

The Impact of Training Intensity on Establishment Productivity

Thomas Zwick

Address:

Dr. Thomas Zwick*

Centre for European Economic Research (ZEW)

P.O. Box 103443

D-68034 Mannheim, Germany

Tel.: ++49-621-1235283

E-mail: zwick@zew.de

Abstract

This paper measures the impact of training intensity on establishment productivity in a production function using the representative German IAB establishment panel set. The share of trained employees in 1997 has a significant productivity impact on productivity in 1998 (but not in 1999) and on average productivity in the period 1997 - 2000. The paper simultaneously corrects for unobserved time-invariant heterogeneity of establishments by using a fixed effects panel regression and for selectivity of training by instrumenting the training intensity variable. In addition, it includes a broad variety of control variables for establishment and employee characteristics as well as several personnel management methods in order to reduce omitted variable bias. This innovative estimation approach demonstrates that the estimation results are sensitive to the three sources of estimation bias. Unobserved heterogeneity and selectivity both lead to an underestimation while omitted variable bias leads to an overestimation of the productivity effect.

JEL Codes: C23, D21, J24

Key Words: Training, Firm Productivity, Panel Estimation

* This paper was mainly written during my research stay at the Centre on Skills, Knowledge and Organisational Performance (SKOPE), University of Oxford, UK. I want to thank seminar participants in Mannheim, Brussels, Paris and Oxford and especially Thomas Hempell, Johannes Ludsteck, Ken Mayhew, Guy Vernon, Elke Wolf, and Andreas Ziegler for helpful comments.

Introduction

The empirical literature on the productivity effects of training intensity is increasing constantly. The results of the studies differ widely, however. The explanations for the worrying diversity seem to lie on the one hand in differences between countries, labour market institutions and data generation and on the other hand in the estimation techniques used.

The central estimation problem is endogeneity of training and other production inputs such as labor and capital. Firms do not decide randomly if they train their employees or not and training therefore is not a strictly exogenous variable in the productivity equation. The decision to increase or decrease other input factors is also inseparably linked to fluctuations in output and productive efficiency influenced by unobservable elements. The endogeneity problem may therefore be the source of two distinct biases. First, firms that offer training may also be structurally more or less productive due to time invariant unobserved factors such as management quality, the exposition to long-term technical change, personnel department activity or management - employee relations. This source of estimation bias is called unobserved time invariant heterogeneity. Second, transitory shocks such as the introduction of a new technology or a change in product or labour market conditions could change output, input decisions and induce changes in training efforts at the same time. This source of estimation bias is called selectivity bias. Another prominent source of estimation bias are omitted variables. The training measure may pick up productivity effects of other relevant variables such as personnel management methods or the qualification level of the workforce that are closely related to the training behaviour and to the productivity of the firm but not taken into account in the estimation.

The main contribution of this paper is to address for the first time unobserved time invariant heterogeneity bias, selectivity bias and omitted variable bias simultaneously on the establishment level. It estimates the productivity impact of the share of employees trained divided by the total number of employees in a standard production function on the basis of representative German establishment panel data. It uses an innovative two step instrumental variable and panel estimation technique and takes a broad range of establishment and employee characteristics into account. By contrasting the estimation results with the uncorrected estimates, it indicates the sign and the size of the three sources of estimation bias mentioned above.

Literature

Human capital, knowledge, and skills are increasingly important competitive assets within firms. The investments in continuous training are considerable: On the basis of answers from 550 enterprises originating from 42 countries worldwide, the American Society for Training and Development (ASTD) reports for example that in 2000 the share of training expenditures on pay-roll was on average 2% in the USA and 2,5% in Europe (Marquardt, King and Ershkine, 2001). The authors add that the expenditures are bound to increase substantially. Although continuous training plays a central role in firm's skill provision and competitiveness, the evidence on its productivity effects is thin and partly contradictory. 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. The estimation results vary strongly, however, depending on the estimation technique used (Bartel, 2000). In this section, a short survey of studies that use firm or establishment level data from several economic sectors is provided focussing on the data and the estimation techniques used and their possible shortcomings.

In one of the first contributions to this topic, Holzer et al. (1993) estimate the effect of training on the scrap rate. The data basis are 390 applicants for the Michigan Job Opportunity Bank-Upgrade between 1987 and 1989. The authors estimate the variables in differences in order to avoid unobserved heterogeneity bias and include indicators for industrial relations and reasons for training. They find that a change in the annual hours of training per employee has a significant and substantial positive impact on product quality. This effect vanishes, however, when also the lagged changes in training are added.

