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Continuous Training and Firm Productivity in Germany

Thomas Zwick

ZEW

Zentrum für Europäische
Wirtschaftsforschung GmbH

Centre for European
Economic Research

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Non-technical summary

Human capital is one of the main competitive assets of German firms. The impact of different training forms and the time pattern of productivity effects have not been discussed for Germany, however. In addition most studies for Germany suffer from estimation bias by not taking into account endogeneity of the training decision and unobserved heterogeneity. This paper derives the estimation equation from an extended Cobb-Douglas production function including training variables. For the estimation, the IAB establishment panel is used, a large and representative data set for all profit oriented sectors of the German economy. Besides the productivity impact of the share of employees trained in the establishment, the impact of seven different training forms is considered. In addition estimation biases, because firms do not randomly choose to offer training (selectivity bias), differ with respect to characteristics not included in the data set (unobserved heterogeneity) and with respect to characteristics included in the data set (omitted variable bias) are taken into account. This paper treats all of these biases simultaneously in a panel estimation and interpretes the biases found.

In the first estimation, the impact of training in the first half of 1997 on value added in the entire year 1997 is calculated. In addition, the lagged impacts of training on productivity 1998 and 1999 are explored. Selectivity bias is avoided by explicitly estimating the decision of the firm to offer training in a first step. The selection probit estimation includes the following identifying variables in addition to several other control variables: three variables indicating that the establishment expects skill gaps and two variables indicating that training and apprenticeship training are the preferred reaction on skill shortages. These identifying variables are correlated with the decision of the firm to offer training in 1997, but not with productivity in the same year or later. In a second step the production function is corrected by adding the normal hazard function for the decision to offer training. Unobserved heterogeneity is controlled for by estimating the production function with only the variable factors labour and capital in a fixed effects panel regression for the period 1997-1999. This allows us to calculate the persistent differences in productivity between the establishments (fixed effects). In a second step, the fixed effects are explained by the (quasi) fixed training variables and other control variables. In a last regression, also selectivity is controlled for in the panel regression by adding the selection correction term in the second step estimation. Omitted variable bias is avoided in all regressions by adding a large set of additional control variables covering firm and workforce heterogeneity and additional personnel management variables that are closely related to training.

Increasing the share of employees participating at training in the first half of a year has a positive and significant effect on firm productivity in the same and the next year. The impact in the third year is positive but insignificant. While formal internal and external training courses increase productivity in the same year and the years after, their impact decreases over time. The positive productivity impact of quality

circles increases over time, instead, while training on the job has a persistent negative productivity effect in the cross section estimations. When we control for selectivity, the measured productivity effects of training further increase, suggesting that firms with an inefficient production structure deliberately use training in order to boost productivity. When we also take unobserved heterogeneity into account in a fixed effects panel regression, the measured impact of training on productivitiy increases further. This suggests that firms offering training have productivity reducing unobserved characteristics. In the panel regressions, formal internal and external courses have the highest positive productivity impact and self-induced learning and quality circles have a lower but still significant impact on the fixed productivity effects. Training on the job, seminars and talks and job rotation do not have an impact on structural productivity differences, however. When training intensity increases by 1%, structural productivity increases by 0.3%. It is finally shown that omitting variables identifying establishment characteristics like co-determination, the legal form, innovation and investment behaviour, personnel measures or the qualification composition of the work force would lead to a strong overestimation of the productivity effects of training.

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Thomas Zwick
E-mail: zwick@zew.de

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Centre for European Economic Research (ZEW)

Abstract
This paper presents for the first time panel evidence on the productivity effects of training intensity and different training forms in Germany. It hereby takes account of selectivity of training activities, unobserved heterogeneity of establishments as well as omitted variable bias. Using the waves 1997 – 2000 of the IAB establishment panel, it is found that when the share of trained employees in 1997 is higher, productivity is significantly higher in the period 1997 - 1999. Formal internal and external courses have the highest positive impact on productivity, self-induced learning and quality circles have a smaller positive impact, while training on the job, seminars and talks and job rotation do not affect productivity. The decision to train is selective. Firms with an inefficient production structure deliberately use training in order to boost productivity.

JEL Codes: C23, D21, J24

Key Words: Training, Firm Productivity, Panel Estimation

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1 Introduction

Human capital, knowledge, and skills are increasingly important competitive assets within firms. Employee training sponsored by the firm is therefore perceived as one of the most important measures to gain and keep productivity. Especially the German economy that is based on a relatively high share of well qualified employees who frequently work in flexible, complex and diversified quality production derives its main competitive advantages from human capital (Appelbaum and Batt, 1994, pp. 39-43, Roth, 1997). In 1998, German firms accordingly invested on average the substantial amount of 1,128 EUR per year per employee in continuous training, Institut der deutschen Wirtschaft (2002), p.99. The positive impact of training on firm productivity in the German economy is not undisputed, however. Some employee training may not contribute to increases in productivity because it is used as a sorting device for employers in order to determine who is promoted or as a tool to increase incentives, motivation or to reduce turnover (de Koning, 1994). Several commentators argue that vocational and continuing training in Germany provides employees with knowledge only temporarily needed, for example if infrequent maintenance or re-organisation is necessary (Roth, 1997). This kind of training primarily is directed at increasing flexibility in emergency situations instead of continuous productivity increases. Therefore, German workers frequently have redundant cognitions and part of their skills is not used in daily work (Berg, 1994). Training may also just be a necessity when the workforce is not adequately qualified and firms are forced to retrain workers internally instead of facing high labour turnover costs and a shortage of skilled workers on the labour market (Zwick and Schröder, 2001). It will be shown that the empirical evidence in Germany on the productivity effects of training is not conclusive and has considerable gaps and therefore this issue is not clear a-priori and still open for empirical evaluation.

This paper explores if the productivity effect of training decreases or increases over time taking into account that the pay-off of the training investment may reveal itself only at some point in the future (Bassi et al., 2001). It also takes a closer look at the productivity effects of different forms of training which is demanded by many commentators, see for example Bartel (1994) or Barrett and O'Connell (2001). The data set used provides us with a wealth of different training dimensions that allow a digression on what form of training enhances productivity in Germany.

A growing number of papers seeks to measure the effect of employer-provided training on productivity using representative firm-level data from several sectors in the economy (Bartel, 1994, Bartel, 1995, Black and Lynch, 1996, Ballot, Fakhfakh and Taymaz, 2001, Barrett and O´Connell, 2001, Bellmann and Büchel, 2001). Usually, a positive (and sometimes significant) effect of training on productivity is found in these studies. The measurement of productivity effects of training may suffer primarily from two biases, however (Kruse, 1993, Dearden, Reed and Van Reenen, 2000, Caroli and Van Reenen, 2001). First, firms that offer training may also be structurally more productive due to time invariant unobserved factors such as management quality, the exposition to technical change, a more active personnel department or better management - employee relations. This is called unobserved heterogeneity. Second, transitory shocks like the introduction of a new technology or a deterioration of market conditions could change productivity and induce changes in training efforts at the same time. We therefore analyze if German firms tend to train in good economic circumstances or – as evidence suggests for the USA and UK (Bartel, 1994 or Dearden, Reed and Van Reenen, 2000) – in periods when they have to catch up with regard to productivity. Summing up, firms do not decide randomly if they train their employees or not and training is not a strictly exogeneous variable in the productivity equation. This source of estimation bias is called selectivity bias.

