Training and Firm Productivity – Panel Evidence for Germany

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Editor's Foreword

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Summary

This paper presents the first panel data evidence on the productivity effects of training in Germany. It uses a large and representative establishment panel data set for all profit-oriented sectors of the economy. Increasing the share of employees participating in training in the first half of a year has a positive and significant effect on firm productivity in the same and the subsequent 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, while training on the job has a persistent negative productivity effect.

When we control for selectivity and unobserved heterogeneity, the measured productivity effects further increase, suggesting that firms with an inefficient production structure deliberately use training in order to boost productivity. In a fixed effects panel regression, simultaneously taking endogeneity of training into account, formal internal and external courses, self-induced learning and quality circles have a positive impact on the fixed productivity effects, while training on the job, seminars and talks, and job rotation do not have an impact on structural productivity differences. When training intensity increases by 1%, structural productivity increases by 0.3%. Finally it is shown that omitted variable bias plays a crucial role in the estimation of productivity effects of training.

Keywords: Training, Firm Productivity, Panel Estimation
JEL-Code: C23, D21, J24

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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 improve and maintain productivity levels. This is particularly the case for 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 and which derives its main competitive advantages from human capital (Appelbaum and Batt, 1994: pp. 39-43, Roth, 1997). However, the positive impact of training on firm productivity in the German economy is not undisputed. Some employee training may not contribute to increases in productivity because it is used as a sorting device by employers to determine who is promoted or as a tool to increase incentives, motivation or reduce turnover (de Koning, 1994). Several commentators argue that vocational and continuing training in Germany provides employees with knowledge that is only temporarily needed, for example, for maintenance or re-organisation projects (Roth, 1997). This kind of training is directed primarily at increasing flexibility in emergency situations rather than at continuous productivity increases. Therefore, German workers frequently have redundant cognitions, while parts of their skills are 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). In this paper, it will be shown that the empirical evidence in Germany is not conclusive and that there remain considerable gaps. As a result, the correlation between training and firm productivity is not clear a-priori and is still open for empirical evaluation.

A further issue that has not been explored to date, is whether German firms tend to train in favourable economic circumstances – as evidence suggests for the USA and UK (Bartel, 1994 or Dearden, Reed and Van Reenen, 2000) – or in order to catch up with regard to productivity. This question will be addressed by controlling for selectivity in the choice of training. In addition, the time structure of the productivity effect will be explored. Many commentators are concerned with the productivity effects of different forms of training (Bartel, 1994, Barrett and O'Connell, 2001). The data set used in this paper provides us with

a wealth of different training dimensions that allow a discussion of what form of training enhances productivity in Germany.

Many German firms invest considerable resources in continuous training of their employees. In an international comparison, Brunello and Medio (2001) state that training incidence in Germany and Japan is dramatically higher than in the USA. Their data include, however, as do most international comparisons, apprenticeship training which constitutes a large part of the training incidence in Germany. When apprenticeship training is excluded, the training incidence in Germany is very much in line with international figures and is actually lower for certain groups (Berg, 1994). Apprenticeship training is omitted from this paper because it is not primarily aimed at improving productivity in the short run. It is usually seen as an instrument to provide a qualified labour force in the future given that German firms face a limited labour market for qualified labour (Zwick and Schröder, 2001).

A growing number of papers seek 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). In most cases a positive (and sometimes significant) effect of training on productivity has been found. However, the measurement of the productivity effects of training may suffer from two biases (Kruse, 1993, Dearden, Reed and Van Reenen, 2000). First, firms that offer training may also be structurally more productive due to unobserved factors such as management quality, the exposure 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 have an impact on productivity and at the same time induce changes to the training effort. Firms, therefore, 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 the productivity effects of training, this paper addresses both problems simultaneously by exploring several different estimation techniques and specifications and, thus, circumvents several drawbacks apparent in comparable papers. In addition, the size and direction of the estimation biases incurred are indicated. Finally, for the first time, representative panel data evidence on the productivity effects of training in German firms is presented.

