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Testing for Firm-size Effects

Jan M. P. De Kok

Tinbergen Institute
The Tinbergen Institute is the institute for economic research of the Erasmus Universiteit Rotterdam, Universiteit van Amsterdam and Vrije Universiteit Amsterdam.

Tinbergen Institute Amsterdam
Keizersgracht 482
1017 EG Amsterdam
The Netherlands
Tel.: +31.(0)20.5513500
Fax: +31.(0)20.5513555

Tinbergen Institute Rotterdam
Burg. Oudlaan 50
3062 PA Rotterdam
The Netherlands
Tel.: +31.(0)10.4088900
Fax: +31.(0)10.4089031

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Jan M.P. de Kok

EIM Business & Policy Research, P.O. Box 7001, 2701 AA Zoetermeer, the Netherlands and Erasmus University Rotterdam, the Netherlands.

Abstract

The returns to firm-provided training depend on many different factors. Firm size is an important indicator of various of these factors, but recent research tends to neglect it. In this study the returns to firm-provided training are estimated, taking account of three possible firm-size effects: the HRM effect, selection effect and scale effect. Using panel data on 173 Dutch firms, support is found for the existence of the HRM effect: training support per working day (the average time a firm spends on setting up and coordinating a training program) has a positive influence on the returns to training. In the absence of training support, training has no effect on production. Since on average smaller firms provide less training support per working day, this implies that small firms benefit less from firm-provided training than their larger counterparts.

Key words: firm-provided training, SMEs

JEL classification: J20; J24

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1 Introduction

Few researchers question the importance of human capital. According to Lucas (1993) the accumulation of human capital constitutes the main engine of macro-economic growth[1]. At the firm level, the resource based theory of the firm points to the (implicit) knowledge of employees as a major source for sustained competitive advantage for individual firms[2]. Individual human capital is determined initially by abilities and schooling, and learning by doing and training can result in further knowledge increases (generally speaking, both knowledge and human capital refer to the same concept: the possession of specific information and skills by individuals[3]. In this study, knowledge and human capital will be treated as synonyms).

The returns to training depend on many different factors[4]. Firm size is an important indicator of various of these factors, but recent research into the returns to firm-provided training tends to neglect this. It is widely acknowledged that small and large firms differ in their use of firm-provided training, as is illustrated for the Netherlands in Table 1. However, little is known about the relation between firm size and the impact of firm-provided training. This paper discusses two indirect and one direct effect of firm size on the returns to firm-provided training. Using panel data on 173 Dutch firms, I estimate a production function with human capital as one of its inputs. I find support for the existence of one, indirect, firm-size effect.

Table 1: Internal and external training courses in the Netherlands, by firm size.

Firm size	Number of courses per employee		Training costs as % of labour costs*	
	1986	1993	1986	1993
5 – 99 empl.	0.10	0.18	0.5%	0.7%
100 – 499 empl.	0.25	0.40	1.2%	1.3%
≥ 500 empl.	0.46	0.52	2.9%	3.0%
Total	0.25	0.35	1.5%	1.7%

* training costs include lost labour costs.
Source: Statistics Netherlands 1988 (Tables 2,6 and 9) and 1995 (Tables 10,11 and 38).

The structure of this paper is as follows. The next section discusses previous research into the (productivity) returns to training. In section 3 hypotheses regarding the impact of firm size on the returns to training are formulated. After a description of the available

1 See also Romer (1987, 1996), Lucas (1988) and Mankiw *et al.* (1992).

2 See Koch and McGrath (1996).

3 The difference in terminology points to different backgrounds: literature on HRM prefers ‘knowledge’, whereas abour economists traditionally use the term ‘human capital’. For example: the index of the Handbook of Labor Economics (1986) contains 26 references to human capital, and none to knowledge.

4 See Lynch and Black (1995), Gelderblom and De Koning (1996) and Holton (1996).

data in section 4, a nested production function will be specified that allows for the testing of these hypotheses. The results are presented and discussed in sections 6 and 7.

2 Training and productivity: a review

Most studies on the returns to training are limited to the employee's share of these returns: the impact of training on wages. The general outcome of these studies is that training has a positive impact on wages (Groot, 1999b). Barron *et al.* (1999) make a distinction between the impact on the level of starting wages, and on subsequent wage growth. Human capital theory predicts a negative relation between (expected) time spent in training and starting wages, but they do not find robust support for this prediction. They do find a positive impact of training on both wage growth and productivity[5].

A limited number of studies considers the impact of training on productivity. These studies focus on productivity at either individual or firm level.

Individual level

Since it is difficult to obtain objective measures of individual productivity, subjective evaluations are used. These are based on comparing productivity before and after training, or by comparing the productivity between employees who have and have not followed training courses.

Groot (1999a) measures training by the number of training days, and he finds a training elasticity of productivity growth of 0.12 for an average training course of 140 days. When data on the number of training days is not available, the incidence of training can be used. Gelderblom and De Koning (1996) conclude that courses aimed at social abilities have a significant positive impact on social abilities, but neither social nor management training can stimulate performance measures related to work-pressure[6].

Bishop (1994) studies whether current productivity of individual employees depends on schooling, work experience and formal training obtained at *previous* employers. Using dummy variables on the incidence of formal training he finds that employees who received formal off-the-job training at previous employers are on average 16% more productive than otherwise comparable employees without previous training.

Firm level

A disadvantage of subjective measurements is that it is not possible to make a comparison between firms (or within a firm over time). This disadvantage can be

5 They measure training by total hours of training provided during the first three months, and use subjective measurements of individual productivity.

