year	release of employees not possible for reasons of time	qualification level of employees sufficient	other reasons
	Figures as %[2]				
1 to 9	**20.3**	13.8	11.4	56.6	26.8
10 to 49	**13.8**	21.2	15.8	57.0	26.9
50 to 99	**6.7**	31.3	13.9	51.9	35.3
100 to 499	**12.5**	38.7	10.6	40.4	39.1
500 and above	**5.3**	49.1	19.3	64.0	59.6
Total	**18.9**	15.5	12.3	56.6	27.0

1 Weighted values.
2 Multiple replies possible.
Source: IAB establishment panel 2003.

Table A2

Panel mortality by firm-size classes 2000 to 2005

Firms with ... employees[1]	No. of firms which belonged to the panel in 2001	No. of firms which belonged to the panel in 2001, 2003 and 2005	Panel mortality = decrease in the number of firms as %
1 to 9	2,598	1,050	59.6
10 to 49	2,890	1,050	63.7
50 to 99	1,177	417	64.6
100 to 499	2,106	836	60.3
500 and above	1,077	453	57.9
Total	9,848	3,806	61.4

1 Classification of the firms into firm-size classes in accordance with their number of employees in 2001.
Unweighted values.
Source: IAB establishment panel 2001, 2003, 2005.

Table A3

Overview of the variables to be explained and the explanatory variables

For the estimates for the longer survey period the data from the IAB establishment panel for 2001, 2003 and 2005 are used, as information about company further training was collected in these three years, for the comparison estimates the data from the IAB establishment panel for 2001 are used.

Characteristic	Estimates for the longer survey period	Comparison estimates for 2001
Variables to be explained		
Further training provision	Further training provision between 2001 and 2005 Variable = 1 if a firm provided further training in 2001 and/or 2003 and/or 2005	Further training provision in 2001 Variable = 1 if a firm provided further training in 2001
Further training intensity	Average further training intensity between 2001 and 2005 $= \left(\sum_{t=1}^{3} \dfrac{\text{Number of employees with further training}_t}{\text{Total number of employees}_t} \right) : 3$ with $t_1 = 2001$, $t_2 = 2003$ and $t_3 = 2005$.	Further training intensity in 2001 = $= \dfrac{\text{Number of employees with further training}_{2001}}{\text{Total number of employees}_{2001}}$
Explanatory variables		
Capital intensity and innovation orientation (plus firm size and industries)		
Total investment per employee	=∑Investment in 2001, 2003 and 2005 : ∑ Number of employees in 2001, 2003 and 2005 (as logs)	= Total investment in 2001 : Number of employees in 2001 (as a log)
Technological state of the plant	dummy = 1 if the plant was classed as modern in 2001, i.e. as "state of the art or modern" (as opposed to "medium level of technology" to "entirely out-of-date" = reference group)	
Investment in comm. technology and EDP	dummy = 1 if such an investment was made in 2001, 2003 or 2005	dummy = 1 if such an investment was made in 2001
Involvement in R & D	dummy = 1 if R & D was conducted in the establishment in 2001 (or was the task of another part of the firm)	
Firm size	Average number of employees in 2001, 2003 and 2005 (as logs)	Number of employees in 2001 (as a log)
Industry dummies	13 industry dummies for 2001	
Employee structure (proportions)		
Unskilled and semi-skilled workers	Average of the proportions of unskilled and semi-skilled workers in 2001, 2003 and 2005	Proportion of unskilled and semi-skilled workers in 2001
Skilled non-manual employees	Average of the proportions of non-manual employees/civil servants for skilled activities in 2001, 2003 and 2005	Proportion of non-manual employees/civil servants for skilled activities in 2001
Women	Average of the proportions of women in 2001, 2003 and 2005	Proportion of women in 2001
Part-time employees	Average of the proportions of part-time employees in 2001, 2003 and 2005	Proportion of part-time employees in 2001
Features that characterise the attractiveness of the jobs and co-determination		
Collective agreement	dummy = 1 if the firm had collective agreements in at least two of the survey waves (industry-side collective agreement or company collective agreement)	dummy = 1 if the firm had collective agreements in 2001
Payment above collectively agreed wage scale	dummy = 1 if the firm had paid employees above the collectively agreed wage scale in at least two of the survey waves	dummy = 1 if the firm paid employees above the collectively agreed wage scale in 2001
Labour turnover	average labour turnover =∑0.5 *(hirings + separations) in 2001, 2003 and 2005 : ∑ No. of employees in 2001, 2003 and 2005	labour turnover in 2001 = 0.5 *(hirings + separations) in 2001 : No. of employees in 2001
Works council	dummy = 1 if the firm had a works council or a staff council in 2003 (the reply for 2003 was used because this was the only time that all firms were asked about it.)	
Reasons for further training		
Investment in comm. tech. and EDP	dummy = 1 if such an investment was made in 2001, 2003 or 2005	dummy = 1 if such an investment was made in 2001
Organisational changes	dummy = 1 if some form of organisational change was undertaken in 2001	
Shift in responsibility down the hierarchy	dummy = 1 if the firm shifted responsibility and decisions down the hierarchy in 2001	
Teamwork	dummy = 1 if the firm introduced teamwork/working groups responsible for themselves in 2001	
Own determination of results/costs	dummy = 1 if the firms set up units that determine their own results/costs in 2001	
Improvement in the technological state of the plant	dummy = 1 if the firm's own classification of its level of technology improved in 2003 or 2005	–
Development of firm size	Change in the number of employees between 2001 and 2005	–