In contrast to most papers on productivity effects of training this paper addresses both problems simultaneously exploring several different estimation techniques and specifications and thus circumvents drawbacks which comparable papers suffer from. In addition, it indicates the size and direction of the estimation biases incurred. Finally, it presents for the first time representative panel data evidence on the productivity effects of training in German firms.

Several papers estimate the productivity impact of training in very parsimonious specifications (Dearden, Reed and Van Reenen, 2000, Ballot, Fakhfakh and Taymaz, 2001, Barrett and O´Connell, 2001, Bellmann and Büchel, 2001). This paper demonstrates that the inclusion of a broad variety of additional firm characteristics and especially of different personnel measures improves the estimation and reduces the measured productivity impact. Estimations excluding these variables therefore may suffer from omitted variable bias and the training measure may pick up productivity effects of other variables that are like some personnel measures frequently closely correlated with training (Wolf and Zwick, 2002).

This paper is constructed as follows. First, a short survey presents the main results and the drawbacks of the literature on the productivity effects of training on the firm level. Then an empirical model correcting for unobserved time invariant heterogeneity and selection bias is developed on the basis of a standard production function. The fourth section presents the data basis and several regressions measuring the impact of training on productivity. The regressions establish that omitted variable, selection, and unobserved heterogeneity bias matter. In addition, the time structure and the productivity effects of different dimensions of training are explored. The last section concludes.

2 Literature

In this section, a short survey of the literature is given which places considerable emphasis on the data and the estimation techniques used and their possible shortcomings (see also the literature review in Dearden, Reed and Van Reenen, 2000). This allows a comparison of the results obtained in this study with those in the literature because it will become clear that the estimation technique and the data basis may play a decisive role for measuring the productivity impacts. Only studies using firm-level data from several sectors are included.

Bartel (1994) first estimates a simple cross section production function including formal training programmes in the effective labour term. She does not find an effect of formal training on productivity in the same year. The estimation may be biased, however, due to unobserved heterogeneity between firms that leads to a correlation between the formal training measure and the error term, see Griliches and Mairesse

(1995). In order to avoid this bias, she estimates a first difference model in which the change in labour productivity between 1983 and 1986 is regressed on changes in the incidence of training programmes. She finds that businesses that were operating below their expected labour productivity levels in 1983 implemented new employee training programmes after 1983 that brought productivity up to the level of comparable businesses by 1986.

Barrett and O´Connell (2001) apply the same estimation strategy while regressing the level of training instead of the change in training on the change in productivity. They argue that training is adding to human capital, which might lead to an increase in productivity later on. They use data of two waves of Irish firms surveyed in 1993 and 1995 with a response rate in the second wave as low as one third of the initial firms. Their main result is that the level of general training has a significantly positive effect on productivity growth while this is not the case for the level of specific training. Neither paper addresses endogeneity of the introduction of training programmes, however, and they are based on deliberately chosen samples (Dearden, Reed and Van Reenen, 2000).

Black and Lynch (1996) estimate a standard Cobb-Douglas production function including training intensity, three specific types of training activities and several controls for other workplace practices. The estimations are based on a data set from the 1994 US-American National Center on the Educational Quality of the Workforce (EQW), an employers survey, which was especially designed for this purpose. They find no impact of the number of employees trained while a high percentage of formal training outside working hours has a positive impact on productivity in manufacturing and computer training has a positive impact on productivity in non-manufacturing. Their cross-section study is prone to unobserved heterogeneity bias, however.

Therefore, Black and Lynch (2001) supplement their data on training and other workplace practices used in their 1996 article with panel data from the Longitudinal Research Database (LRD). They check for observed and unobserved time-invariant heterogeneity between the firms by estimating a Cobb-Douglas production function without the workplace practices in several fixed effects panel models. From these regressions, they calculate the average firm-specific, time-invariant residual. In a second step, they regress this average residual on training and other workplace practices. In this paper, training measured by the number of employees trained still has no impact on productivity in any regression (correcting for heterogeneity or not) while some other personnel measures do have one. Black and Lynch (2001), p. 443, admit, however, that their estimation techniques are prone to endogeneity bias in the second estimation step.

Ballot, Fakhfakh and Taymaz (2001) study the impact of the level of human capital and R&D expenditures on firm performance for French and Swedish data. They present results for several estimators (simultaneous OLS, random effects, lagged random effects, fixed effects and panel GMM as well as system GMM). They find that the impact of training hours and expenditures per employee on firm productivity depends strongly on the estimation technique. In their preferred specification, the system GMM, that takes training as an exogeneous variable, training has a positive and significant impact in France, while in Sweden the effect is insignificant. Their specification is very parsimonious taking only intangible assets and their interactions into account, while further firm and personnel characteristics are absent. In addition, their sample size with 90 firms in France and 270 firms in Sweden is small and specific. The French data set only contains large firms that all engage in training, while the Swedish data set also includes non-training firms.

Bassi et al. (2001) correlate training expenditures with indicators for firm performance a year later. They find that training expenditures have no correlation with total sales per employee and a negative impact on income and profits in the next year. The impact on Tobin´s Q and share prices is positive, however. This impact is supernormally high which leads the authors to conclude that firms are underinvesting in training. As they use only a very limited set of additional control variables, the authors mention that training may serve as a marker for other unmeasured firm-level attributes that are correlated with a firm´s long-term profitability.

Bellmann and Büchel (2001) estimate the productivity effects of training and check for the selectivity bias in the decision to offer training or not. On the basis of the German IAB establishment panel, they use an estimation of a cross-section Cobb-Douglas production function including the training intensity. They explain first the probability of an enterprise to offer training using a probit estimation and add the probability to provide training to the production function estimation (see also Greene, 2000 and section 4 in this paper). They find that training intensity has a positive and significant effect on productivity. After correcting for selectivity, training intensity has a slightly higher but now insignificant effect on productivity. In their regression, selectivity is found to be random, however, i.e. the correction term is not significant in their productivity equation. Their cross section results are prone to biases from unobserved heterogeneity. A final problem with their study is that they do not take into account further possibly complementary workplace practices and firm characteristics.

Dearden, Reed and Van Reenen (2000) present a study on the productivity impact of training on the industry level in Great Britain. They use a long panel data set between 1983 and 1996 that entails information on training in every year. They address unobserved heterogeneity as well as endogeneity by using a variety of estimation strategies including system GMM methods. In addition, they calculate the impact and the sign of the biases on the estimation results. They find a positive and significant effect of training on sector productivity (therefore including inter firm knowledge spill-overs). The estimation results increase when endogeneity and unobserved heterogeneity are taken into account. There are two major drawbacks, however. First they combine data on different aggregation levels which may lead to aggregation bias. Second they do not control for additional personnel management measures and therefore might incur omitted variable bias as well. A smaller problem is that information on training covers only 4 weeks per year, respectively and service firms have been dropped due to "measurement problems" in most regressions. In addition, the effect of training on firm productivity may be the more relevant question than the effect on sector productivity, because also personnel managers who decide on offering training to employees do not take knowledge spillovers into account, De Koning (1994).

Summing up the literature survey, most studies on the firm level find a positive (although frequently insignificant) impact of training on productivity. In addition, some training forms like general training, off-the-job training, and computer training seem to have a higher impact on productivity while sector effects may be higher than firm effects. Most studies are plagued by severe measurement problems, however, and there is only scant, cross-section evidence for Germany.