Bartel (1994) first estimates a simple cross section production function including a dummy for formal training programmes in the effective labor 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 where the change in labor 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 labor 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, regress the level of training intensity instead of the change in training intensity on the change in productivity, however. 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. The effect of training intensity in their paper depends on the measurement of training: if it is measured as trainers/total employment or training days/total employment it has a positive significant effect on changes in labor productivity, if it is measured as training expenditures/total employment the effect is not significant. In their study the inclusion of several personnel management measures does not have an impact on the training coefficient. The studies by Bartel and Barrett and O'Connell do not address selectivity of the introduction of training programmes, 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 on sales 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 and they take training as an exogenous variable in their regression, however.

In order to correct for unobserved time invariant heterogeneity between firms, 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). In the first estimation step they calculate the average firm-specific, time-invariant residual in a fixed effects Cobb-Douglas production function without the almost time invariant workplace practices, training methods and other firm and employee characteristics. They therefore include only labor and capital here. In a second step, they regress this average establishment residual on training and the other quasi fixed factors. In this regression, training measured by the number of employees trained still has no impact on productivity in any regression (correcting for unobserved time-invariant heterogeneity or not) while some other personnel measures do have one. Black and Lynch (2001: 443), admit, however, that their estimation techniques only correct for endogeneity in the time variant parameters included in the first step and therefore the second step estimates (including training intensity) are prone to selectivity bias.

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 find that the impact of training hours and expenditures for training per employee on firm productivity depends strongly on the estimation technique used. In their preferred specification, a system GMM estimation that takes account of possible endogeneity of labor, capital, training and R&D in the productivity estimation, training has a positive and significant impact on value added in France, while in Sweden the effect is insignificant. Their instruments (lagged values of the explanatory variables by one or two years) may be weak, however, because all instrumented variables and the dependend variable may be affected by shocks that take longer than one or two years (Dearden, Reed and Van Reenen, 2000). Their panel includes 6 years and is too short to introduce longer lags, however. In addition, their specification is very parsimonious and takes only tangible assets and their interactions into account, while further firm and personnel characteristics are absent. Finally, 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 control 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. They find that training 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, the decision to train or not is found to be random, however, i.e. the correction term is not significant in their productivity equation including training intensity. 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 selectivity of training simultaneously by using a system GMM estimation including levels, first differences and lags of capital, labor as well as training intensity (Blundell and Bond, 1999). In addition, they calculate the impact and the sign of the biases incurred when training is taken as exogenous in the estimation. They find a positive and significant effect of training intensity on sector productivity (therefore including inter firm knowledge spill-overs). The productivity effects significantly increase when endogeneity of training is taken into account. There are two major drawbacks of their approach, however. First, they combine data on different aggregation levels which may lead to aggregation bias. Second, lagged variables might be weak instruments for current levels of training, capital and labor (Griliches and Mairesse, 1998). Smaller problems are that they do not control for additional personnel management measures and therefore might incur omitted variable bias. Their information on training covers only 4 weeks per year, respectively, and service firms have been dropped due to “measurement problems” in most regressions.

Summing up the literature survey, most studies on the firm or establishment level find a positive (although frequently insignificant) impact of training intensity on productivity while most studies are plagued by estimation or data problems.

Derivation of the Empirical Models

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

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

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 labor productivity. Equation (1) can be re-written as:

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

where $L_i = L_{Ti} + L_{Ui}$ is the number of employees 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 $\ln(1+x) = x$ for small x (see Dearden, Reed, and Van Reenen, 2000), we get:

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

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 establishment productivity.

Cross Section Estimation

Empirically, many further factors in addition to capital, labor and training intensity are relevant for establishment 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 such as the share of qualified employees and establishment heterogeneity such as the state of technical equipment and a dummy for establishments investing in IT, co-determined or exporting establishments are included.

Training measures are closely correlated with other innovative personnel measures that increase the participation of employees and are usually labeled “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, a couple of crucial additional controls for relevant innovative personnel measures are added: 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), a vector V_i entailing the variables described above is added. As many empirical assessments of the productivity effect of training use parsimonious specifications similar to (3), estimation results excluding further control variables are also reported. This reveals the size of the omitted variable bias.

Training cannot be expected to have an instantaneous effect on productivity and employees may actually be less productive during the time that they are trained (Bartel, 1995, Dearden, Reed and Van Reenen, 2000, Bassi et al., 2001). Therefore, different lags between $T_{t-z,i}$ and $Y_{t,i}$ are used with t a year indicator and z an indicator for the lags in the estimation specification, see equation (4). Cross section equations with varying z also allow us to see if there are time effects in the productivity impact of training. As training intensity is correlated over the years, the effects found in later years can not be interpreted as pure lagged effects, however.

$$(4) \quad \ln Y_{t,i} = \ln A_{t,i} + \beta \ln K_{t,i} + \gamma \ln L_{t,i} + \gamma(\tau - 1)T_{t-z,i} + \delta V_{t,i} + \varepsilon_{t,i}.$$