Table A4

Comparison of different probit estimates of the determinants of firms' further training provision[1] in 2001, 2003 and 2005

	2001 (model 1.1)			2003 (model 1.2)			2005 (model 1.3)		
	Co-efficient	Stand. dev. (robust)	P > |z|[2]	Co-efficient	Stand. dev. (robust)	P > |z|[2]	Co-efficient	Stand. dev. (robust)	P > |z|[2]
Total investment per employee	.0250193	.0094056	0.008**	.0405688	.0090306	0.000**	.0364037	.0094929	0.000**
Modern plant	.1756653	.0589582	0.003**	.2636657	.0574226	0.000**	.1782616	.0563790	0.002**
Involvement in R & D[3]	.2616020	.0975704	0.007**	.1361186	.0972011	0.161	.1895390	.0955930	0.047*
Firm size	.3594962	.0268802	0.000**	.3794779	.0268499	0.000**	.4192090	.0267453	0.000**
Unskilled and semi-skilled workers	-.6027070	.1380020	0.000**	−.5967904	.1382618	0.000**	−.8492941	.1357398	0.000**
Skilled non-manual employees	.5717890	.1184814	0.000**	.5703396	.1176896	0.000**	.4716366	.1133785	0.000
Women	.1677942	.1296583	0.196	.1770899	.1290071	0.170	.1828895	.1222275	0.135
Part-time employees	−.2480135	.1378542	0.072+	−.2262201	.1337760	0.091+	−.1409802	.1296218	0.277
Works council	.1431515	.0792289	0.071+	.0663067	.0823961	0.421	.1600049	.0791764	0.043*
Collective agreement	.2049237	.0647642	0.002**	.1908113	.0718544	0.008**	.2168325	.0691856	0.002**
Payment above collectively agreed wage scale	.1697270	.0630920	0.007**	.0306455	.0769800	0.691	.0303221	.0777251	0.696
Labour turnover	−.5482337	.2467270	0.026*	−.8440287	.2913073	0.004**	−.1001108	.2207192	0.650
Investment in communication technology and EDP	.2508964	.0763561	0.001**	.1193853	.0742827	0.108	.1535349	.0765803	0.045*
Organisational changes[3]	.3684118	.0690339	0.000**	.2350417	.0680723	0.001**	.2250927	.0679876	0.001**
Shift in responsibility down the hierarchy[3]	.0958174	.0960028	0.318	.1782968	.0928368	0.055+	.1514662	.0898586	0.092+
Introduction of teamwork[3]	.1123399	.1266249	0.375	.0029533	.1178460	0.980	−.0167099	.1119558	0.881
Introduction of own determination of results/costs[3]	.0029725	.1290681	0.982	.1320996	.1290421	0.306	−.0787794	.1235535	0.524
Industry dummies	yes			yes			yes		
Constants	−1.839490	.1268339	0.000**	−1.680744	.1186081	0.000**	−1.680744	.1186081	0.000**
	n = 3,353 Wald $\chi^2(29)$ = 982.89 Prob. > χ^2 = 0.000 Pseudo-R^2 = 0.3525			n = 3,383 Wald $\chi^2(29)$ = 955.21 Prob. > χ^2 = 0.0000 Pseudo-R^2 = 0.3478			n = 3,554 Wald $\chi^2(29)$ = 912.56 Prob. > χ^2 = 0.0000 Pseudo-R^2 = 0.3685		