3 Derivation of the Empirical Models

Analogous to the previous literature, we assume a standard Cobb-Douglas production function. Output Y_i of firm *i* is a function of capital K_i and "effective labour" EL_i weighted by the number of employees trained, (Bartel, 1995, Dearden, Reed and Van Reenen, 2000):

$$(1) \qquad Y_i = A_i * K_i^{\beta} * EL_i^{\gamma} \qquad \text{with } EL = L_{Ui} + \tau L_{Ti},$$

where A_i is a Hicks neutral efficiency parameter, L_{Ui} is the number of untrained and L_{Ti} the number of trained employees. The parameter τ is larger than one if training has a positive effect on labour productivity. Equation (1) can be re-written as:

$$(2) \qquad Y_i = A_i * K_i^{\beta} * L_i^{\gamma}(1+(\tau-1)T_i)^{\gamma},$$

where $L_i = L_{Ti} + L_{Ui}$ and $T_i = L_{Ti}/L_i$ is the proportion of trained workers in an establishment, or training intensity. If we take logs and use the approximation $\ln(1+x) = x$ when x is small (see Dearden, Reed, and Van Reenen, 2000), we get:

$$(3) \qquad \ln Y_i = \ln A_i + \beta \ln K_i + \gamma \ln L_i + \gamma(\tau-1)T_i + \varepsilon_i.$$

Our hypothesis is that trained employees are more productive than untrained employees, or $\gamma(\tau-1)$ is larger than zero which means that increasing the training intensity has a positive impact on firm productivity.

The available empirical literature distinguishes only very crudely between different training forms. Especially the difference between general and specific training (Barrett and O´Connell, 2001), different training subjects (Black and Lynch, 1996) and training for managers and other employees (Ballot, Fakhfakh and Taymaz, 2001) has been analyzed. Different training forms that may be chosen by the personnel department or the employee to reach certain qualification goals like internal versus external courses, job rotation versus training on the job etc. have not been analyzed thoroughly, however. This paper therefore analyzes the productivity impact of seven partly highly popular and widespread training forms (see the incidence of the different training forms in 1997 in table A1). In order to estimate the impact of the incidence of different training forms, we extend the Cobb-Douglas production function accordingly by adding dummy variables $D_{i,j}$ indicating if a firm offered formal external and internal training, self-induced learning, quality circles, training on the job, seminars and talks or job rotation. Including these seven training forms leads us to the following estimation equation:

$$(3A) \qquad \ln Y_i = \ln A_i + \beta \ln K_i + \gamma \ln L_i + \tau_j D_{i,j} + \delta V_i + \varepsilon_i \text{ with } j = 1,...,7.$$

3.1 Cross Section Evidence

Empirically, many further factors in addition to capital, labour and training intensity are relevant for firm productivity. In order to avoid omitted variable bias, a large vector of further explanatory variables is considered (Dearden, Reed, and Van Reenen, 2000, Black and Lynch, 2001). In particular, other dimensions of worker heterogeneity like the share of qualified employees and firm heterogeneity like the state of technical equipment and a dummy for firms investing in IT, co-determined or exporting firms are included.

Training measures are closely correlated with other innovative personnel measures increasing the participation of employees and usually summarised as "high performance workplaces" (Whitfield, 2000, Barrett and O'Connell, 2001, and Wolf and Zwick, 2002). Indeed, higher involvement of employees might increase the inclination of employees to train. On the other hand, new workplace practices might also increase the necessity of training especially when they go hand in hand with increased flexibility and a higher grade of discretion for non-managerial employees. Whitfield (2000) demonstrates that the average number of training days per employee is positively correlated with the introduction of innovative personnel measures. Wolf and Zwick (2002) also find a high joint incidence of training and new workplace organisations. In order to avoid that the training dummy picks up productivity effects from other personnel measures, we add a couple of crucial additional controls for relevant innovative personnel measures: more responsibilities for non-managers, team work, groups with their own cost responsibility, strong selection procedures when hiring new employees, employee share ownership, and profit sharing.

In order to estimate equation (3), we add a vector V_i entailing the variables described above. As many empirical assessments of the productivity effect of training use parsimonious specifications similar to (3), see Ballot, Fakhfakh, and Taymaz (2001), Bellmann and Büchel (2001) and Barrett and O'Connell (2001), we also report estimation results excluding further control variables and thereby show the size of the omitted variable bias.

As training cannot be expected to have an instanteneous effect on productivity (Bartel, 1995, Bassi et al., 2001), we use different lags between $T_{t-z,i}$, $D_{t.z,i,j}$ and $Y_{t,i}$ with t a year indicator and z an indicator for the lags used in our final cross section specification, see equations (3′) and (3′′). This also allows us to see if there are time effects in the productivity impact of training. As training intensity as well as the incidence of different training forms are correlated over the years, the effects found in later years can not be interpreted as pure lagged effects, however.

(3′) $$\ln Y_{t,i} = \ln A_{t,i} + \beta \ln K_{t,i} + \gamma \ln L_{t,i} + \gamma(\tau - 1)T_{t-z,i} + \delta V_{t,i} + \varepsilon_{t,i},$$

(3A′) $$\ln Y_{t,i} = \ln A_{t,i} + \beta \ln K_{t,i} + \gamma \ln L_{t,i} + \tau_j D_{t-z,i,j} + \delta V_{t,i} + \varepsilon_{t,i} \text{ with } j = 1,...,7.$$

3.2 Instrumental Variables Approach

The empirical results of the estimated productivity functions (3′) and (3A′) may be biased because firms do not randomly decide to train. Investment in training is an endogenous decision of the firm, instead, which depends on the productivity effects and the investment costs of training and other factors (Dearden, Reed, and Van Reenen, 2000, Caroli and Van Reenen, 2001, Bellmann and Büchel, 2001). Therefore the impact of training on productivity can be interpreted as a treatment effect with endogeneous choice of the treatment (Maddala, 1983, Greene, 2000). Our first measure against endogeneity is to take only lagged training intensity as explanatory variable for value added. This should capture most of the endogeneity problem (Bassi et al., 2001, Caroli and Van Reenen, 2001).

It can be shown, however, that the decision how many employees to train or to offer training or not still is not truely exogeneous. Therefore, the training intensity variable in equation (3′) and the decision to train or not in equation (3A′) have to be instrumented in order to make them exogeneous by explaining these decisions explicitly by variables correlated with training but not with productivity. Empirically, the decision on the training intensity can be modelled as a reduced form in a tobit model.[1] The latent variable $T_{t,i}*$ is therefore the optimal share of employees trained in period t and can be defined as:

(4) $T_{t,i}* = \delta' Z_{t,i} + u_{t,i},$

where $Z_{t,i}$ is a vector of relevant variables for the training intensity decision of the firm. For the observable training intensity $T_{t,i}$, we obtain: $T_{t,i}=1$ when $T_{t,i}*>1$, $T_{t,i}=0$ if $T_{t,i}* < 0$, and $T_{t,i}= T_{t,i}*$ if $0\leq T_{t,i}*\leq 1$.

The decision to offer training or not in period t can be specified as a reduced form in a probit model where the dependent variable $I_{t,i}$ has the value one when the firm offers training and zero otherwise. The latent variable $I_{t,i}*$ is therefore the difference between benefits and costs of offering training and can be defined as:

(4A) $I_{t,i}* = \delta' Z_{t,i} + u_{t,i},$

where Z_i is again the vector of relevant variables for the decision of the firm to engage in training or not. A firm introduces training $(I_i=1)$ when $I_i* > 0$ (or $\delta' Z_i > -u_i$) and it does not invest in training $(I_i=0)$ if $I_i* \leq 0$.