Several papers estimate the productivity impact of training using 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 different personnel measures, improves the estimation and reduces the measured productivity impact. Estimations excluding these variables, therefore, may be biased and the training measure may pick up the 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 drawbacks of the literature on the productivity effects of training at the firm level. Then an empirical model correcting for unobserved time invariant heterogeneity and selection bias is developed. The fourth section presents the data base and several regressions measuring the impact of training on productivity. They establish that 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). By comparing the results obtained in this study with those in the literature it becomes clear that the estimation technique and the data base may play a decisive role in measuring the productivity impacts. Only studies using firm-level data from several sectors are included.

Bartel (1994) 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. 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 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 from two waves of Irish firms surveyed in 1993 and 1995, with a low response rate of one third of the initial firms answering the second wave. Their main result is that the level of general training has a significantly positive effect on productivity growth, although this is not the case for the level of specific training. However, neither paper addresses endogeneity of the introduction of training programmes, while they are both 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 National 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. However, their cross-section study is prone to unobserved heterogeneity bias.

As a result, Black and Lynch (2001) supplement their specific data on training and other workplace practices, used in their 1996 article, with panel data from the Longitudinal Research Database (LRD). They control 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, 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 with 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 exogenous 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 of 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 in the Swedish data set there are also non-training firms included.

Bellmann and Büchel (2001) control for 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 offering 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 positive but insignificant effect on productivity. In their regression selectivity is found to be random, i.e. the correction term is not significant in their productivity equation. One reason may be that they are not able to find proper identifying variables for the selectivity regression. Therefore, including the insignificant selection correction term should not change their results. In addition, 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 at the industry level in Great Britain. They use a long panel data set between 1983 and 1996 that contains information on training in each year. They address unobserved heterogeneity as well as endogeneity by using a variety of estimation strategies including system GMM methods. In addition, they show the impact and the sign of the biases on the estimation results. They find a positive and significant effect of training on sector productivity (thereby including inter-firm knowledge spill-overs). The estimation results increase when endogeneity and unobserved heterogeneity are taken into account. However, there are two major drawbacks. 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 incurr omitted variable bias as well. A lesser problem is that information on training covers only 4 weeks per year, 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, as personnel managers who decide to offer training to employees do not take knowledge spillovers into account (De Koning, 1994).

Summing up the literature survey, most studies at the firm level find a positive (although frequently insignificant) impact of training on productivity. In addition, some training forms (general training, off-the-job 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   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 (Bartel, 1995, Dearden, Reed and Van Reenen, 2000):

(1) $\quad Y_i \ = \ A_i * K_i^{\boldsymbol{b}} * EL_i^{\boldsymbol{g}} \qquad \text{with } EL = L_{Ui} + \boldsymbol{t} L_{Ti},$

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 $\boldsymbol{t}$ is larger than one if training has a positive effect on labour productivity. Equation (1) can be re-written as:

(2) $\quad Y_i \ = \ A_i * K_i^{\boldsymbol{b}} * L_i^{\boldsymbol{g}} (1 + (\boldsymbol{t} - 1) T_i)^{\boldsymbol{g}},$

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) $\quad \ln Y_i = \ln A_i + \boldsymbol{b} \ln K_i + \boldsymbol{g} \ln L_i + \boldsymbol{g}(\boldsymbol{t} - 1) T_i + \boldsymbol{d} V_i + \boldsymbol{e}_i.$

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, such as the share of qualified employees and firm heterogeneity, 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 that increase the participation of employees, 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 degree 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 correlation between training and new workplace organisations. In order to avoid the training dummy picking 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.

The additional explanatory variables are called V_i for simplicity and the complete vector of explanatory variables without the training term (i.e. V_i plus capital, labour and the constant) is labelled X_i. 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.

In order to see if there are time effects in the productivity impact of training, equation (3) is re-estimated with different lags between $T_{i,t}$ and $Y_{i,t}$ with t a year indicator. As training intensity, as well as the incidence of different training forms, is highly correlated over the years, the effects found in later years, however, cannot be interpreted as pure lagged effects.

The empirical results of productivity function (3) may also be biased because firms do not randomly decide to train. Investment in training is an endogenous decision of the firm, which depends on the productivity effects and costs of training and other factors (Dearden, Reed, and Van Reenen, 2000, 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). Empirically, the decision to offer training or not can be specified as a reduced form in a probit model where the dependent variable I_i has the value one when the firm offers training and zero otherwise. The latent variable I_i* is, then, the difference between the benefits and costs of offering training and can be defined as:

(4) $I_i* = \boldsymbol{d}'Z_i + u_i,$

where Z_i is a 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 $\boldsymbol{d}'Z_i > - u_i$) and it does not invest in training *($I_i=0$)* if $I_i* \pounds\ 0$.