6 These include working under time pressure and simultaneously working on more tasks.

avoided by estimating the effects of training at firm level, but this requires information on firm production. Only few studies are known that follow this approach.

Bartel (1994) employs a panel with observations for 1983 and 1986, to estimate the effect of formal employee training programs on labour productivity. She finds that firms that implemented new training programmes for specific groups of employees between 1983 and 1986, experienced significant productivity gains (of on average 19%). Whether changes in the training program (for example the amount of training) also influence labour productivity can however not be investigated.

Lynch and Black (1995) estimate a production function to test whether labour productivity depends on the number of workers who received training. Only if they include other dimensions of the training programs[7] do they find significant positive effects. In particular, computer training increases labour productivity by more than 20%. In addition, for manufacturing the proportion of time spent in formal off-the-job training has a significant positive effect on firm productivity[8].

Boon and Van der Eijken (1997) use panel data for 1990 and 1993, which contains detailed information on the amount of training provided by individual firms, including the costs of training and total time spent in training. Information on training costs is used to construct a measurement for the stock of human capital within a firm. The current stock of human capital is a combination of the stock of last year (minus depreciation) and a human capital increase resulting from firm-provided training. They estimate the impact of the human capital stock on gross production and value added, using two different estimation methods (fixed effects and random effects estimators). Only the random effects estimator on value added results in a significantly positive elasticity of human capital of 0.07[9].

Firm-provided training is just one of many human resource management (HRM) practices. The studies discussed so far all focus on the relevance of training. In contrast, Ichniowski *et al.* (1997) look into the combined effects of various HRM practices on productivity. To investigate the complementarities of these practices, they classify observations into four different HRM systems, ranging from 'traditional' to 'innovative'. Their findings are that adopting a system of more innovative HRM practices has large effects on productivity, while changes in individual work practices have little or no effect. This conclusion also holds for the incidence of off-the-job training.

7 The proportion of time spent in formal off-the-job training, the content of training programs, and a distinction between manufacturing and non-manufacturing companies.

8 In Black and Lynch (1996) they show that these conclusions also hold if production instead of labour productivity is being explained.

9 Because of the construction of the human capital stock (HC), this elasticity is not necessarily identical to the elasticity of training (T). If training is assumed to have a constant (pre-sample) annual growth rate g, it can be shown that $HC_t=T_t/(g+d)$, with d the depreciation rate of human capital. The human capital elasticity of training then equals 1, and the elasticities of human capital and of training are the same. If g is not constant, this equality doesn't hold.

Some conclusions

Despite the variety in methods and variables used, it is possible to draw some general conclusions from these studies. First of all, estimating the effects on individual level, with subjective measurements, mostly generates significant positive effects. However, often the difference is measured between either taking a course or not, without distinguishing between one-day courses and courses that take several months[10]. Secondly, if productivity is measured at the firm level, it is more difficult to find significant effects of training on productivity. These studies have the advantage of using objective data, but information on the total time (and costs) spent in training is mostly not available.

The results of Gelderblom and De Koning (1996) and Lynch and Black (1995) illustrate that part of the difficulty of finding a positive relation between training and productivity is its complexity: the returns to training strongly depend on what is being taught and when. And even if a significant positive relation is found, Ichniowski *et al.* (1997) identify another problem: the estimated effect of training on productivity will be biased upwards if no information on complementary HRM practices is available. This bias is due to the strong correlation between training (incidence) and other HRM practices.

In this study I try to control for both problems. To take account of the complexity of the transformation process from training to production, I will explicitly model three specific aspects of that process[11]. These aspects are discussed in the next section. And in the discussion I will argue that it is likely that the training-related variables used to estimate the production function are not correlated with the incidence of other HRM practices.

3 Three firm-size effects of the returns to training

None of the studies discussed above considers firm size as a possible determinant for the returns to training. In this section I will argue why firm size should be considered. My arguments are based on a closer inspection of the process by which training is assumed to increase firm performance.

The primary outcome of a training course is that something must be learned, for example specific knowledge, skills and/or different attitudes[12]. If an employee has learned something, this can result in improved individual production. The transition from learning to improving individual production is however very complicated, and success is not guaranteed. It not only depends on what has been learned, but also on the motivation to actually apply the learning outcomes at the workplace. Both the design of the training program and the motivation of employers and employees are important in this respect.

[10] Groot (1999a) finds that training duration has a very skewed distribution, with an average of 140 days.

[11] The choice for these aspects is dictated by the available data.

[12] No distinction is made between general and specific human capital. This distinction is important if one studies the distribution of costs and benefits of training, but is less relevant for the returns to training.

Finally, individual production should increase production and productivity at firm level (Holton, 1996).

An increase in knowledge or human capital can affect both level and growth of productivity. Four different mechanisms can be distinguished by which human capital may affect productivity (Cörvers, 1997):

- the worker effect: workers with more human capital make a more efficient use of available resources in producing a certain output. The more complex the production technique is, the larger the worker effect can be.
- the allocative effect: workers with more human capital can make a more efficient allocation of the various input factors between the alternative uses available.
- the diffusion effect states that employees with more human capital are more able to adapt to technological change, and will introduce new production techniques more quickly.
- the R&D effect refers to the role of human capital as an important input in R&D activities. A higher share of highly educated employees is beneficial to R&D activities, resulting in a faster introduction of technological progress and productivity growth.