According to Maddala (1983) or Greene (2000), p. 933, we can consistently estimate the production functions (3) and (3A) by using the estimated training intensity $\hat{T}_i$ from the tobit estimation (4) instead of T_i in (3′) and by adding a selection correction term for training firms and non-training firms in equation (3A′) as follows:

(3′′) $\ln Y_{t,i} = \beta X_{t,i} + \gamma(\tau - 1)T_{t-z,i} + \varepsilon_{t,i},$

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[1] Alternative and closely related estimation procedures are logit and normit, see Greene (2000). The main difference to the tobit model is that these techniques assume a nonlinear S-bended relationship between the endogeneous and the exogeneous variables. A problem arises with logit or normit estimation, if – as in this case – the training intensity equals zero or one. These firms would either have to be dropped or their shares would have to be changed ad hoc.

$$E[\ln Y_{t,i} \mid I_{t-z,i}=0] = \beta X_{t,i} + \sigma \frac{-\varphi(\gamma' Z_{t,i})}{1-\Phi(\gamma' Z_{t,i})},$$

(3A′′)

$$E[\ln Y_i \mid I_{t-z,i}=1] = \beta X_{t,i} + \tau_j D_{t-z,i,j} + \sigma \frac{\varphi(\gamma' Z_{t,i})}{\Phi(\gamma' Z_{t,i})} \text{ with } j=1,...,7,$$

where $X_{t,i}$ is the complete vector of explanatory variables without the training variables, i.e. V_i plus capital, labour and the constant and $\phi(\gamma' Z)$ is the density function and $\Phi(\gamma' Z)$ the distribution function of the estimated parameters in equation (4). The parameter σ therefore measures the covariance between the error terms in the production function (3A′) and the selection equation (4A), $\sigma = \text{cov}(u_i, \varepsilon_i)$.

3.3 Fixed Effects Estimation

The second source of possible estimation bias considered here is unobserved time-invariant heterogeneity. This can be corrected by estimating equations (3′′) and (3A′′) by a fixed effects panel regression. Between two years, training intensity and most other explanatory variables in V_i do not change much, however, and therefore the ratio between signal and noise is low if the training intensity, the incidence of different training forms, and other quasi fixed variables would be included into the fixed effects equation (Dearden, Reed, and Van Reenen, 2000). We therefore adopt the two step procedure proposed by Black and Lynch (2001). In the first step, productivity is estimated by the variable production factors capital and labour and additional time dummies:

(5) $$\ln Y_{i,t} = \ln A_{i,t} + \beta \ln K_{i,t} + \gamma \ln L_{i,t} + \delta P_t + v_i + \varepsilon_{i,t}.$$

with v_i the unobserved time independent fixed effect and $\varepsilon_{i,t}$ the idiosyncratic component of the error term and P_t the time dummies. The fixed effect is the average establishment specific difference from productivity expected on the basis of the inputs. This time invariant variable therefore measures if establishment productivity structurally was below or above that of the other firms and serves as dependent variable for the second estimation step. In the second step, the quasi fixed variables like training intensity, firm characteristics or personnel measures explain these fixed effects:

(6) $$v_i = \beta V_{t,i} + \gamma(\tau - 1)T_{t,i} + \zeta_{t,i},$$

(6A) $$v_i = \beta V_{t,i} + \tau D_{t,i,j} + \zeta_{t,i} \text{ with } j=1,\dots,7.$$

We correct for the unobserved heterogeneity and the selectivity bias simultaneously by including the estimated training intensity T_i such as in (3′′) and adding the selectivity correction term (the normal hazard function) for the decision of the firm to offer training from (3A´´) in equation (6) or (6A).[2]

4 The Data

The empirical analysis of the impact of training on firm productivity is performed on the basis of the IAB establishment panel (for detailed information see Bellmann et al., 2000 and Bellmann and Büchel, 2001). Firms in this panel are drawn from all establishments in Germany with at least one employee who has a social security number. Therefore, only establishments consisting of employees not covered by social insurance (mainly farmers, mine workers, artists, and journalists) along with public enterprises with only federal employees are excluded. There is a large set of questions that is asked every year on production, investment, industry sector, employee structure, personnel problems, business strategy and vocational training. The survey is held in the middle of the year. Some questions like average employment during one year, output and profit situation are therefore asked retrospectively in the following wave. Every year, additional questions are added on an irregular basis. In the waves 1997 and 1999, additional detailed information on the training behaviour of the firms was collected. Panel information from the waves 1997 until 2000 is used here.

Capital is not directly measured in the data set and therefore it is approximated by total investments minus expansion investments. The logic behind this is that firms on average write off a fixed share of their capital and replace this yearly. Implicitly it is therefore assumed that replacement investments equal capital depreciation. Investments are deflated by the input price index of the German Federal Statistical Office (Statistisches Bundesamt, 2001). A construction of the capital stock by the perpetual inventory method (Hall and Mairesse, 1995) that depends on the assumption of a constant investment growth rate and a constant linear depreciation rate for capital lead to similar results. Value added (i.e. revenues minus input costs) is depreciated by the product price index for different sectors. We include only profit oriented establishments and those that have not been merged with other establishments or have merged other establishments. In 1997, we have 5675 establishments in our gross sample, in 1998 we have 6192 and in 1999 6886. Descriptive statistics of the data used can be found in Tables A1 – A3 in the appendix.

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[2] This provides us with:

(6′) $$v_i = \beta V_{t,i} + \gamma(\tau - 1)T_{t,i} + \zeta_{t,i} ,$$

$$E[v_i \mid I_{t,i} = 0] = \beta V_{t,i} + \sigma \frac{-\varphi(\gamma' Z_{t,i})}{1 - \Phi(\gamma' Z_{t,i})} ,$$

(6A′)

$$E[v_i \mid I_{t,i} = 1] = \beta V_{t,i} + \tau_j D_{t,i,j} + \sigma \frac{\varphi(\gamma' Z_{t,i})}{\Phi(\gamma' Z_{t,i})} \text{ with } j = 1,...,7.$$

4.1 The training decision of the firm

About one third of the firms in Germany do not invest in continuous employee training at all and cope with qualification demands by other measures. In 1997, about 64% of the commercial firms offered training for their employees while on average 19% of the workforce in these firms participated in courses (compare Table A1). In 1999, the number of training firms (calculated also from the IAB establishment panel) increased to 66% while training intensity was 21%. The expenditures for different training forms are differing widely, see Table 1. While the enterprises spend by far the most per employee on internal and external formal courses, expenditures for self-induced learning and participation at seminars and talks are considerably smaller. Also the incidence of different training forms varies. Besides formal training, most training firms also offer training on the job and participation at seminars or talks. Job rotation, quality circles and self-induced training are much less wide spread.

Table 1: Training costs per employee and incidence, different training forms

Training form	Expenditures*	Incidence**
Formal internal training	562	37%
Formal external training	215	55%
Seminars and talks	39	42%
Training on the job	111	40%
Job Rotation	not available	9%
Quality circles	not available	13%
Self-induced learning	35	14%

Source: *Institut der deutschen Wirtschaft (2002), figures in Euro for 1998, ** IAB Establishment Panel, Wave 1997, own calculations.