According to Maddala (1983) or Greene (2000), p. 933, we can consistently estimate the production functions of firms that train and those that do not train by adding a selection correction term for training firms and non-training firms as follows:

(3')
$$E[\ln Y_i \,|\, I_i = 0] \;=\; \boldsymbol{b}X_i \;+ \boldsymbol{s}\,\frac{-\boldsymbol{j}\,(\boldsymbol{g}'Z_i)}{1-\Phi(\boldsymbol{g}'Z_i)},$$

$$E[\ln Y_i \,|\, I_i = 1] \;=\; \boldsymbol{b}X_i \;+\boldsymbol{g}(\boldsymbol{t}-1)T_i +\boldsymbol{s}\,\frac{\boldsymbol{j}\,(\boldsymbol{g}'Z_i)}{\Phi(\boldsymbol{g}'Z_i)},$$

where $\boldsymbol{f}(\boldsymbol{g}'Z)$ is the density function and $\Phi(\boldsymbol{g}'Z)$ the distribution function of the estimated parameters in equation (4). The parameter $\boldsymbol{s}$, therefore, measures the covariance between the error terms in the production function (3) and the selection equation (4), $\boldsymbol{s} = \text{cov}(u_i, \boldsymbol{e}_i)$.

The second source of possible estimation bias is unobserved time-invariant heterogeneity. This can be corrected by differentiating equation (3) and estimating the differences by a fixed effects regression. Between the two years, training intensity and most other explanatory variables in V_i does not change much and, therefore, the ratio between signal and noise is low, if the training intensity and other quasi fixed variables were included

in the fixed effects equation (Dearden, Reed, and Van Reenen, 2000). As a result, we 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 time dummies:

$$(5) \qquad \ln Y_{i,t} = \ln A_{i,t} + \boldsymbol{b} \ln K_{i,t} + \boldsymbol{g} \ln L_{i,t} + \boldsymbol{d} D_t + \boldsymbol{n}_i + \boldsymbol{e}_{i,t}.$$

where $?_i$ is the unobserved time independent fixed effect and $e_{i,t}$ is the idiosyncratic component of the error term, and D_t are 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 measures whether establishment productivity was structurally below or above that of the other firms and serves as a 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:

$$(6) \qquad \boldsymbol{n}_i = \boldsymbol{b} V_i + \boldsymbol{g}(\boldsymbol{t} - 1) T_i + \boldsymbol{z}_i.$$

We correct for the unobserved heterogeneity and the selectivity bias simultaneously by adding the selectivity correction term (the normal hazard function) for the decision of the firm to offer training from (3´) in equation (6).

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., 1999, 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. 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. A large set of questions is asked every year on production, investment, 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 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. Panel information from the waves 1997 until 2000 is used here.

We include only profit oriented establishments and those that have not merged with other establishments. In 1997, we have 5675 establishments in our gross sample, in 1998 we have 6192 and in 1999 6886.

4.1 When do firms offer training?

When we only take training for non-apprentices into account, about one third of the establishments in Germany do not invest in 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 in courses. In 1999, the number of training establishments increased to 66% while training intensity was 21%.

This paper concentrates on the influence of training in 1997 on productivity in the years 1997 until 1999. This allows us to distinguish between contemporaneous and lagged effects. In this section, the selection equation to offer training in 1997 is estimated. Thus, the decision of establishments to pay for the training of their employees is modeled in a binary probit model. In order to effectively control for selectivity in the productivity estimation, we have to find identifying variables that have a significant influence on the decision to train 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 to skill shortages as suitable identifying variables. When firms expect skill gaps because some employees will be on maternity leave or made redundant in the near future or because the demand for skills increases generally, this may induce them to introduce training immediately. It can be shown that productivity in the same period 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) to skill shortages has the same properties. When the establishment prefers to react with additional apprenticeship training or training of the employees on skill gaps (instead of 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, like 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 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 results of the estimation of equation (4) are summarized in Table 1.

Table 1: 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 maternity leave	0.295***	2.87
High qualification need expected	0.545***	6.77
Apprenticeship training high priority reaction to skill shortages	0.230***	4.46
Training high priority reaction to 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 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.