Instrumental Variables Approach

The empirical results of the estimated productivity function (4) may be biased because establishments do not randomly decide to train. Investment in training is an endogenous decision of the establishment, 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 endogenous choice of the treatment (Maddala, 1983, Greene, 2000). Our first measure against endogeneity is to take only lagged training intensities as explanatory variables 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 of the establishment how many employees to train still is not truly exogenous. Therefore, the training intensity variable in equation (4) has to be instrumented in order to make it exogenous in the production function. This explicitly explains the training intensity decision of the establishment by using external variables correlated with training but not with productivity. Empirically, the decision on training intensity can be modelled as a reduced form in a tobit model.¹ The latent training intensity $T_{t,i}^*$ is therefore the optimal share of employees trained in period t and can be defined as:

$$(5) \quad T_{t,i}^* = \delta' Z_{t,i} + u_{t,i},$$

where $Z_{t,i}$ is a vector of relevant variables for the training intensity decision of the establishment. 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 $0 \leq T_{t,i}^* \leq 1$.

According to Maddala (1983) or Greene (2000), p. 933, we can consistently estimate the production function (4) by using the estimated training intensity $T_{t,i}^*$ from the tobit estimation (5) instead of T_i in (3) as follows:

$$(6) \quad \ln Y_{t,i} = \beta X_{t,i} + \gamma(\tau - 1)T_{t-z,i}^* + \varepsilon_{t,i},$$

where $X_{t,i}$ is the complete vector of explanatory variables without the training variables, i.e. V_i plus capital K_i , labor L_i and the constant A_i .

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 endogenous and the exogenous variables. A problem arises with the logit or normit estimation, if – as it is the case here – 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.

Fixed Effects Estimation

Even if we control for selectivity in the decision on training intensity, the cross-section production function estimation may be biased because other explanatory variables (especially capital and labor) are endogenous (Griliches and Mairesse, 1998, Blundell and Bond, 1999). Important reasons for endogeneity of labor, capital and other variables in the production function may be that unobserved factors such as management quality, industrial relations, or the impact of technological change have an impact on the explanatory variables and on value added. A possibility to correct for biases due to omitted but time-invariant establishment-specific biases is to use panel estimation methods that eliminate the establishment fixed effects. When for example in a fixed effects estimation the deviations from an establishment's mean or first differences of equation (4) are taken, all time-invariant fixed effects drop out. This also means, however, that the impact of observed time-invariant effects can not be observed. Between two years, the training intensity and most other employee and establishment characteristics in V_i do not change much, and therefore the ratio between signal and noise is low if the incidence of different training forms and other quasi fixed variables are included into a fixed effects estimator (Dearden, Reed, and Van Reenen, 2000). We only have 4 observation periods and information on several explanatory variables is not available in every year. Therefore not all variables can be included in a fixed effects estimation based on the changes in the variables over time and the two step procedure proposed by Black and Lynch (2001) is adopted here.

In the first step, the productivity impact of the variable production factors – capital and labor – as well as time and industry dummies (in order to control for differences between sectors and in the business cycle) is estimated using panel estimation techniques that take account of unobserved time-invariant heterogeneity. From this estimation the establishment-specific, time-invariant component of the residual is calculated. In the second step, the average establishment fixed effect is regressed on the quasi-fixed explanatory variables in V_i and training intensity T_i .

For the first step estimation a within estimator is used that allows the calculation of an establishment fixed effect from the panel data (compare also Black and Lynch, 2001).² The first step of the panel regression therefore can be written as follows:

$$(7) \quad \ln Y_{i,t} = \ln A_{i,t} + \beta \ln K_{i,t} + \gamma \ln L_{i,t} + v_i + \varepsilon_{i,t},$$

with v_i the unobserved time-invariant establishment fixed effect and $\varepsilon_{i,t}$ the idiosyncratic component of the error term. The fixed effect is the average

² An alternative to the within estimator is the SYS-GMM estimator proposed by Arellano and Bover (1995). This estimator has several disadvantages, however, and therefore its results are not presented here. First, it uses information only from firms that answered in at least 3 periods in a row. Second, the capital and labour intensities obtained are not satisfactory (labour has a coefficient above one and the capital coefficient is insignificant). Third, the results are strongly dependent on the specification used, for example, if sector and time dummies and/or their interactions are included, the length of the panel, which internal instruments are used for levels and differences, etc..