The worker and allocative effect refer to the level of productivity, whereas the diffusion and R&D effects influence the growth rate of productivity. The diffusion effect follows technological progress, whilst the R&D effect (partially) causes technological progress. This implies that only the R&D effect can result in embodied progress. I assume that the R&D effect is not relevant for firm-provided training, which implies that the effects of training will only be embodied in the employees, not in capital.

Human resource management effect

If the effects of training depend on various influences, then a firm must control for all these influences if it wants to obtain a maximal return to training. Setting up a training program with maximal efficiency requires a firm to follow certain steps[13]:

1. identify the knowledge gap (what must be learned?).
2. formulate the goals of training, and the criteria to evaluate it by. This is beneficial to the transition from learning outcomes to individual productivity, but can also stimulate the motivation to learn and apply.
3. choose the evaluation system.
4. determine the training design (training method, materials used, time and place, etc.).
5. perform the training course.
6. evaluate to which extent the training has reached the formulated goals; not only to learn more about the effects of this specific training course, but also to stimulate the motivation of employees to apply their newly gained knowledge in practice.

Carrying out these steps takes time, and requires specific knowledge on (the effects of) training and available training courses. *The first hypothesis (1a) is that a positive*

[13] See Scarpello and Ledvinka (1988).

relation exists between the time spent on performing these steps (the 'training support') and the average effect of an additional training day on individual productivity. This is the HRM effect.

How does this relate to firm size? On average, smaller firms have fewer possibilities to gather knowledge on firm training, since fewer resources are available for investment (of time and money) in this topic. Also, smaller firms in general are less formalized, which further hampers the development of a more formalized training program. This leads to *hypothesis 1b: larger firms will provide more training support (per full-time equivalent) than smaller firms.* If both hypotheses are accepted, we can conclude that a positive relation exists between firm size and the returns to training.

Selection effect

Previous empirical studies implicitly assumed that the returns to training exhibit constant returns to scale: the marginal returns to an additional training day are independent of the number of training days (per employee) already taken. It is possible, however, that a selection effect causes the marginal returns to training to decrease. This will be the case if a training program is organized in such a way that the most productive combinations of training course and trainee are selected first. This is translated in *hypothesis 2a: the returns to training are negatively related with the number of training days per full-time equivalent* (the selection effect).

The selection effect alone does not result in a firm-size effect. This will result only if smaller firms provide on average less training per employee than large firms. To be more precise, this must hold for the subsample of firms that provide training. *Hypothesis 2b states that given training incidence, firm size and training days per full-time equivalent are positively related.*

But is it likely that a selection effect will occur? Perhaps not, since the marginal returns to training will only decrease if several conditions are met. First, firms must have correct information on the qualities of their employees, the qualities of the available training courses, and the quality of every match between employee and training course. Next, training costs are assumed identical, which will in general not be the case. Thirdly, the range of available courses an employee can choose from can depend on the courses already taken[14]. Finally, the decision of a profit-maximising firm also depends on the time different employees are expected to remain with the firm. Given these arguments, it is not clear whether a selection effect should be expected.

Scale effect

Both the HRM effect and the selection effect imply indirect effects of firm size. A more direct effect is that larger firms can benefit from economies of scale: if more employees need to take certain courses, it is possible to develop courses that are adjusted to the

[14] A course can have a follow-up course that can be taken only after the first course has been successfully completed.

specific needs of the firm. This includes the topic of the course, but also for example the presentation, the time and the location. It is likely that these adjustments increase the returns to training. This leads to *hypothesis 3: after correcting for HRM and selection effects, the impact of firm-provided training is positively related with firm size.*

4 Data

To estimate the returns to firm-provided training at the level of individual firms, detailed information is needed. For the years 1990 and 1993 such information is available for the Netherlands. For those two years, Statistics Netherlands has created a balanced panel by combining information from the Training Survey, the Wage and Employment Survey and the Production Survey. This dataset has first been discussed and analysed by Boon and Van der Eijken (1997, 1998). The following description is based on their study.

Training Survey

The Training Survey asks firms in the private sector with five or more employees to provide information on formal training, which is financed completely or partly by firms. The sample used for this study is a sub-sample, originating from firms that were active in training. These firms received a comprehensive questionnaire about training expenditure, training participation, number of days worked by training staff, number of training days followed and the time devoted to the administration and coordination of firm-provided training.

Wage and Employment Survey

From the Wage and Employment Survey information is available on number of days worked and wages for firms which have employees. This survey is based on a two-stage sample design. First a stratified sample of firms is taken, and then each sampled firm takes a simple random sample of its employees. Sample information on the number of hours worked is then used to estimate the total number of hours worked.

Double counting of training hours is avoided by adjusting the total hours worked for the amounts used in training. This implies that labour input is defined exclusive of the hours worked by (in-firm) trainers and of lost working time by trainees.

Production Survey

In the annual Production Survey firms in the manufacturing sector are asked for detailed information on inputs and outputs. This information includes sales, gross output, gross value added (at market prices), wage bill, number of employees, costs of materials, electricity consumption and capital consumption allowances (depreciation costs). Since 1987 all firms with 20 or more employees have been surveyed.

The nominal variables in the data set are all deflated to 1990 guilders. Output and materials are deflated by applying 3-digit SIC[15] product and material price index numbers to all firms within the corresponding industry.

Two different methods of measuring capital input are available. First, depreciation costs can be used as a proxy for capital input. Variations in the utilization of the capital stock can result in differences between the depreciation data and the desired measurement of the flow of capital services. A second measurement for capital input is the consumption of electricity. This variable is more likely to reflect fluctuations in the capital usage over time.