1 Dependent variable: 1 = provision of further training in 2001, 2003 and 2005 (model 1.1 to 1.3); 0 = no provision.
2 Levels of significance: ** $P < 0.01$; * $P < 0.05$; + $P < 0.1$.
3 Dummy for 2001.
Source: IAB establishment panel 2001, 2003, 2005.

Table A5

Comparison of different quasi-likelihood estimates according to Papke/Wooldridge for the determinants of firms' intensity of further training[1] in 2001, 2003 und 2005

	2001 (model 1.1)			2003 (model 1.2)			2005 (model 1.3)		
	Co-efficient	Stand. dev. (robust)	P > |z|[2]	Co-efficient	Stand. dev. (robust)	P > |z|[2]	Co-efficient	Stand. dev. (robust)	P > |z|[2]
Total investment per employee	.0213963	.0114023	0.061+	.0325714	.0107881	0.003**	.0309119	.0109291	0.005**
Modern plant	.1695162	.0652344	0.009**	.2676736	.0641271	0.000**	.2592603	.0622211	0.000**
Involvement in R & D[3]	.3360246	.0872425	0.000**	.1818787	.0845216	0.031*	.1709761	.0803008	0.033*
Firm size	−.1040264	.0240221	0.000**	−.0670459	.0231691	0.004**	−.0718575	.0236966	0.002**
Unskilled and semi-skilled workers	−.7842202	.1660485	0.000**	−.2065972	.1785177	0.247	−.5057363	.1661570	0.002**
Skilled non-manual employees	.7380839	.1336637	0.000**	.7550585	.1328130	0.000**	.8971638	.1282317	0.000**
Women	.3609029	.1500656	0.016*	.3106512	.1537141	0.043*	.3090914	.1408021	0.028*
Part-time employees	−.3591464	.1727078	0.038*	−.2678288	.1638011	0.102	−.2829916	.1572603	0.072+
Works council	.2671710	.0853200	0.002**	.2036163	.0797661	0.011*	.0417203	.0843001	0.621
Collective agreement	.1784174	.0752999	0.018*	.1254448	.0834854	0.133	.2376260	.0796316	0.003**
Payment above collectively agreed wage scale	.2156386	.0665842	0.001**	.0813504	.0765900	0.288	−.0008623	.0723187	0.990
Labour turnover	−.5205490	.3236298	0.108	.0630904	.4157678	0.879	−.0564598	.0370596	0.128
Investment in communication technology and EDP	.1294052	.0910156	0.155	.0668237	.0830032	0.421	.0873331	.0847210	0.303
Organisational changes[3]	.2750591	.0749716	0.000**	.2994900	.0726801	0.000**	.2704935	.0710331	0.000**
Shift in responsibility down the hierarchy[3]	.1574359	.0732464	0.032*	.1091753	.0738598	0.139	.1301896	.0725677	0.073+
Introduction of teamwork[3]	.1455545	.0875618	0.096+	.0961049	.0866564	0.267	−.0226879	.0841735	0.788
Introduction of own determination of results/costs[3]	.0137657	.0897388	0.878	.0876445	.086790	0.313	−.0829816	.0842860	0.325
Industry dummies	yes			yes			yes		
Constants	-2.627381	.148	0.000**	-2.302556	.1420397	0.000**	−2.368565	.1256497	0.000**
	n = 3,323 LR χ²(12) = 29.20 Prob. > χ² = 0.0037			n = 3,379 LR χ²(12) = 33.05 Prob. > χ² = 0.0010			n = 3,482 LR χ²(12) = 24.38 Prob. > χ² = 0.0180		

1 Dependent variable: intensity of further training = number of a firm's employees who have undertaken further training: total number of a firm's employees.
*2 Level of significance: ** P < 0.01; * P < 0.05; + P < 0.1.*
3 Dummy for 2001.
Source: IAB establishment panel 2001, 2003, 2005.