This paper concentrates on the influence of training in 1997 on productivity in the years 1998 and 1999. In our cross section regressions, we therefore have t = 1998, 1999 and z = 1,2. This allows us to identify lagged productivity effects of training. We will show that although we use lagged training variables, nevertheless endogeneity of training plays a role for our results. In this section, the selection equation to offer training in 1997 and the decision on training intensity in 1997 are estimated. Thus, the decision of firms to pay for training of their employees is modeled in a binary probit model and the decision of the firm how many of their employees should obtain training is modeled in a tobit model. In order to effectively control for selectivity in the productivity estimation presented in the next section, we have to find identifying variables that have a significant influence on the decision to train or on training intensity but not on productivity (Dearden, Reed, and Van Reenen, 2000). This paper uses a unique set of questions that identifies expected skill gaps and the reaction of the personnel department on skill shortages as suitable identifying variables for both decisions. When firms expect skill gaps in the future because some employees will be on maternal leave or made redundant in the near future or because the demand for skills increases in general, this may induce them to introduce training now. It can be shown that productivity is not affected by these expectations which means that there is no strong correlation between the expected skill gaps over time or between the expected and the actual skill gaps. Moreover, the preferred reaction of the establishment (i.e. mainly the personnel department) on skill shortages has the same statistical properties. When the establishment mainly reacts by additional apprenticeship training or training of the employees on skill gaps (instead of a high priority on hiring skilled employees from the labour market), this increases the probability that the establishment offers training but it does not have an impact on contemporary productivity.

In addition, usual explanatory variables for the inclination of the establishment to train or for the determination of the chosen training intensity such as the number of employees, the share of qualified employees, a dummy for investors in information and communication technology (IT technology), state of the art technical installations, a dummy for establishments with collective wage agreements, co-determination and apprenticeship training, sector dummies, and the location of the establishment in East or West Germany are added (Jirjahn, 1998, Düll and Bellmann, 1998, Gerlach and Jirjahn, 2001, Bellmann and Büchel, 2001). The descriptive statistics of these variables can be found in Table A1 in the appendix. The determinants of the training decision according to equation (4A) are summarized in Table 2 while the determinants of training intensity according to equation (4) are summarized in Table 3. For both decisions the same set of explanatory variables is used.

Table 2: Probit estimation to explain if a firm trains or not, 1997

Exogenous Variables	Coefficients	z-Value
Redundancies expected	0.243***	3.82
Many employees are expected to be on maternal leave	0.295***	2.87
High qualification need expected	0.545***	6.77
Apprenticeship training high priority reaction on skill shortages	0.230***	4.46
Training high priority reaction on skill shortages	0.646***	12.91
Number of employees	0.322***	19.57
Share of qualified employees	0.558***	7.75
State of the art technical equipment	0.188***	4.37
Investor in IT	0.229***	5.00
Collective wage agreement	0.189***	4.23
Apprenticeship training	0.368***	7.95
15 sector dummies and East Germany dummy	Yes	
Pseudo R^2	0.33	
Number of observations	5640	

Comment: The significance level is marked by stars: *** significant at 1 percent.
Source: IAB Establishment Panel, Waves 1997 and 1998, own calculations.

From this regression, we calculate the probability that a firm offers continuous training and add it as a correction term in the production function, see equation (3A´). It would have been desirable to have a separate correction term for all training forms. This does not seem achievable, however, because the categories are not mutually exclusive and therefore a multivariate probit is not possible. When we estimate the probability to offer each category separately, we incur a bias because the training forms are strongly correlated with each other. Therefore a single correction term characterizing the decision to offer training or not seems the best we can achieve.

Table 3: Tobit estimation to explain training intensity, 1997

Exogenous Variables	Coefficients	z-Value
Redundancies expected	0.057***	3.06
Many employees are expected to be on maternal leave	0.059**	2.01
High qualification need expected	0.151***	7.17
Apprenticeship training high priority reaction on skill shortages	0.094***	5.13
Training high priority reaction on skill shortages	0.227***	12.92
Firm size 20-199	0.070***	4.17
Firm size 200-499	0.101***	3.69
Firm size 500-1000	0.084**	2.20
Firm size 1001+	0.062*	1.67
Co-determination	0.120**	2.24
Share of qualified employees	0.236***	9.47
State of the art technical equipment	0.084***	5.64
Investor in IT	0.067***	4.58
Collective wage agreement	0.091***	5.78
Apprenticeship training	0.108***	6.81
15 sector dummies and East Germany dummy	Yes	
Pseudo R^2	0.18	
Number of observations	5561	
2598 left-censored observations (training intensity = 0)		
2730 uncensored observations		
233 right-censored observations (training intensity = 1)		

Comment: The significance levels are marked by stars: *** significant at 1 percent, ** at 5 percent and * at 10 percent.

Source: IAB Establishment Panel, Waves 1997 and 1998, own calculations.

From this equation, we calculate the predicted training intensity values and replace the training intensities from the data, see equation (3´).

Most German firms react on skill shortages by additional training efforts because the external skilled labour market is thin (Roth, 1997, Zwick and Schröder, 2001). Therefore, it is not surprising that firms that expect that workers will leave, be on maternal leave or that expect that they will encounter difficulties in finding new skilled workers step up training. It can also be anticipated that firms that give a higher priority to additional apprenticeship training and continuous training efforts instead of hiring skilled employees from the labour market when they have vacancies for skilled jobs are more prone to offer training. It is also well known that additional apprenticeship training, IT investments and state of the art technical equipment induce training needs (Düll and Bellmann, 1998, Dearden, Reed and Van Reenen, 2000, Gerlach and Jirjahn, 2001). Large firms usually train more because they frequently have an own training department and the incidence of employees with training needs is larger. Collective wage agreements frequently also entail fringe benefits like training and a co-determined management gives continuous training a higher priority. The higher the qualification level of the employees the higher is their training need and therefore firms with a larger share of qualified employees tend to train more. Finally, firms offering apprenticeship training in order to provide the needed skills, frequently also offer training for their employees. All these correlations have been empirically shown for German firms for example by Düll and Bellmann (1998), Bellmann and Büchel (2001), and Gerlach and Jirjahn (2001). We also find these correlations while the East Germany dummy and the sector dummies are jointly significant, see Table 1. We do not report in Table 1 that in comparison to the banking sector – which is the reference sector – agriculture, the consumption goods industry, retail and wholesale trade and interestingly also the educational establishments offer significantly less training while insurance and business services offer more training.

4.2 Estimation of the Productivity Effects of Training

In order to estimate the productivity effects of increasing continuous training intensity and different continuous training forms, first equations (3) and (3A) without selection correction are estimated. The estimation results for the lagged impact of training intensity in the first half of 1997 on value added in 1998 and 1999 are shown in the Tables 4 and 5. In addition to capital and labour, we add 15 sector dummies and a dummy for East German firms in order to capture the differences in productivity between the sectors and the productivity gap of East German firms. We also take account of productivity differences between different legal forms. Qualified employees, investments in IT and a state of the art technical equipment usually increase firm productivity (Black and Lynch, 2001) while firms facing international competition and firms with co-determination are also more productive (Jirjahn, 1998). We finally add employee participation, teamwork, units with own costs and results accounting, stringent hiring rules and incentive payments as dummies for several dimensions of personnel management that may be correlated with training and relevant for productivity (Wolf and Zwick, 2002). The descriptive statistics of the variables used can be found in Tables A2 and A3 in the appendix.