Linking the surveys

The individual firms belonging to the cross-sectional data sets for 1990 and 1993 (428 and 643 firms resp.) are linked to each other. This results in a balanced panel consisting of 173 firms. The firms belonging to the panel contributed to 30% of total manufacturing training expenditure and covered 17% of total manufacturing employment in 1993.

The firms in the balanced panel have, on average, a larger workforce than the average Dutch manufacturing firm (see Table 2). In 1993 95% of the firms in the panel had between 75 and 5000 employees, and the average number was about 700. Only 4% of the firms in the panel had on average less than 100 employees, while this size class accounts for more than 80% of all Dutch industrial firms with at least 20 employees (ENSR, 1997). The larger average firm size of the panel reflects the fact that larger firms are more likely to provide training. Finally, the chemical industry is over represented in the balanced panel.

Table 2 presents some summary statistics, and compares these with the production survey (covering over 6000 firms). The two years under review differ to some extent. Employment, gross output and value added decreased in the period 1990-1993. This is not specific for the balanced panel: the complete production survey showed the same development.

[15] SIC denotes Standard Industrial Classification of Statistics Netherlands. The 3-digit level allocates industrial firms to 122 groups.

Table 2: Summary statistics[a] for the balanced panel of linked data (Panel) and the Production Survey for total manufacturing (PS), 1990-1993.

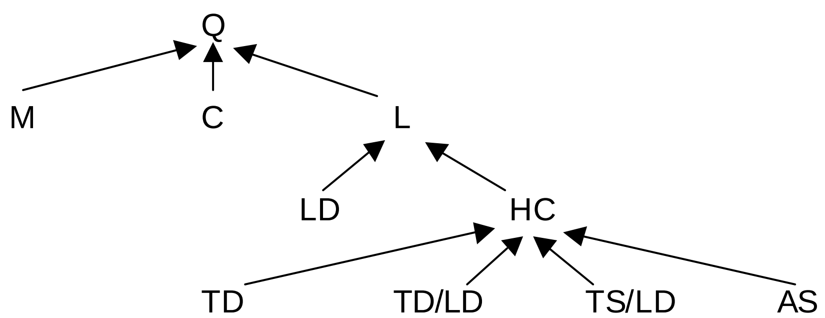
	Panel		PS	
	1990	1993	1990	1993
gross output[b]	298	252	46	41
value added[b]	96	91	13	11
number of employees	859	714	127	108
number of hours worked[c]	1522	1186		
Labour productivity[d]	106	108	101	102
number of firms	173	173	6154	6681

[a] averages.
[b] in million 1990 guilders.
[c] in thousand working hours.
[d] value added per employee in thousand 1990 guilders.
Source: Boon and Van der Eijken (1997).

5 The production function

To test the hypotheses derived in section 3, a nested production function will be estimated. The structure of this function is depicted in Figure 1. Gross production Q for firm i at year t is a function of materials M, capital C and labour L. Labour has both a quantitative and a qualitative dimension, represented by the amount of days worked LD, and the stock of human capital HC. The human capital stock is determined by the average schooling level AS of the work force and firm-provided training. The impact of firm-provided training on human capital is modelled as a function of the number of training days (TD), the HRM effect (TS/LD) and the selection effect (TD/LD).

Figure 1: a nested production function structure



Deriving the production function

Using a Cobb-Douglas production function, gross output of individual firms is modelled as

$$q_{i,t} = \alpha_0 + \alpha_1 \cdot m_{i,t} + \alpha_2 \cdot c_{i,t} + \alpha_3 \cdot l_{i,t} + \alpha_4 \cdot D_t + u_{1i,t} \qquad (1)$$

where small letters represent the logs of the variables, D_t a year dummy (1993=1) and $u_{1i,t}$ a vector of independent identically distributed (i.i.d.) residuals. The parameters α_1, α_2 and α_3 denote the output elasticity's of the respective inputs, and α_0 is a constant term.

Labour is modelled as

$$l_{i,t} = \delta_1 \cdot ld_{i,t} + \delta_2 \cdot hc_{i,t} + u_{2i,t} \qquad (2)$$

where $ld_{i,t}$ is the total number of days worked (corrected for time spent in training), $hc_{i,t}$ the amount of human capital within the firm and $u_{2i,t}$ an i.i.d. disturbance term.

Substituting (2) in (1) gives the following expression:

$$q_{i,t} = \alpha_0 + \alpha_1 \cdot m_{i,t} + \alpha_2 \cdot c_{i,t} + \alpha_{31} \cdot ld_{i,t} + \alpha_{32} \cdot hc_{i,t} + \alpha_4 \cdot D_t + \varepsilon_{i,t} \qquad (3)$$

where α_{31}, α_{32} and $\varepsilon_{i,t}$ are defined implicitly. With this specification I assume that increases in the stock of human capital will increase the level of production, not the growth rate. For the empirical investigation, the distinction between level and growth effect is however not relevant: since I only have information on two different points in time, these effects cannot be distinguished from each other.

The human capital stock of a firm changes each year, due to changes in the composition of the work force and changes in the human capital of individual employees. I assume that changes in the composition of the work force only play a minor role, given the short time span of the available data. The stock of human capital of firm i in year t is given by the following definition:

$$HC_{i,t} = (1-\delta) \cdot HC_{i,t-1} + THC_{i,t-1.} \qquad (4)$$

In this equation, δ represents the annual depreciation rate of human capital and THC the increase of human capital due to training of employees[16]. The human capital increase resulting from firm-provided training is not only dependent on the quality and quantity of the training program, but also on the average schooling level of the work force:

$$thc_{i,t} = \beta_0 + \gamma_{i,t} \cdot td_{i,t} + as_{i,t} + u_{3i,t} \qquad (5)$$

where TD is the number of firm-provided training days, AS the average schooling level and $u_{3i,t}$ an i.i.d. disturbance term. No information on the average schooling level is available. If I however assume that this remains constant for the individual firms over the three-year period under consideration, then panel data estimation methods offer a possibility to control for this lack of information.