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 establishments and serves as dependent variable for the second estimation step. In the second step, the quasi fixed variables such as training intensity, establishment characteristics or personnel measures explain these fixed effects:

$$(8) \quad v_i = \beta V_{t,i} + \gamma(\tau - 1)T_{t,i} + \zeta_{t,i}.$$

The two-step panel estimation addresses biases that may arise in the estimation of the coefficients of capital and labor on value added. It does not address biases in the second estimation step, however. These biases may come from correlations between the second stage regressors and unobserved establishment characteristics or with the average of the idiosyncratic shocks (Black and Lynch, 2001). In analogy to the argument for the cross section regression, an establishment's decision on training intensity may be related to business performance or to the position in the business cycle. Therefore also in equation (8) the truly exogenous estimated training intensity T_i such as in equation (6) should be used. This corrects for unobserved heterogeneity and the selectivity bias in the training decision simultaneously:

$$(9) \quad v_i = \beta V_{t,i} + \gamma(\tau - 1)T_{t,i} + \zeta_{t,i}.$$

The Data

The empirical analysis of the impact of training intensity on establishment productivity is calculated the basis of the IAB establishment panel (for detailed information see Bellmann et al., 2000 and Bellmann and Büchel, 2001). Establishments 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 such as 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 establishments was collected. In 1998, detailed information on personnel management measures is available. 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 establishments 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 leads 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 establishments. Descriptive statistics of the data used can be found in Tables A1 – A3 in the appendix.

Results

The training decision of the establishment

About one third of the establishments 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 establishments offered training for their employees while on average 19% of the workforce in these establishments participated (compare Table A1). In 1999, the number of training establishments (calculated also from the IAB establishment panel) increased to 66% while training intensity was 21%.

This paper concentrates on the influence of training intensity in 1997 on productivity in the years 1998 and 1999. In the cross section regressions, we therefore have $t = 1998, 1999$ and $z = 1, 2$. This allows us to identify lagged productivity effects of training. It will be shown that although lagged training variables are used, nevertheless endogeneity of training plays a role for the results. In this section, the decision on training intensity in 1997 is estimated in a tobit model. In order to effectively control for selectivity in the productivity estimation presented in the next section, external identifying variables have to be found that exert a significant influence on training intensity but not on productivity (Bartel, 2000, 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 establishments 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 preferably reacts by additional apprenticeship training or training of the employees on skill gaps (instead of a high priority on hiring skilled employees from the labor 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 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), and 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 (Lynch and Black, 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. Training intensity is censored on both tails. Therefore the determinants of training intensity according to equation (4) are estimated by tobit maximum likelihood (Lynch and Black, 1998), see Table 1. From the tobit estimation, we calculate the predicted training intensity values $T_{i,i}^*$ and replace the observed training intensities, see equation (6).

Most German establishments react on skill shortages by additional training efforts because the external skilled labor market is thin (Roth, 1997, Zwick and Schröder, 2001). Therefore, it is not surprising that establishments step up training when they expect that workers will leave, be on maternal leave or when they expect that they will encounter difficulties in finding new skilled workers. It can also be anticipated that establishments that give a higher priority to additional apprenticeship training and continuous training efforts instead of hiring skilled employees from the labor market when they have vacancies for skilled jobs are more prone to offer training. It is also well known that 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 establishments usually train a higher percentage of employees because they frequently have an own training department and can spread fixed training costs over a larger pool of employees (Lynch and Black, 1998). Collective wage agreements frequently also entail fringe benefits such as 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 establishments with a larger share of qualified employees tend to train more. All correlations have been empirically shown for German establishments 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. 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 (not reported in Table 1).

Estimation of the Productivity Effects of Training Intensity

In order to estimate the productivity effects of increasing continuous training intensity, first equation (4) is 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 Table 2. In addition to capital and labor, 15 sector dummies and a dummy for East German establishments are added in order to capture the differences in productivity between the sectors and the productivity gap of East German establishments. Qualified employees, investments in IT and a state of the art technical equipment usually increase establishment productivity (Black and Lynch,

2001) while establishments facing international competition and establishments with co-determination are also more productive (Wolf and Zwick, 2002). Finally employee participation, teamwork, units with own costs and results accounting, stringent hiring rules and incentive payments as dummies for several dimensions of personnel management are added because they may be correlated with training and relevant for productivity. Also productivity differences between four legal establishment forms are taken account of (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 (4) shows that training intensity in the first half of 1997 has a positive impact on productivity, see column 2 and 6 in Table 2. The impact on establishment productivity in 1998 is almost 0.16. The impact is smaller and not significant after two years (in 1999), however. In addition, we find that the establishments produce with a capital intensity between 0.16 and 0.18 and a labour intensity between 0.75 and 0.80 depending on the estimation specification.³ The additional explanatory variables have the expected sign. The share of qualified employees and the dummies for exporting establishments, establishments investing in IT and those having state of the art equipment and that are co-determined all have a positive impact on productivity while individual establishments are significantly less productive than establishments with limited liability (the reference category). Employee participation, stringent hiring rules, units with own costs and results accounting, and incentive payments have a tendency to improve productivity while the dummy for establishments with teamwork has a negative sign. Most personnel measures have individually an insignificant, but jointly a 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, labor 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 labor, capital, training and very few additional training parameters into account suffers from omitted variable bias and tends to overestimate the productivity impact of continuous training in Germany.