Most German firms react to skill shortages by additional training efforts because the external skilled labour market is limited (Roth, 1997, Zwick and Schröder, 2001). Therefore, it is not

surprising that firms that expect workers will leave, be on maternity leave or 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 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 their own training department, can afford that some employees do not produce during training spells, and have a larger number of employees with training needs. Collective wage agreements frequently also entail fringe benefits like training. The higher the qualification level of the employee 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 skills needed frequently offer training to 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.

4.2 Estimation of the Productivity Effects of Training

In order to estimate the productivity effects of training, first equation (3) without selection correction 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 the second and sixth column of Table 2. 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 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 their 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. The descriptive statistics of the variables used can be found in Tables A2 and A3 in the appendix.

We find 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 firm productivity in 1997 (not shown here) and 1998 is statistically the same and around 0.15. It is smaller, however, and not significant after two years (in 1999). 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.[1] The impact of the additional explanatory variables has 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 signficantly 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 their 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 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 training.

When we differentiate between several dimensions of training, we find that formal external courses have a positive significant impact on productivity, see columns 2 and 6 in Table 3 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 1997 (not shown here) and 1998 only, while there is no effect in 1999. Training on the job has a persistent negative effect on

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[1] The capital intensity is low in comparison to other production function regressions. This is probably caused by the use of replacement investments as a proxy for capital and the measurement errors this entails. In comparable estimations using the same indicator, capital intensity was in the same category (Möller, 2000).

productivity. Quality 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 terms on the basis of the selection estimates in Table 1 are added in the estimation of equation (3') in Tables 2 and 3 (see columns 4 and 8 respectively). The selection correction term is negative and the corrected impact of training on productivity increases accordingly.[2] Therefore, firms have a higher inclination to train when they have a productivity disadvantage. Not taking selectivity into account underestimates the productivity effects of training. While the estimated productivity impact of training intensity increases after selection correction, the other explanatory variables are virtually unchanged. The same applies for the alternative regressions differentiating between several training forms. The 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, however, 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.[3] Our result can be interpreted in different ways. Firms probably 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. 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. 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 column 2 of Table 3. Formal external and internal

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2 The selectivity term is only significant when we differentiate between training forms.
3 This may be a consequence of a different definition of the selection correction term that is neither defined explicitly nor interpreted in their paper.

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. All[4] estimates are higher than in the comparable cross section regressions and we can, therefore, also deduce that the unobserved time invariant characteristics of the firms reduce productivity particularly for firms offering training. In other words, firms with a structural productivity problem tend to train more.[5] This is also found by Dearden, Reed and Van Reenen (2000).

When selectivity is simultaneously taken into account by including the selection correction term from (3´), the estimated productivity impact of training intensity increases slightly again and indicates that productivity increases by 0.28% if the share of trained employees increases by 1%. 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 column 8 in Table 4).

5   Conclusions

This paper shows that training intensity has a positive and significant effect on firm productivity in Germany. The impact decreases in the second year after the training. 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. Training on the job has a persistent negative effect on firm productivity and quality circles only have a productivity impact with a time lag of more than one year.

Endogeneity and unobserved heterogeneity both have a significant impact on the measurement of the productivity impact. Controlling for endogeneity by adding a selection correction term increases the measured productivity impact of training intensity. This means that firms facing a productivity gap select training as a measure to close it. Moreover, also firms having structural productivity problems tend to train more. We can conclude that one motivation for 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 productivity estimates that are too low.

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[4]   Except the impact of quality circles after 2 years.
[5] The inclusion of additional explanatory variables in V_i again reduces the estimated impact of training intensity significantly. Without the additional variables the estimated productivity impact is 0.78 without selectivity correction and an implausibly high 1.06 with selectivity correction.

The paper also shows that frequently used and relatively cheap 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 more structural approaches, like formal internal and external training courses. Also self-induced learning based on electonic training devices and quality circles, that are used by around 10% of the German firms, have a positive impact on structural firm productivity.

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. This is found in a fixed effects panel regression taking account of unobserved heterogeneity.