[16] Effects of learning by doing are not taken into account.

The coefficients β_0 and $\gamma_{i,t}$ (the elasticity of training) indicate how much human capital can increase due to an extra day of training. The elasticity can be modelled as a function of the three firm-size effects.

The human resource management and selection effects

Training support per working day (TS/LD) is used as an indicator for the HRM effect. Training support is defined as the number of days a firm spends on administrating and coordinating firm-provided training (carried out by a specific department or employee concerned with training programs). Training support per working day represents the average amount of training support per full-time equivalent[17]. The selection effect can be tested by including the fraction of total working days spent in training (TD/LD). Some statistics on these indicators are presented in Table 3.

Table 3: Panel summary statistics[a] on the HRM and selection effect, 1990-1993, by size class.

	1990			1993		
	number of employees:			number of employees:		
	<150	150-500	>500	<150	150-500	>500
Number of employees	127	283	3095	112	262	2501
Training support / working day[b]	0.16	0.37	0.96	0.16	0.34	0.72
Training days / working day[b]	1.1%	1.2%	1.9%	1.2%	1.5%	1.8%
Number of firms	46	89	38	45[c]	89	38

[a] averages.
[b] working days adjusted for training.
[c] within this size class, one firm reported a fraction of training days per working day of 95% in 1993. This observation has been excluded from this Table, and the firm is excluded from further analyses.

The human capital elasticity of training γ can be modelled as a linear function of these indicators:

$$\gamma_{i,t} = \beta_1 + \beta_2 \cdot TS/LD_{i,t} + \beta_3 \cdot TD/LD_{i,t} + u_{4i,t}, \qquad (6)$$

where $u_{4i,t}$ represents an i.i.d. disturbance term. According to the HRM effect (hypothesis 1a) $\beta_2 > 0$ must hold. Hypothesis 1b states that $TS/LD_{i,t}$ and the number of employees are positively related. Likewise, the selection effect (hypothesis 2a) implies that $\beta_3 > 0$ and hypothesis 2b states that $TD/LD_{i,t}$ and the number of employees are positively related.

The scale effect

The presence of the scale effect can be investigated by introducing a size class dummy in equation (6):

$$\gamma_{i,t} = \beta_1(1+\beta'_1 D_{SC\ i,t}) + \beta_2 \cdot TS/LD_{i,t}\ (1+\beta'_2 D_{SC\ i,t}) + \beta_3 \cdot TD/LD_{i,t}\ (1+\beta'_3 D_{SC\ i,t}) + u_{4i,t,} (6')$$

17 Other options have also been investigated: training support per training day and total training support. These options could however explain less of the variance (as measured by the R^2 of the estimated equations).

where D_{SC} =1 for large firms and zero otherwise. An F-test on the hypothesis that $\beta'_1 = \beta'_2 = \beta'_3 = 0$ can be used to investigate the scale effect (hypothesis 3).

The next step is to substitute the firm-size effects into the production function. Substituting (6)[18] in (5) results in:

$$thc_{i,t} = \beta_0 + \beta_1 \cdot td_{i,t} + \beta_2 \cdot TS/LD_{i,t} \cdot td_{i,t} + \beta_3 \cdot TD/LD_{i,t} \cdot td_{i,t} + as_{i,t} + u_{3i,t} + u_{4i,t} \cdot td_{i,t} \qquad (7)$$

Equations (4) and (7) can be used to construct a time series of human capital stock $HC_{i,t}$ based on the investment $thc_{i,t}$, for every firm i and year t for which data are available[19]. This would however result in a production function that is non-linear in the parameters to be estimated. In order to avoid the computational complications that are associated with estimating non-linear functions, this method has not been applied. Alternatively, the human capital increase from training THC can be used as an indicator for the stock of human capital:

$$HC_{i,t} = THC_{i,t} \qquad (8)$$

for both years, 1990 and 1993[20].

The production function is obtained by substituting (7) in (3), using (8):

$$q_{it} = \alpha_0' + \alpha_1 \cdot m_{i,t} + \alpha_2 \cdot c_{i,t} + \alpha_{31} \cdot ld_{i,t} + \alpha_{32}\beta_1 \cdot td_{i,t} + \alpha_{32}\beta_2 \cdot TS/LD_{i,t} \cdot td_{i,t} + \alpha_{32}\beta_3 \cdot TD/LD_{i,t} \cdot td_{i,t} + \alpha_4 \cdot D_t + u_{i,t},$$

with $\alpha_0' = \alpha_0 + \alpha_{32} \cdot \beta_0$

$$u_{i,t} = u_{1i,t} + \alpha_3 \cdot u_{2i,t} + \alpha_{32} \cdot u_{3i,t} + \alpha_{32} \cdot u_{4i,t} \cdot td_{i,t} + \alpha_{32} \cdot as_{i,t.} \qquad (9)$$

The average schooling level AS is included in the disturbance term, since no information on this variable is available.

In this specification, the production elasticity of human capital (α_{32}) is not identified. Consequently, it is not possible to test for constant returns to scale with respect to the firm production function (1). Also note that the human capital elasticity of training *support* is by definition strongly correlated with firm size: this elasticity equals $\beta_2 \cdot TS/LD \cdot td$[21], and the amount of training days and the number of employees are strongly correlated. This elasticity will therefore not be discussed in the next section.