In order to correct for selectivity bias in the regression described above, the selection correction term on basis of the selection estimates in Table 1 is added in the estimation of equation (6) in Table 2. The estimates for the instrumented training intensities are considerably higher in both years than that of the observed training intensities. We learn from this exercise that establishments have a higher inclination to train in times of a productivity disadvantage. This result can be interpreted in different ways. Probably establishments train in slack periods, i.e. when it is cheap to

³ The capital intensity is low in comparison to other production function estimations but in the same range as in comparable estimations (see for example Black and Lynch, 2001). This is probably caused by the use of replacement investments as a proxy for capital.

engage employees with other tasks than production or they train in order to catch up with the productivity level of their competitors (Bartel, 1994, Black and Lynch, 2001). Not taking into account that training is a choice variable therefore underestimates the productivity effects of training. While the estimated productivity impact of training increases after selection correction, the impact of the other explanatory variables on productivity is virtually unchanged. Nickell et al. (2001) also show that British establishments introduced personnel practices that cost time but save money in difficult times. Bellmann and Büchel (2001) find on the other hand for German data that after controlling for selectivity, the measured contemporaneous productivity impact of training intensity decreases and loses significance.

Time invariant unobserved heterogeneity is controlled in a fixed effects panel regression for the period 1997 - 2000. This involves a two-step procedure. In the first step, value added is regressed on the variable input factors capital, labor and time dummies in a fixed effects estimation on the basis of equation (7). This estimation step suffers from the well-known low capital and labor coefficients in fixed effects regressions on value added, but the results are comparable to those in Black and Lynch (2001) see Table A5 in the appendix. The within estimator produces implausibly low capital coefficients and returns to scale, because measurement errors in the explanatory variables (especially when capital is approximated by replacement investments) bias the coefficients towards zero. In addition, the lagged levels of capital (or replacement investments) or labour are usually only weakly correlated with the subsequent first differences of these variables and therefore have a weak explanatory power (Griliches and Mairesse, 1998, Blundell and Bond, 1999). Then the fixed effects v_i are determined by calculating the average error terms per establishment during the estimation period (see Black and Lynch, 2001). In the second estimation step, these fixed effects are regressed on the quasi fixed factors training intensity and the other variables in X_i .⁴ Training intensity has a significant positive impact on the fixed effects that is higher than in the cross section regressions for 1998 and 1999, see Table 3. An increased productivity estimate after controlling for unobserved heterogeneity was also found by Bartel (1994) and Dearden, Reed and Van Reenen (2000) for the UK and USA. Bartel (1994) concludes that businesses that are operating at below-expected levels of labor productivity can eliminate this gap by implementing employee training programmes.

When selectivity and unobserved time invariant heterogeneity are simultaneously taken into account by using the predicted training intensity variables, see equation (9), the estimated productivity impact of training intensity increases again considerably to 0.57. Therefore, even after controlling for establishment heterogeneity, endogeneity still biases the estimation results. Training in the establishments 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” effect instead of an average productivity effect and it is save to assume that

⁴ The first stage is estimated on a larger sample in order to obtain more precise estimates. The second stage contains fewer observations due to missing data on training intensity or other control variables, compare also Black and Lynch (2001).

the productivity effect of training would decrease when training intensity would be increased more than marginally (Dearden, Reed, Van Reenen, 2000). Omitted variable bias would again change these results. When we re-calculate the second estimation step in Table 3 taking account of selectivity and including besides the training intensity, only the East Germany dummy and the sector controls, we would obtain an impact of training intensity on average establishment productivity of 0.71 for equation (8) without selectivity control and 3.84 for equation (9) with selectivity control.

Conclusions

This paper shows that increasing the training intensity has a positive and significant effect on establishment productivity in Germany. It takes into account selectivity of training by using expected skill shortages and personnel department activity as external instruments that identify the training decision. In addition, unobserved heterogeneity is corrected by estimating a fixed effects panel estimation instead of cross section estimations. Finally, both sources of estimation bias are controlled simultaneously.

The estimation steps demonstrate that both biases reduce the measured productivity impact and that even after controlling for unobserved establishment heterogeneity, the training decision is selective. This indicates that establishments facing a structural productivity gap increase training efforts as a measure to close it. In addition, establishment strategically intensify training when they expect qualification gaps in the future and cover their qualification demand mainly by own training efforts instead of hiring qualified labour from the labour market. It can be concluded that one motivation of establishments to increase training intensity is an attempt to regain competitiveness and close qualification gaps because training is a suitable means to reduce productivity gaps with respect to competitors. This paper also detects significant omitted variable bias. If a broad variety of establishment, employee and especially personnel management characteristics is not taken into account, the estimated productivity impact of training intensity is much too high.