Estimation of equation (3) shows that training intensity in the first half of 1997 has a positive impact on productivity, see column 2 and 6 in Table 4. The impact on firm productivity in 1998 is around 0.15. It is smaller and not significant after two years (in 1999) any more, however. In addition, we find that the firms produce with constant scale elasticities and a capital intensity between 0.15 and 0.18 depending on the estimation specification.[3] The additional explanatory variables have the expected sign. The share of qualified employees and the dummies for exporting firms, firms investing in IT and those having state of the art equipment and being co-determined all have a positive (but frequently insignificant) impact on productivity while individual firms are significantly less productive than firms with limited liability. Employee participation, stringent hiring rules and incentive payments have a tendency to improve productivity while the dummies for firms with teamwork and units with own costs and results accounting have a negative sign. The additional personnel measures have individually frequently an insignificant, but jointly a highly significant impact on productivity (see also Wolf and Zwick, 2002). The East Germany dummy and the sector dummies are also jointly highly significant.

In contrast for example to Bartel (1994), the size of the estimated productivity impact is clearly reduced when we add further variables in matrix V_i while the explanatory power of the regression increases. In a production function regression entailing besides capital, labour and training intensity only the East Germany dummy and the 15 sector dummies, the parameter of training intensity is highly significant and equals 0.23 for 1998 and 0.18 for 1999. Therefore a parsimonious estimation that only takes labour, capital, training and very few additional training parameters into account tends to overestimate the productivity impact of continuous training in Germany.

When we differentiate between several training forms, see equation (3A′), we find that formal external courses have a positive significant impact on productivity, see Table 5 for the lagged productivity effects in 1998 and 1999. While the productivity impact of external training in the first half of 1997 increases from 1998 to 1999, the impact of formal internal courses has a positive impact on productivity in 1998 only, while there is no effect in 1999. Training on the job has a persistent negative effect on productivity. Training circles only create a positive productivity impact with a lag of more than one year.

In order to correct for selectivity bias in these regressions, the selection correction term on basis of the selection estimates in Table 2 are added in the estimation of equation (3A’′) in Table 5. The selection correction term is negative for (3A′′) and the corrected impact of all continuous training forms on productivity increases accordingly (except for quality circles). The same is observed when the predicted training intensities are used instead of the observed training intensities. The productivity impact increases considerably for both years. We learn from this exercise that firms have a higher inclination to train in times of a productivity disadvantage. Not taking selectivity into account underestimates the productivity

[3] The capital intensity is low in comparison to other production function estimations. This is probably caused by the use of a proxy for capital because we lack direct information on capital.

effects of training, accordingly. While the estimated productivity impact of training increases after selection correction, the impact of the other explanatory variables on productivity is virtually unchanged. This pattern of an increased productivity estimate after selectivity control was also found in Bartel (1994) and Dearden, Reed and Van Reenen (2000) for the UK and USA. Bellmann and Büchel (2001) find on the other hand that after controlling for selectivity, the measured contemporaneous productivity impact of training intensity decreases and loses significance. The selection correction term in their regression is negative and insignificant, however.[4] Our result can be interpreted in different ways. Probably firms train in slack periods, i.e. when it is cheap to engage employees with other tasks than production or they train in order to catch up with the productivity level of their competitors.

In order to correct for time invariant unobserved heterogeneity, we estimate a fixed effects panel regression for the period 1997-1999. This involves a two-step procedure regressing first value added on capital, labour and time dummies in a fixed effects estimation on the basis of equation (5). Then the fixed effects are determined by calculating the average error terms per firm during the estimation period (see Black and Lynch, 2001). In the second step, these fixed effects are regressed on the quasi fixed factors training intensity, the different training forms and the other explanatory variables in 1997. The first estimation step suffers from the well-known low capital and labour estimates in regressions on value added (Griliches and Mairesse, 1995), but the results are comparable to those in Black and Lynch (2001), see Table A4 in the appendix. The second step regresses the establishment fixed effects calculated from the first step on the quasi fixed factors training and the other variables in X_i. Training intensity has a significant positive impact on the fixed effects, see Table 6. Formal external and internal courses, self-induced learning and quality circles have a positive significant impact on productivity, while training on the job, seminars and talks as well as job rotation have no impact.

When selectivity is simultaneously taken into account by using the predicted training intensity variables, see equation (6´) or including the selection correction term from (6A´), the estimated productivity impact of training intensity increases again. Also the measured productivity impact of formal courses increases (most notably that of formal external courses) while the impact of self-induced learning and quality circles is almost unchanged (see Table 6). Training in the firms frequently is assigned to those employees who are best able to benefit from it. Therefore the estimated productivity effect is a so-called "treatment on the treated" than an average productivity effect and it is save to assume that the productivity effect of training would decrease when training intensity would be increased more than marginally (Dearden, Reed, Van Reenen, 2000). The dummy variables for the different training forms on the other hand describe the potential effect of an increase of say formal external training from no employees to all employees which is the maximal and empirically rather improbable effect of introducing a certain training measure for all employees. Omitted variable bias would again change these results. When we re-calculate the second estimation step in Table 6 taking account of selectivity and including besides the training variables only the East Germany dummy and the sector

[4] This may be a consequence of a different definition of the selection correction term that is neither defined explicitly nor interpreted in their paper.

controls, we would obtain an impact of training intensity of 4.26 and positive impacts of all training forms between 0.01 (job rotation) and 1.07 (formal external courses).

5 Conclusions

This paper shows that training intensity has a positive and significant effect on firm productivity in Germany even after two years. While formal internal and external training has a positive impact on firm productivity in the same year and the following year, the impact of internal training decreases in the third year. Although it is widespread and firms spend a lot of money for it, training on the job has a persistent negative effect on firm productivity. Quality circles only have a productivity impact with a time lag of more than one year.

Endogeneity and unobserved heterogeneity both have an impact on the measurement of the productivity impact. Checking for endogeneity by adding a selection correction term and using instrumental variable techniques increases the measured productivity impact of training intensity and different training forms. This means that firms facing a productivity gap select training as a measure to close it. We can conclude that one motivation of firms to train is in order to regain competitiveness because it is a suitable means to reduce productivity gaps with respect to competitors. Therefore unobserved heterogeneity should be controlled for in addition to selectivity in order not to obtain biased productivity estimates.

The paper also shows that frequently used measures like training on the job and participation at seminars or talks do not have an impact on the fixed productivity effects of the establishment. The highest productivity impact can be obtained by offering more structural approaches like formal internal and external training courses. Also cheap measures such as self-induced learning (which is frequently based on e-learning) and quality circles that are used by around 10% of the German firms only have a positive impact on structural firm productivity. It therefore seems that these measures are still under-utilized in Germany.

Finally, significant omitted variable bias is detected. When a broad variety of firm, employee and personnel management characteristics is not taken into account, the estimated productivity impact is much too high.