[18] For notational convenience, the production function will be derived using (6) instead of (6').

[19] Boon and Van der Eijken (1997) use this approach on training expenditures, and Hall and Mairesse (1995) on R&D investments.

[20] Boon and Van der Eijken (1997) find that using (4) and (8) to represent human capital in a production function yields comparable results.

[21] The human capital elasticity of training support is defined as (dHC/d(TS/LD)) x ((TS/LD)/HC), which equals (dTHC/d(TS/LD)) x ((TS/LD)/THC). Since $dTHC/d(TS/LD) = THC \cdot \ln(TD) \cdot \beta_2 = \beta_2 \cdot td \cdot THC$, the human capital elasticity is equal to $\beta_2 \cdot TS/LD \cdot td$.

Estimation techniques

The production function (9) can be estimated using ordinary least squares, under the assumption that the disturbance term $u_{i,t}$ is i.i.d. with mean zero and a constant variance. However, these assumptions are likely to be violated due to the inclusion of the average schooling level and the term $\alpha_{32} \cdot u_{4i,t} \cdot td_{i,t}$ in the disturbance term. Even without these explicit components of the disturbance term, heterogeneity across firms can occur because of differences in technologies used, type of output and other HRM measures aimed at improving performance. This heterogeneity between firms can be represented by a firm-specific effect $?_i$. In symbols :

$$u_{i,t} = ?_i + ?_{i,t} \quad (10)$$

where $?_{i,t}$ denotes the remaining disturbance, which is assumed to be i.i.d. following a standard normal distribution. Specifically, the average schooling level becomes part of the firm-specific effect, assuming that the average schooling level remains constant during the relatively short period under consideration (1990-1993).

Panel data estimators exploit this specification of the disturbance term. The fixed effects (FE) estimator assumes the firm-specific effects to be fixed parameters, which have to be estimated by including firm-specific dummies in the regression (with $?_{i,t}$ replacing $u_{i,t}$ as the disturbance term). Because the sample only covers two different years, the fixed effects estimator is identical to using ordinary least squares on the first differences of the production function (9). The random effects (RE) estimator assumes $?_i$ to be a random variable. If the firm-specific effects are uncorrelated with the explanatory variables, then the RE estimator is more efficient than the FE estimator. It is furthermore preferred over the FE estimator, because the RE estimator delivers unconditional results whereas the results of the FE estimator are conditional on the specific firms in the sample (Hsiao, 1986).

6 Results

The hypotheses regarding the HRM, selection and scale effects are tested by estimating the production function (9). But first a correlation analysis is used to investigate hypotheses 1b and 2b, which state that the number of employees is positively related with both training support per working day and training days per working day.

The correlations given in Table 4 indicate that positive relations indeed exist, but in a non-linear way: both training support (per working day) and training days (per working day) are stronger correlated with the log of the number of employees than with the number of employees. Apparently, the correlations with firm size are stronger for smaller and medium-sized enterprises than for large enterprises. Furthermore, the correlation is stronger for training support than for training days.

Table 4: correlations between number of employees and training support / training days

	number of employees	log(number of employees)
training support / working day (TS/LD)	0.14 (0.009)	0.32 (0.000)
training days / working day (TD/LD)	0.07 (0.19)	0.17 (0.001)

Note: standard errors given between brackets

Before estimating the production function, I investigate the possibility of multicollinearity. This can be done by inspection of the correlations between the regressors. Because this dataset only covers two time periods, the fixed effect estimation is identical to estimating the production function in first differences. So, rather than checking the correlations between the levels of the regressors, the correlations between the first differences of these variables should be looked at. It turns out that the largest correlation (between changes in td and changes in $TD/LD \cdot td$) is only 0.55. Apparently, there is no danger of multicollinearity.

The production function (9) is estimated using both the fixed effects and the random effects estimator. The results are reported in Tables 5 (explaining gross production) and 6 (explaining value added). Capital is measured by electricity usage; using depreciation costs invariably results in an insignificant elasticity of capital. The use of panel data estimation techniques is justified by the F-test for firm-specific effects: the hypothesis that no effects are present is rejected for the FE estimations (see Tables 5 and 6).

From equation (9) it is clear that the disturbance term $u_{,t}$ is not i.i.d. Specifically, the component $\alpha_{32} \cdot u_{4i,t} \cdot td_{i,t}$ suggests that it is likely that the firm-specific effects will be correlated with the regressors. If so, FE provides consistent estimates, but the RE estimator doesn't. To test for a dependency between regressors and firm-specific effects, Hausman's test statistic can be used. According to this statistic, the RE estimator is to be preferred: its value of 6.70[22] (for gross production) cannot reject the hypothesis that the firm-specific effects are uncorrelated with the regressors. For value added, the results are similar.

There are however reasons to doubt this conclusion. First, if depreciation costs are used to measure capital, Hausman's test statistic does reject the no-correlation hypothesis[23]. Secondly, this test statistic is based on the assumption that the disturbance is homoscedastic. The Goldfeld-Quandt test statistics reported in Tables 5 and 6, however, indicate that the disturbances are heteroscedastic. Finally, theory predicts that firm-specific effects are correlated with the amount of training days. I therefore prefer the FE specification. For this specification, a heteroscedastic-robust estimation has been performed. Both the standard and the robust estimates of the standard errors of the parameters are given in Tables 5 and 6. Especially the standard errors of the training-related variables benefit from this correction.