Literature

- Appelbaum, Eileen/Batt, Rosemary (1994): *The New American Workplace: Transforming Work Systems in the United States*, ILR Press, New York.
- Barrett, Alan/Philip O'Connell (2001): Does Training Generally Work? The Returns to In-Company Training, in: *Industrial and Labor Relations Review*, 54(3), pp. 647-662.
- Ballot, Gérard/Fakhfakh, Fathi/Taymaz, Erol (2001): Firms' human capital, R&D and performance: a study on French and Swedish firms, in: *Labour Economics*, 8, pp. 443-462.
- Bartel, Ann (1994): Productivity Gains from the Implementation of Employee Training Programs, in: *Industrial Relations*, 33, pp. 411-425.
- Bartel, Ann (1995): Training, Wage Growth, and Job Performance: Evidence from a company Database, in: *Journal of Labor Economics*, 13, pp. 401-425.
- Bartel, Ann (2000): Measuring the Employer's Return on Investment in Training: Evidence from the Literature, in: *Industrial Relations*, 39, pp. 502-524.
- Bassi, Laurie/Harrison, Paul/Ludwig, Jens/McMurrer, Daniel (2001): *Human Capital Investments and Firm Performance*, Mimeo, Human Capital Dynamics, Bethesda.
- Bellmann, Lutz/Büchel, Felix (2001): Betrieblich finanzierte Weiterbildung und Unternehmenserfolg, in: *Bildungssystem und betriebliche Beschäftigungsstrategien*, Uschi Backes-Gellner and Petra Moog (eds.), Duncker-Humblot, Berlin, pp. 75-92.
- Bellmann, Lutz/Kölling, Arnd/Kistler, Ernst/Hilpert, Markus/Heinecker, Paula/Conrads, Ralph (2000): *Codebook zum IAB-Betriebspanel*, Nürnberg.
- Berg, Peter (1994): Strategic Adjustments in Training: A Comparative Analysis of the US and German Automobile Industries, in: Lisa Lynch (ed.): *Training and the Private Sector: International Comparison*, University of Chicago Press, Chicago.
- Black, Sandra/Lynch, Lisa (1996): Human Capital Investments and Productivity, *American Economic Review (Papers&Proceedings)*, 86, pp. 263-267.
- Black, Sandra/Lynch, Lisa (2001): How to Compete: The Impact of Workplace Practices and Information Technology on Productivity, in: *The Review of Economics and Statistics*, 83, pp. 434-445.
- Blundell, Richard/Bond, Steven (1999): *GMM Estimation with Persistent Panel Data: An Application to Production Function*, Institute for Fiscal Studies Working paper 4/99, London.
- Caroli, Eve/Reenen, van John (2001): Skill-Biased Organizational Change? Evidence from a Panel of British and French Establishments, in: *Quarterly Journal of Economics*, 116, pp. 1449-1492.
- Dearden, Lorraine/Reed, Howard/Reenen, John Van (2000): *Who Gains when Workers Train? Training and Corporate Productivity in a Panel of British Industries*, IFS Working Paper 00/01, London.

- Düll, Herbert/Bellmann, Lutz (1998): Betriebliche Weiterbildungsaktivitäten in West- und Ostdeutschland, in: Mitteilungen aus der Arbeitsmarkt- und Berufsforschung, 31, S. 205-225.
- Gerlach, Knut/Jirjahn, Uwe (2001): Employer Provided Further Training: Evidence from German Establishment Data, in: Schmollers Jahrbuch, 121, pp. 139-164.
- Greene, William (2000): *Econometric Analysis*, 4th edition, Prentice-Hall: Upper Saddle River.
- Griliches, Zvi/Hausman, Jerry (1986): Errors in Variables in Panel Data, *Journal of Econometrics*, 31, pp. 93-118.
- Griliches, Zvi/Mairesse, Jacques (1998): Production Functions: The Search for Identification, in: Strøm, Steinar (ed.): *Econometrics and Economic Theory in the 20th Century*, Cambridge University Press, Cambridge.
- Hall, Brian/Mairesse, Jacques (1995): Exploring the relationship between R&D and productivity in French Manufacturing firms, *Journal of Econometrics*, 65, pp. 263-293.
- Ichniowski, Casey/Shaw, Kathrin/Prennushi, Giovanna (1997): The Effects of Human Resource Management Practices on Productivity, in: *American Economic Review*, 87, pp. 291-313.
- Institut der deutschen Wirtschaft (2002): *Deutschland in Zahlen*, Köln.
- Holzer, Harry/Block, Richard/ Cheatham, Marcus/Knott, Jack (1993): "Are Training Subsidies for Firms Effective? The Michigan Experience." *Industrial and Labor Relations Review*, Vol. 46, No. 4, pp. 625-636.
- Kruse, Douglas (1993): *Profit Sharing: Does it Make a Difference?*, Upjohn Institute: Kalamazoo.
- Lynch, Lisa/Black, Sandra (1998): "Beyond the Incidence of Employer-Provided Training." *Industrial and Labor Relations Review*, Vol. 52, No. 1, pp. 64-81.
- Maddala, Gangadharrao (1983): *Limited-dependent and qualitative variables in econometrics*, Cambridge: Cambridge University Press.
- Marquardt, Michael/King, Stephen/Ershkine, William (2002): *International Comparisons: ASTD's Annual Accounting of Worldwide Patterns in Employer-Provided Training*, Alexandria, VA.
- Nickell, S., D. Nicolitsas and M. Patterson (2001): Does Doing Badly Encourage Management Innovation?, *Oxford Bulletin of Economics and Statistics* Vol. 63, 5-28.
- Roth, Siegfried (1997): Germany: Labor's Perspective on Lean Production, in: *After Lean Production*, Thomas Kochan, Russel Lansbury and John MacDuffie (Eds.), ILR Press, Ithaca, pp. 117-136.
- Statistisches Bundesamt (2001): *Statistical Yearbook for the Federal Republic of Germany*, Schaeffer-Pöschel, Stuttgart.