6 Appendix

Table A1: Descriptive Statistics 1997

Variables	Average	Answers	Comments
Training 1997	0.64	5675	Share of firms offering training in first half of 1997
Training intensity 1997	0.19	5428	Number of trained employees in first half of 1997/number of employees
Formal external courses	0.55	5428	External courses, seminars offered in first half of 1997, Yes/No
Formal internal courses	0.37	5428	Internal courses, seminars offered in first half of 1997, Yes/No
Training on the job	0.40	5428	Training on the job (instruction, learning by doing) offered in first half of 1997, Yes/No
Participation at seminars and talks	0.42	5428	Participation at presentations, seminars, fairs offered in first half of 1997, Yes/No
Job rotation	0.09	5428	Job rotation offered in 1997, Yes/No
Self-induced learning	0.14	5428	Self induced learning on the basis of computer aided programmes, literatures offered in first half of 1997, Yes/No
Quality circles	0.13	5428	Quality circles, discussion groups, participation groups etc. offered in first half of 1997, Yes/No
Redundancies expected	0.14	5640	Over the next 2 years, redundancies are expected, Yes/No
Many employees are expected to be on maternal leave	0.05	5460	Over the next 2 years, organisational problems due to maternity leave are expected, Yes/No
High qualification need expected	0.11	5640	Over the next 2 years, a large demand for training and qualifications is expected
Apprenticeship training reaction to skill shortages	0.35	5640	Apprenticeship training highest priority to fill skills gap (in contrast to training and hiring skilled workers)
Training reaction to skill shortages	0.35	5640	Training own employees has highest priority to fill skills gap (in contrast to apprenticeship training and hiring skilled employees)
Investment in IT	0.65	5675	Investment in communication or electronic data procession, Yes/No

Table A1 (continued)

Share of qualified employees 1997	0.60	5666	Share of employees with a formal qualification degree on all employees
Exporter	0.22	5450	Exporter, from wave 1998, Yes/No
Co-determination	0.34	5640	Firm has a work council Yes/No
State of the art technical equipment	0.72	5450	Technical equipment is marked state of the art in comparison to sector
Firm size 1-19 (reference)	0.40	5640	Establishment has 1-19 employees in 1997
Firm size 20-199	0.40	5640	Establishment has 20-199 employees in 1997
Firm size 200-499	0.10	5640	Establishment has 200-499 employees in 1997
Firm size 500-999	0.04	5640	Establishment has 500-999 employees in 1997
Firm size 1,000+	0.06	5640	Establishment has more than 1,000 employees in 1997
Collective wage	0.68	5640	Firm is subject to collective wage agreements, Yes/No
Apprenticeship	0.61	5640	Firm offers apprenticeship training, Yes/No
Individual firm	0.27	5640	Individual firm, Yes/No
Partnership	0.10	5640	Partnership, Yes/No
Limited company (reference category)	0.49	5640	Limited Company, Yes/No
Publicly listed company	0.07	5640	Publicly listed company, Yes/No

Source: IAB Establishment Panel, Waves 1997-2000, representative values

Table A2: Descriptive Statistics 1998

Variables	Average	Answers	Comments
Value Added	14.07	4154	Turnover minus input costs and costs for third parties, deflated, ln
Capital	11.85	6221	Proxy: Investments minus expansion investments, logs, ln, deflated, from wave 1999
Labour	3.21	6192	Number of employees, ln
Investment in IT	0.66	6176	Investment in communication or electronic data procession, Yes/No
Share of qualified employees	0.62	6187	Share of employees with a formal qualification degree on all employees
Exports	0.22	6180	Exporter, from wave 1999, Yes/No
State of the art technical equimpment equipment	0.75	6179	Technical equipment is marked state of the art in comparison to sector, Yes/No
Employee Participation	0.23	6079	Firm shifted responsibility and decisions to lower ranks until 1998, Yes/No
Teamwork	0.16	6079	Firm has team work and independent groups in 1998, Yes/No
Units with own costs and results accounting	0.12	6079	Firm has units with own costs and results accounting in 1998, Yes/No
Stringent hiring rules	0.27	6079	Firm has formal hiring rules in 1998, Yes/No
Incentive payments	0.13	6079	Firm has gain sharing or employee share ownership in 1998, Yes/No
Co-determination	0.34	6170	Firm has a work council, Yes/No
Exporter	0.22	6221	Firm exports, Yes, No
Individual firm	0.27	6221	Individual firm, Yes/No
Partnership	0.10	6221	Partnership, Yes/No
Limited company (reference category)	0.51	6221	Limited Company, Yes/No
Publicly listed company	0.06	6221	Publicly listed company, Yes/No
State of the art technical equipment	0.75	6199	Technical equipment is marked state of the art in comparison to sector, Yes/No

Source: IAB Establishment Panel, Waves 1998 and 1999, own calculations

Table A3: Descriptive Statistics 1999

Variables	Average	Answers	Comments
Value Added	14.14	5969	Turnover minus input costs and costs for third parties, in DM, ln, deflated, from wave 2000
Capital	13.11	8854	Proxy: Investments minus expansion investments, logs, in DM, ln, deflated, from wave 2000
Labour	3.17	6670	Number of employees at 1.6.1999, ln
Investment in IT	0.87	6886	Investment in communication or electronic data procession, Yes/No
Share of qualified employees	0.69	6886	Share of employees with a formal qualification degree on all employees
Exporter	0.26	6886	Exporter, Yes/No
Co-determination	0.36	6701	Firm has a work council, Yes/No
State of the art technical equipment	0.75	5450	Technical equipment is marked state of the art in comparison to sector, Yes/No
Profit sharing	0.14	6701	Firm has profit sharing rules for employees, Yes/No
Collective wage	0.68	6701	Firm is subject to collective wage agreements, Yes/No
Individual firm	0.27	6701	Individual firm, Yes/No
Partnership	0.10	6701	Partnership, Yes/No
Limited company (reference category)	0.51	6701	Limited Company, Yes/No
Publicly listed company	0.06	6701	Publicly listed company, Yes/No

Source: IAB Establishment Panel, Waves 1999 and 2000, own calculations

Table A4: Fixed effects productivitiy estimation, value added 1997 – 1999 (equation (5)).

	Coefficients	z-values
Capital	0.028***	2.88
Labour	0.321***	5.17
Year Dummy 1998	- 0.015	- 0.83
Year Dummy 1999	0.023	1.25
Constant	13.16***	54.45
Number of observations	5652	
Adjusted R^2	0.85	

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Table 4: Lagged productivity effects of training intensity, OLS regressions

	Equation (3´), for1998		Equation (3´´), for 1998		Equation (3´), for 1999		Equation (3´´), for 1999	
Exogeneous Variables	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values
Capital	0.160***	10.35	0.157***	10.18	0.181***	10.73	0.177***	10.59
Labour	0.795***	33.90	0.780***	32.54	0.745***	27.72	0.731***	26.86
Training intensity 1997	0.161**	2.08	0.318**	2.39	0.071	0.79	0.438***	3.04
Share of qualified employees	0.340***	4.30	0.285***	3.48	0.380***	3.97	0.315***	3.21
Exporter	0.234***	3.90	0.234***	3.94	0.206***	2.91	0.188***	2.69
State of the art technical equipment	0.107**	2.33	0.111**	2.41	0.205***	3.91	0.191***	3.67
Investment in IT	0.045	0.99	0.035	0.75	0.122**	2.04	0.097	1.62
Co-determination	0.180***	2.90	0.182***	2.94	0.276***	3.87	0.262***	3.70
Individual firm	-0.337***	-5.76	-0.328***	-5.60	-0.351*	-5.23	-0.341***	-5.14
Partnership	-0.002	-0.03	0.006	0.08	-0.061	-0.76	-0.053	-0.66
Publicly listed company	0.067	0.64	0.072	0.70	-0.066	-0.56	-0.061	-0.53
Employee Participation	0.088*	1.65	0.079	1.49	0.072	1.16	0.062	1.00
Teamwork	-0.020	-0.33	-0.015	-0.26	-0.009	-0.13	-0.016	-0.24
Units with own costs and results accounting	0.064	0.97	0.058	0.89	0.012	0.17	0.002	0.03
Stringent hiring rules	0.035	0.65	0.037	0.68	0.055	0.87	0.051	0.83
Incentive payments	0.101	1.52	0.102	1.55	0.111	1.44	0.113	1.47
Constant	9.702***	52.83	9.835***	52.23	9.626***	51.99	9.794***	51.31
15 Sector dummies and East Germany dummy	Yes		Yes		Yes		Yes	
Number of Observations	1440		1454		1209		1219	
Adjusted R^2	0.89		0.87		0.87		0.87	

Comment: The significance levels are marked by stars: *** significant at 1 percent, ** at 5 percent and * at 10 percent.