[22] Following a chi-squared (6) distribution; the associated probability-value is 0.35.

[23] For gross production, the value of the test statistic is 20.09, with a probability-value of 0.0027.

Table 5: Estimation results of a Cobb-Douglas production function explaining log(gross production).

	fixed effects estimation			random effects estimation	
		st. error	robust[d] st. error		st. error
materials	0.76	0.030***	0.032***	0.78	0.012***
capital[a]	0.047	0.022**	0.020**	0.021	0.008***
labour	0.20	0.036***	0.035***	0.21	0.016***
training days	-0.0042	0.01	0.008	0.0037	0.0083
training support per working day (HRM effect)	0.23	0.12*	0.083***	0.22	0.11**
training days per working day (selection effect)	0.013	0.063	0.056	0.013	0.057
time-dummy	-0.017	0.0077**	-	-0.015	0.0073**
F-test for firm-specific effects[b]	5.15	(0.000)			
F-test for scale effect[b]	1.10		(0.35)	0.47	(0.70)
F-test for returns to training[b]	1.60		(0.19)	0.92	(0.43)
Goldfeld-Quandt[b,c]	1.48	(0.01)		1.50	(0.009)
Jarque-Bera[b]	36.7		(0.000)		
adjusted R^2	0.9969		0.8788	0.9936	
N	344		172	344	

Note: constant and parameters for three sector dummies not reported;

[a] capital measured by electricity consumption;

[b] p-value between brackets. if given in column 'robust st. error', the test statistic is calculated from the robust estimation results;

[c] observations ordered by training days; 75 firms with smallest and largest values are compared; similar conclusions are obtained if observations are ordered by gross production and labour;

[d] heteroscedastic-consistent estimates, obtained by estimating the FE model as OLS on first differences. This causes the time-dummy to disappear from the regression equation, the number of observations is halved and the adjusted R^2 is computed differently;

* significant at 10%;

** significant at 5%;

*** significant at 1%;

The human resource management effect: returns to training are related to firm size

The estimation results indicate that a human resource management effect (hypothesis 1a) indeed exists. Both FE (robust) and RE report a significant impact of training support per working day on gross production and value added.

What does this mean? The more support employees receive, the more effective training is. The results even suggest that training has no effect at all, if it is not accompanied by training support: the parameter for training days does not significantly differ from zero. Because smaller firms provide on average less training support per working day than larger firms, smaller firms benefit less (cet. par.) from additional training.

Table 6: Estimation results of a Cobb-Douglas production function explaining log(value added).

	fixed effects estimation			random effects estimation	
		st. error	robust[d] st. error		st. error
capital[a]	0.23	0.086***	0.092**	0.11	0.026***
labour	0.80	0.13***	0.13***	0.87	0.052***
training days	0.014	0.038	0.033	0.055	0.031*
training support per working day (HRM effect)	0.73	0.47	0.31**	1.00	0.42**
training days per working day (selection effect)	0.024	0.25	0.16	-0.059	0.21
time-dummy	-0.072	0.030**	-	-0.064	0.028**
F-test for firm-specific effects[b]	4.08	(0.000)			
F-test for scale effect[b]	0.73		(0.53)	0.18	(0.91)
F-test for returns to training[b]	1.37		(0.25)	0.70	(0.55)
Goldfeld-Quandt[b, c]	2.19	(0.000)		2.25	(0.000)
Jarque-Bera[b]	363.7		(0.000)		
adjusted R^2	0.9505		0.3094	0.8982	
N	344		172	344	

Note: constant and parameters for three sector dummies not reported;

[a] capital measured by electricity consumption;

[b] p-value between brackets. if given in column 'robust st. error', the test statistic is calculated from the robust estimation results;

[c] observations ordered by training days; 75 firms with smallest and largest values are compared; similar conclusions are obtained if observations are ordered by gross production and labour;

[d] heteroscedastic-consistent estimates, obtained by estimating the FE model as OLS on first differences. This causes the time-dummy to disappear from the regression equation, the number of observations is halved and the adjusted R2 is computed differently;

* significant at 10%;

** significant at 5%;

*** significant at 1%;

No selection effect

From the discussion in section 3 it is not clear whether a selection effect (hypothesis 2a) is to be expected. According to the estimation results, there is no selection effect in this sample: the returns to training do not depend on the number of training days per working day.

No scale effects

I have estimated an alternative specification of the production function, with the human capital elasticity defined by equation (6') instead of (6). This enables the use of an F-test to test for the presence of a scale effect (hypothesis 3), comparing 45 firms with less than 150 employees (1990) with 127 larger firms. I cannot reject the hypothesis of no scale effect, for none of the four specifications (Tables 5 and 6).

Interpreting the numbers

The estimation results imply that without training support, training has no effect at all: the parameters of both training days and training days per working day are not significantly different from zero. With only an HRM effect, the human capital elasticity of training equals $\beta_2 \cdot TS/LD$, and the production elasticity of training becomes $\alpha_{32}\beta_2 \cdot TS/LD$. Using average numbers for TS/LD for different size classes, the estimated impact of a 10% increase in training days is given in Table 7.

Table 7: Estimated impact of increase of training days for different size classes

size class	TS/LD '93	TD +10% gross production	value added
<150	0.16	+0.37%	+1.2%
150-500	0.34	+0.78%	+2.5%
>500	0.72	+1.66%	+5.3%

These calculations illustrate the firm-size effect. The 'average' small firm in this sample can expect an increase in gross production of 0.37% if it raises the amount of training days with 10%. Under the same circumstances, the 'average' large firm would see its gross output grow with 1.66%.