- Whitfield, Keith (2000): High-Performance Workplaces, Training, and the Distribution of Skills, in: *Industrial Relations*, 39, pp. 1-25.
- Wolf, Elke/Zwick, Thomas (2002): Reassessing the impact of high performance workplaces. ZEW Discussion Paper 02-07, Mannheim
- Zwick, Thomas/Schröder, Helmut (2001), Wie aktuell ist die Berufsbildung im Dienstleistungssektor?, ZEW Wirtschaftsanalysen, Bd. 55, Nomos: Baden-Baden.

Table 2: Lagged productivity effects of training intensity, OLS regressions

Exogenous Variables	Equation (4), for 1998		Equation (6), for 1998		Equation (4), for 1999		Equation (6), for 1999	
	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values
Capital	0.160***	9.02	0.157***	8.88	0.181***	10.44	0.176***	10.34
Labor	0.795***	27.23	0.782***	25.95	0.746***	25.18	0.733***	24.62
Training intensity 1997	0.158**	1.97	0.314**	2.22	0.069	0.75	0.458***	3.28
Share of qualified employees	0.341***	3.72	0.287***	3.04	0.383***	3.60	0.313***	2.98
Exporter	0.233***	3.64	0.232***	3.67	0.204***	3.08	0.186***	2.81
State of the art technical equipment	0.109**	2.37	0.112**	2.47	0.206***	4.18	0.190***	3.96
Investment in IT	0.046	1.01	0.036	0.79	0.122**	2.11	0.097*	1.69
Co-determination	0.185***	2.90	0.179***	2.80	0.279***	4.13	0.252***	3.71
Individual firm	- 0.336***	- 5.76	- 0.327***	- 5.52	- 0.350***	- 4.92	- 0.340***	- 4.83
Partnership	- 0.003	- 0.05	0.004	0.06	- 0.062	- 0.74	- 0.053	- 0.64
Publicly listed company	0.066	0.65	0.071	0.70	- 0.069	- 0.63	- 0.064	- 0.60
Employee Participation	0.088	1.62	0.079	1.48	0.071	1.16	0.060	0.99
Teamwork	- 0.021	- 0.35	- 0.016	- 0.28	- 0.010	- 0.17	- 0.016	- 0.27
Units with own costs and results accounting	0.064	1.02	0.058	0.94	0.011	0.16	0.002	0.03
Stringent hiring rules	0.030	0.53	0.032	0.56	0.052	0.84	0.049	0.80
Incentive payments	0.100	1.58	0.101	1.60	0.110*	1.71	0.110*	1.73
Constant	9.684***	47.63	9.824***	46.39	9.626***	50.61	9.800***	51.34
15 Sector dummies and East Germany dummy	Yes		Yes		Yes		Yes	
Number of Observations	1437		1451		1208		1219	
Adjusted R ²	0.89		0.89		0.87		0.87	

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

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

Table 1: Tobit estimation to explain training intensity 1997, equation (5)

Exogenous Variables	Coefficients	z-Value
Redundancies expected	0.056***	3.00
Many employees are expected to be on maternal leave	0.061**	2.06
High qualification need expected	0.150***	7.13
Apprenticeship training high priority reaction on skill shortages	0.094***	5.14
Training high priority reaction on skill shortages	0.226***	12.82
Establishment size 20-199	0.064***	3.75
Establishment size 200-499	0.087***	3.00
Establishment size 500-1000	0.071*	1.78
Establishment size 1001+	0.042	1.08
Co-determination	0.031	1.58
Share of qualified employees	0.235***	9.42
State of the art technical equipment	0.084***	5.66
Investor in IT	0.061***	4.00
Collective wage agreement	0.089***	5.64
Apprenticeship training	0.108***	6.81
15 sector dummies and East Germany dummy	Yes	
Pseudo R ²	0.18	
Number of observations	5550	
2593 left-censored observations (training intensity = 0)		
2725 uncensored observations		
232 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, heteroscedasticity corrected standard errors.