6 Appendix

Table A1: Descriptive Statistics 1997

Variables	Average	Responses	Comments
Value added	14.13	3793	Turnover minus input costs and costs for third parties, ln, from wave 1998
Capital	13.20	3307	Replacement Investments, ln, from wave 1998
Labour	3.04	5675	Number of employees on 1.6.1997, ln
Training	0.64	5675	Share of firms offering training
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
Paticipation 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 maternity 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
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 works 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		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	Responses	Comments
Value Added	14.07	4154	Turnover minus input costs and costs for third parties, ln
Capital	11.85	6221	Replacement Investments, ln, 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 works 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	Responses	Comments
Value Added	14.14	5969	Turnover minus input costs and costs for third parties, ln, from wave 2000
Capital	11.83	6221	Replacement Investments, ln, 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 works 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: Two Step Panel Estimates first step within estimator, dependent variable: value added 1997 – 1999

	Coefficients	z-values
Capital	0.028***	2.86
Labour	0.322***	5.17
Year Dummy 1998	- 0.015	- 0.85
Year Dummy 1999	0.023	1.19
Constant	13.17***	54.50
Number of observations	5652	
Adjusted R^2	0.85	

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

Exogenous Variables	Equation (3), for1998		Equation (3'), for 1998		Equation (3), for 1999		Equation (3'), for 1999	
	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values
Capital	0.159***	10.31	0.159***	10.29	0.182***	10.78	0.181***	10.80
Labour	0.796***	33.96	0.795***	33.91	0.746***	27.73	0.757***	28.40
Training intensity 1997	0.161**	2.09	0.222**	2.42	0.071	0.79	0.149	1.41
Share of qualified employees	0.340***	4.29	0.340***	4.30	0.379***	3.95	0.388***	4.06
Exporter	0.234***	3.90	0.236***	3.92	0.206***	2.91	0.206***	2.91
State of the art technical equipment	0.108**	2.34	0.109**	2.36	0.205***	3.90	0.212***	4.06
Investment in IT	0.045	0.99	0.041	0.90	0.122**	2.04	0.117**	1.96
Co-determination	0.180***	2.90	0.181***	2.91	0.276***	3.87	0.277***	3.94
Individual firm	- 0.337***	- 5.76	- 0.337***	- 5.75	- 0.351*	- 5.23	- 0.329***	- 4.92
Partnership	- 0.002	- 0.03	0.001	0.01	- 0.062	- 0.57	- 0.074	- 0.93
Publicly listed company	0.065	0.62	0.006	0.63	- 0.067	- 0.57	- 0.074	- 0.62
Employee Participation	0.088*	1.65	0.089*	1.65	0.072	1.16	0.048	0.73
Teamwork	- 0.020	- 0.33	- 0.022	- 0.35	- 0.010	- 0.14	- 0.084	- 1.03
Units with own costs and results accounting	0.065	0.96	0.062	0.96	0.011	0.16	- 0.019	- 0.23
Stringent hiring rules	0.035	0.65	0.040	0.63	0.054	0.86	0.020	0.17
Incentive payments	0.101	1.53	0.096	1.53	0.113	1.46	0.253***	3.56
Selection Correction term			- 0.043	- 1.24			- 0.047	- 1.21
Constant	9.712***	53.00	9.709***	52.98	9.631***	52.24	9.583***	52.32
15 Sector dummies and East Germany dummy	Yes		Yes		Yes		Yes	
Number of Observations	1440		1440		1209		1207	
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.
Source: IAB Establishment Panel, Waves 1997 - 2000, own calculations.

Table 3: Lagged productivity effects of alternative forms of training, OLS regressions