Additional tests

Some additional calculations can be made to establish how robust these conclusions are. First of all, the conclusions regarding the returns to training do not depend on the choice of capital measurements available to us. Using a robust fixed effects estimator, the HRM effect is significant (at a 1% level) for both gross production and value added if capital is measured by depreciation costs.

Next, I have included the share of training days held externally and the fraction of training days held during working hours in the production function. Contrary to Lynch and Black (1995), I do not find an indication of any relevance of these variables for production levels.

If training expenditures instead of training days are used, the parameter estimates are comparable. The significance of the training-related variables drops however; only the RE specification finds a significant effect of training, on valued added (this result is comparable with Boon and Van der Eijken (1997), who use the same dataset). This is no reason to doubt the conclusions. If we look at labour, the impact of labour on production is measured using the amount of working days, and not the total wage bill. Likewise, the impact of training on production should be measured using the number of days spent in training, and not the training costs. The finding that using training expenditures gives less significant results can be seen as a confirmation of this argument.

In addition to testing for the significance of the separate firm-size effects, I investigate the joint significance of all effects. To this end, an F- test is performed: the production function is estimated with and without the training-related variables, and the F-test statistic for returns to training is calculated using the residual sum of squares of these alternative specifications. Despite the fact that the HRM effect significantly differs from zero, the F-test for returns to training cannot reject the hypothesis of no returns to training (see Tables 5 and 6).

A final test statistic shows that the above results must be interpreted with some caution: these tests all assume that the disturbances are normally distributed, but according to the Jarque-Bera test this is not the case (see Tables 5 and 6).

7 Discussion

Three different firm-size effects have been identified on the returns to firm-provided training: the HRM effect, the selection effect and the scale effect. I found no empirical support for the selection and scale effects. There is evidence of a positive relation between firm size and the amount of training per working day (hypothesis 2b), but without selection effect this has no impact on the returns to training. Note, however, that the available dataset only includes 11 firms with less than 100 employees. It therefore remains an open question whether selection and scale effects exist between firms with more and less than 100 employees, and within the (large) group of smaller firms.

The estimation results suggest that there is an indirect firm-size effect, which is the combined effect of the HRM effect (hypothesis 1a) and the positive relation between training support (per working day) and firm size (hypothesis 1b). If firms increase their relative amount of training support, they are likely to benefit more from the courses those employees take. This conclusion is in line with Gelderblom and De Koning (1996) and Lynch and Black (1995), who find that it is necessary to take account of some aspects of the complexity of the training process, in order to measure the returns to training.

With only the HRM effect present, it is possible to calculate the production elasticity of training days for different values of training support per working day. For the average large firm in the sample this elasticity is more than 4 times that of the average small firm (0.17 compared to 0.037 for gross production, and 0.53 to 0.12 for value added). The estimates for the effects on value added are higher than the elasticity of 0.07 reported by Boon and Van der Eijken (1997)[24]. These results must not be taken as an indication that small firms do not provide enough training support (or training days): without information on the costs of training programs and turnover levels of employees, nothing can be said on the optimal level of training support and training days for firms of different size classes.

I find that the estimation results become more robust if training is measured by training days instead of training expenditures, and the HRM effect is included: the HRM effect is significant for gross output and value added, according to both the RE and (robust) FE estimator, irrespective of the capital measure. The results must however be interpreted

24 Boon and van der Eijken have calculated the elasticity of *human capital*, which is not the same as the elasticity of *training*.

with some caution. Contrary to the significance of the HRM effect, the F-test for returns to training cannot reject the hypothesis of no returns to training. Finally, one might even argue that nothing can be said on the significance of parameters because the disturbances are not normally distributed.

Groot (1999b) discusses the possibility that the incidence of firm-provided training is correlated with changes in production techniques. If this were the case, then the reported effects of training on production would in fact be indicators of the returns to production technique improvements. Although I cannot control for this possibility empirically, I do not think that this source of bias is relevant here: I assume that changes in production technique are not correlated with training support per working day, which is the most significant training-related variable in this study.

Ichniowski *et al.* (1997) note that there is a potential danger of overestimating the returns to training, if no information on complementary HRM practices is available. This danger would however disappear, if the training variables used were not correlated with the (unmeasured) incidence of other HRM practices. I argue that this is the case in this study. All three training-related variables in the production function (td, $TS/LD \cdot td$ and $TD/LD \cdot td$) are correlated with the (log of the) total number of training days, which in turn is strongly correlated with firm size[25]. If I assume that in the current sample[26] firm size is uncorrelated with the incidence of HRM practices, it follows that the training-related variables are not (or only weakly) correlated with the incidence of other HRM measures. And as far as the general state of the HRM policy is constant over a period of three years, this is treated as a firm-specific effect.

To increase our knowledge on the returns to training, additional studies should be carried out. Cross-country studies are needed to investigate the relevance of institutional settings. More smaller firms must be included in the samples to further examine the selection and scale effects. Ideally, panels should be used that cover several time periods, which would enable us to introduce lags in the calculation of the stock of human capital. Another option is to collect information on firms with training programs, without training programs, and firms that start with training programs during the sample period. This would allow us to study not just the impact of increasing training efforts, but also the effect of introducing firm-provided training (Bartel, 1994). We should also look to improve the production function specification in such a way, that a meaningful calculation of the elasticity of training support can be made.

[25] The correlation between the total number of training days and the total number of employees is 0.95.

[26] Where almost all firms have at least 50 employees, and all have formal training programs.

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