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

Table 3: Two-Step Panel estimates, second step estimates, dependent variable: average residual 1997 – 2000

Exogenous Variables	Equation (8)		Equation (9)	
	Coefficients	t-Values	Coefficients	t-Values
Training intensity	0.226***	3.53	0.574***	4.55
Share of qualified employees	0.616***	9.43	0.485***	6.57
Exporter	0.220***	4.50	0.206***	4.22
State of the art technical equipment	0.193***	5.55	0.141***	3.88
Investment in IT	0.110***	3.14	0.181**	2.26
Co-determination	0.517***	10.29	0.480***	9.37
Individual firm	- 0.504***	- 10.91	- 0.497***	- 10.85
Partnership	- 0.096*	- 1.78	- 0.094*	- 1.74
Publicly listed company	0.135	1.60	0.140*	1.64
Employee Participation	0.111***	2.68	0.104**	2.55
Teamwork	- 0.029	- 0.56	- 0.033	- 0.64
Units with own costs and results accounting	- 0.005	- 0.09	- 0.015	- 0.30
Stringent hiring rules	0.080*	1.71	0.083*	1.78
Incentive payments	0.096*	1.84	0.114**	2.15
Firm size 20-199	0.856***	18.89	0.781***	16.14
Firm size 200-499	1.596***	22.24	1.485***	19.78
Firm size 499-1000	1.868***	17.14	1.761***	16.11
Firm size 1,000+	2.437***	24.67	2.385***	22.10
Constant	- 1.214***	- 13.12	- 0.993***	- 9.52
15 Sector dummies and East Germany dummy	Yes		Yes	
Number of Observations	2647		2460	
Adjusted R ²	0.72		0.75	

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

Source: IAB Establishment Panel, Waves 1997 - 2001, own calculations.

Appendix

Table A1: Descriptive Statistics 1997

Variables	Average	Answers	Comments
Training intensity 1997	0.19	5428	Number of trained employees in first half of 1997/number of employees
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 shortage	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
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
State of the art technical equipment	0.72	5450	Technical equipment is marked state of the art in comparison to sector
Establishment size 1-19 (ref.)	0.40	5640	Establishment has 1-19 employees
Establishment size 20-199	0.40	5640	Establishment has 20-199 employees
Establishment size 200-499	0.10	5640	Establishment has 200-499 employees
Establishment size 500-999	0.04	5640	Establishment has 500-999 employees
Establishment size 1,000+	0.06	5640	Establishment has more than 1,000 employees
Collective wage agreement	0.68	5640	Establishment is subject to collective wage agreements, Yes/No
Apprenticeship training	0.61	5640	Establishment offers apprenticeship training, Yes/No
Individual establishment	0.27	5640	Individual establishment, 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 and 1998, representative values, own calculations.

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
Labor	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 equipment	0.75	6179	Technical equipment is marked state of the art in comparison to sector, Yes/No
Employee Participation	0.23	6079	Establishment shifted responsibility and decisions to lower ranks until 1998, Yes/No
Teamwork	0.16	6079	Establishment has team work and independent groups, Yes/No
Units with own costs and results accounting	0.12	6079	Establishment has units with own costs and results accounting, Yes/No
Stringent hiring rules	0.27	6079	Establishment has formal hiring rules, Yes/No
Incentive payments	0.13	6079	Establishment has gain sharing or employee share ownership, Yes/No
Co-determination	0.34	6170	Establishment has a work council, Yes/No
Exporter	0.22	6221	Establishment exports, Yes, No
Individual establishment	0.27	6221	Individual establishment, 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

Source: IAB Establishment Panel, Waves 1998 and 1999, representative values, 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
Labor	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	Establishment 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	Establishment has profit sharing rules for employees, Yes/No
Collective wage	0.68	6701	Establishment is subject to collective wage agreements, Yes/No
Individual establishment	0.27	6701	Individual establishment, 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: Descriptive Statistics 2000

Variables	Average	Answers	Comments
Value Added	14.25	8892	Turnover minus input costs and costs for third parties, in DM, ln, deflated, from wave 2001
Capital	11.83	7054	Proxy: Investments minus expansion investments, logs, in DM, ln, deflated, from wave 2001
Labour	3.14	10013	Number of employees at 1.6.2000, ln

Source: IAB Establishment Panel, Waves 2000 and 2001, own calculations

Table A5: Fixed effects productivity estimation, value added 1997 – 2000, equation (7).

	Coefficients	z-values
Capital	0.026***	3.52
Labor	0.421***	9.54
Year Dummy 1998	- 0.013	- 0.71
Year Dummy 1999	0.018	0.98
Year Dummy 2000	0.063***	3.49
Constant	12.88***	73.77
Number of observations	9348	
F(5,3756)	25.61	Prob>F < 0.001
Adjusted R ²	0.84	

Note: The standard errors are heteroscedasticity corrected.