Source: IAB Establishment Panel, Waves 1997 - 2000, own calculations.

Table 5: Lagged productivity effects of alternative forms of training, OLS regressions

	Equation (3A´), for 1998		Equation (3A´´), for 1998		Equation (3A´), for 1999		Equation (3A´´), for 1999	
Exogeneous Variables	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values
Capital	0.159***	10.35	0.155***	10.21	0.157***	12.74	0.175***	10.56
Labour	0.778***	32.19	0.761***	29.82	0.785***	39.58	0.709***	24.88
Formal external courses 1997	0.113**	2.13	0.203***	3.08	0.174***	3.17	0.351***	4.56
Formal internal courses 1997	0.174***	3.09	0.194***	3.42	-0.046	-0.73	-0.011	-0.17
Training on the job 1997	-0.130**	-2.34	-0.106*	-1.87	-0.118*	-1.88	-0.094	-1.45
Seminars and talks 1997	-0.055	-1.00	-0.029	-0.52	0.014	0.24	0.056	0.88
Job rotation 1997	-0.035	-0.44	-0.034	-0.43	-0.100	-1.12	-0.101	-1.09
Self-induced learning 1997	0.099	1.54	0.104	1.63	0.047	0.66	0.039	0.54
Quality circles 1997	0.091	1.22	0.089	1.20	0.275***	3.37	0.275***	3.24
Share of qualified employees	0.339***	4.32	0.336***	4.29	0.437***	6.18	0.367***	3.89
Exporter	0.223***	3.75	0.219***	3.69	0.185***	3.79	0.168**	2.41
State of the art technical equipment	0.111**	2.44	0.111**	2.45	0.118***	3.13	0.205***	3.98
Investment in IT	0.057	1.25	0.045	0.98	0.118***	2.68	0.108*	1.84
Co-determination	0.169***	2.72	0.170***	2.73	0.207***	4.19	0.251***	3.56
Individual firm	-0.347***	-5.95	-0.345***	-5.92	-0.322***	-6.66	-0.358***	-5.41
Partnership	-0.002	-0.02	0.007	0.09	-0.047	-0.83	-0.043	-0.55
Publicly listed company	0.053	0.51	0.058	0.56	-0.053	-0.56	-0.055	-0.47
Employee Participation	0.084	1.58	0.081	1.53	0.076	1.52	0.063	1.04
Teamwork	-0.032	-0.54	-0.031	-0.52	-0.034	-0.62	-0.013	-0.18
Units with own costs and results accounting	0.057	0.87	0.051	0.80	-0.051	-0.88	-0.011	-0.15
Stringent hiring rules	0.020	0.37	0.024	0.31	-0.001	-0.02	0.063	0.98
Incentive payments	0.085	1.28	0.077	1.26	0.158**	2.49	0.108	1.45
Selection Correction term			-0.103***	-2.30			-0.187***	-3.62
Constant	9.738***	53.24	9.768***	53.54	9.766***	72.18	9.677***	53.09
15 Sector dummies and East Germany dummy	Yes		Yes		Yes		Yes	
Number of Observations	1454		1454		1220		1219	
Adjusted R^2	0.89		0.89		0.86		0.88	

Comment: The significance levels are marked by stars: *** significant at 1 percent, ** at 5 percent and * at 10 percent.
Source: IAB Establishment Panel, Waves 1997 - 2000, own calculations.

Table 6: Two-step panel estimates, second step estimates, dependent variable: average residual 1997 - 1999

	Equation (6)		Equation (6´)		Equation (6A)		Equation (6A´)	
Exogeneous Variables	Coefficients	t-Values	Coefficients	t-Values	Coefficients	t-Values	Coefficients	t-Values
Training intensity	0.233***	3.41	0.765***	5.71				
Formal external courses					0.183***	3.99	0.406***	7.02
Formal internal courses					0.238***	4.74	0.289***	5.73
Training on the job					-0.033	-0.67	0.013	0.26
Seminars and talks					-0.015	-0.32	0.039	0.81
Job rotation					0.037	0.49	0.031	0.42
Self-induced learning					0.112*	1.88	0.110*	1.87
Quality circles					0.140**	2.09	0.134**	2.02
Share of qualified employees	0.679***	10.11	0.496***	6.50	0.669***	10.10	0.612***	9.23
Exporter	0.268***	5.06	0.251***	4.79	0.225***	4.32	0.213***	4.11
State of the art technical equipment	0.188***	4.89	0.121***	3.02	0.172***	4.55	0.152***	4.04
Investment in IT	0.157***	4.05	0.111***	2.80	0.137***	3.57	0.103***	2.68
Co-determination	0.042	0.22	-0.037	-0.19	0.033	0.17	0.025	0.13
Individual firm	-0.569***	-11.29	-0.560***	-11.17	-0.558***	-11.20	-0.536***	-10.82
Partnership	-0.080	-1.30	-0.075	-1.24	-0.085	-1.40	-0.067	-1.11
Publicly listed company	0.276***	2.85	0.257***	2.72	0.235**	2.49	0.237**	2.53
Employee Participation	0.117**	2.45	0.105**	2.22	0.092*	1.95	0.086*	1.84
Teamwork	-0.023	-0.41	-0.024	-0.46	-0.045	-0.84	-0.042	-0.78
Units with own costs accounting	-0.017	-0.29	-0.017	-0.42	-0.027	-0.48	-0.034	-0.60
Stringent hiring rules	0.200***	4.13	0.199***	4.16	0.169***	3.51	0.157***	3.28
Incentive payments	0.157***	2.59	0.170***	2.84	0.122**	2.05	0.127**	2.13
Firm size 20-199	1.130***	23.63	1.019***	19.84	1.043***	21.45	0.960***	19.19
Firm size 200-499	2.189***	28.26	2.015***	24.53	1.994***	24.90	1.841***	22.15
Firm size 499-1000	2.545***	22.66	2.377***	20.79	2.307***	20.22	2.118***	18.08
Firm size 1,000+	3.186***	28.18	3.037***	26.98	2.946***	25.33	2.758***	23.13
Selection correction term							-0.240***	-6.26
Constant	-1.347***	-14.68	-1.065***	-10.46	-1.344***	-14.85	-1.386***	-15.39
15 Sector, East Germany dummies	Yes		Yes		Yes		Yes	
Number of Observations	2432		2460		2460		2460	
Adjusted R^2	0.74		0.75		0.75		0.75	

Comment: The significance levels are marked by stars: *** significant at 1 percent, ** at 5 percent and * at 10 percent.

Source: IAB Establishment Panel, Waves 1997 - 2000, own calculations.