Exogeneous Variables	Equation (3), for 1998		Equation (3'), for 1998		Equation (3), for 1999		Equation (3'), for 1999	
	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values	Coefficients	z-Values
Capital	0.158***	10.31	0.155***	10.21	0.157***	12.77	0.175***	10.56
Labour	0.779***	32.15	0.761***	29.82	0.785***	39.59	0.709***	24.88
Formal external courses 1997	0.113**	2.13	0.203***	3.08	0.174***	3.16	0.351***	4.56
Formal internal courses 1997	0.174***	3.10	0.194***	3.42	- 0.046	- 0.73	- 0.011	- 0.17
Training on the job 1997	- 0.131**	- 2.35	- 0.106*	- 1.87	- 0.118*	- 1.88	- 0.094	- 1.45
Seminars and talks 1997	- 0.054	- 0.99	- 0.029	- 0.52	0.015	0.24	0.056	0.88
Job rotation 1997	- 0.036	- 0.45	- 0.034	- 0.43	- 0.100	- 1.13	- 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	1.23	0.089	1.20	0.275***	3.37	0.275**	3.24
Share of qualified employees	0.339***	4.31	0.336***	4.29	0.436***	6.16	0.367***	3.89
Exporter	0.223***	3.75	0.219***	3.69	0.185***	3.78	0.168**	2.41
State of the art technical equipment	0.112**	2.45	0.111**	2.45	0.118***	3.13	0.205***	3.98
Investment in IT	0.052	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***	4.16	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	- 0.84	- 0.043	- 0.55
Publicly listed company	0.05	0.49	0.058	0.56	- 0.053	- 0.56	- 0.055	- 0.47
Employee Participation	0.083	1.58	0.081	1.53	0.076	1.52	0.063	1.04
Teamwork	- 0.032	- 0.54	- 0.031	- 0.52	- 0.048	- 0.84	- 0.013	- 0.18
Units with own costs and results accounting	0.057	0.87	0.051	0.80	- 0.52	- 0.89	- 0.011	- 0.15
Stringent hiring rules	0.020	0.37	0.024	0.31	- 0.005	- 0.11	0.063	0.98
Incentive payments	0.086	1.29	0.077	1.26	0.159**	2.49	0.108	1.45
Selection Correction term			- 0.103***	- 2.30			- 0.187***	- 3.62
Constant	9.748***	53.41	9.768***	53.54	9.771***	72.50	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 4: Two-step panel estimates, second step estimates, dependent variable: average residual 1997 - 1999

Exogeneous Variables	Equation (3)		Equation (3')		Equation (3)		Equation (3')	
	Coefficients	t-Values	Coefficients	t-Values	Coefficients	t-Values	Coefficients	t-Values
Training intensity	0.233***	3.41	0.276***	3.31				
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	0.675***	10.02	0.669***	10.10	0.612***	9.23
Exporter	0.268***	5.06	0.268***	5.05	0.225***	4.32	0.213***	4.11
State of the art technical equipment	0.188***	4.89	0.186***	4.85	0.172***	4.55	0.152***	4.04
Investment in IT	0.157***	4.05	0.155***	3.99	0.137***	3.57	0.103***	2.68
Co-determination	0.042	0.22	0.035	0.18	0.033	0.17	0.025	0.13
Individual firm	- 0.569***	- 11.29	- 0.567***	- 11.25	- 0.558***	- 11.20	- 0.536***	- 10.82
Partnership	- 0.080	- 1.30	- 0.078	- 1.27	- 0.085	- 1.40	- 0.067	- 1.11
Publicly listed company	0.276***	2.85	0.276***	2.85	0.235**	2.49	0.237**	2.53
Employee Participation	0.117**	2.45	0.118**	2.46	0.092*	1.95	0.086*	1.84
Teamwork	- 0.023	- 0.41	- 0.022	- 0.41	- 0.045	- 0.84	- 0.042	- 0.78
Units with own costs and results accounting	- 0.017	- 0.29	- 0.017	- 0.29	- 0.027	- 0.48	- 0.034	- 0.60
Stringent hiring rules	0.200***	4.13	0.199***	4.12	0.169***	3.51	0.157***	3.28
Incentive payments	0.157***	2.59	0.157***	2.60	0.122**	2.05	0.127**	2.13
Firm size 20-199	1.130***	23.63	1.130***	23.63	1.043***	21.45	0.960***	19.19
Firm size 200-499	2.189***	28.26	2.190***	28.27	1.994***	24.90	1.841***	22.15
Firm size 499-1000	2.545***	22.66	2.546***	22.67	2.307***	20.22	2.118***	18.08
Firm size 1,000+	3.186***	28.18	3.185***	28.18	2.946***	25.33	2.758***	23.13
Selection correction term			- 0.028	- 0.90			- 0.240***	- 6.26
Constant	- 1.347***	- 14.69	- 1.352***	- 14.71	- 1.344***	- 14.85	- 1.386***	- 15.39
15 Sector dummies and East Germany dummy	Yes		Yes		Yes		Yes	
Number of Observations	2432		2432		2460		2460	
Adjusted R^2	0.74		0.74		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.