European Centre for the Development
of Vocational Training

RESEARCH PAPER

No 19

The impact of vocational education and training on company performance

Luxembourg:
Publications Office of the European Union, 2011

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Luxembourg: Publications Office of the European Union, 2011

ISBN 978-92-896-0893-0
ISSN 1831-5860
doi:10.2801/37083

The **European Centre for the Development of Vocational Training** (Cedefop) is the European Union's reference centre for vocational education and training. We provide information on and analyses of vocational education and training systems, policies, research and practice. Cedefop was established in 1975 by Council Regulation (EEC) No 337/75.

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Foreword

European economies have to invest in VET programmes to alleviate the social costs of the economic downturn; they must also invest in skills to prepare their economies and labour markets for the demands and changes of increased global competition. Over the past few years, Europe-wide analyses have emphasised the importance of investing in skills, future economic growth, innovation and business performance. Employers will have to increase private levels of investment in skills and innovation as public investment is curtailed by austerity measures that reduce available government finance.

Organisations can also offer training opportunities and create learning potential by the way production processes are laid out. Properly structured, they become learning organisations in which workers have the opportunity to develop professional and social competences through peer learning.

It is generally accepted that workers will benefit from investment in skills: many studies provide evidence of positive and sizeable returns on human capital investments. This may not be the case for firms as the returns they might expect from their investments in training, in terms of productivity gains, have received far less attention in literature.

Cedefop is actively engaged in analysing the returns on company investments in skills, looking to collect robust evidence on this important issue. The report *Learning while working: success stories of workplace learning in Europe* (Cedefop, 2011a) takes stock of Cedefop's previous work and shows that investments in skills are also beneficial to firms in the way they aid innovation. The introduction of new products and services, the adoption of technological developments and major changes in work processes and work organisation stimulate training needs. A highly skilled workforce is an asset that makes it easier for companies to adapt to changes and to compete in new markets.

The present report summarises — by means of a meta-analysis — the results of a large body of scientific research on the impact of training (and vocational education) investments on company productivity and other performance indicators. Direct comparison between studies is difficult as skill investment (number of workers trained, monetary cost of training, training duration) is measured in different ways, and various measures of performance have been adopted by the different studies.

Despite the fact that a relationship between the size of the investment in training and the size of the effect on performance indicators is hard to establish, the study yields a clear result: investments in training (however measured, but mainly representing forms of adult learning and continuous vocational education and training) have a positive and significant impact on company performance indicators. This link is particularly obvious when performance is measured in terms of productivity. This result confirms the key role attributed to the investment in skills in the European strategy for smart and sustainable growth, Europe 2020, and the initiative *Agenda for new skills and jobs*.

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Acting Director

Acknowledgements

This is publication is the result of a team effort. Cedefop is grateful to Marion Collewet, Jaap de Koning, and Arie Gelderblom from SEOR for carrying out the research on which this report is based, and to Hendry Hagen for his excellent contribution to the project during his internship at SEOR. Many researchers from Cedefop contributed to the report. Manfred Tessaring and Guy Tchibozo supervised the initial phase of the project. Pascaline Descy and Jasper Van Loo coordinated the project throughout. Giovanni Russo steered the research and the publication process. Vladimir Kvetan provided additional comments that substantially increased the quality of this report.

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Executive summary

The aim of this study was to summarise the evidence available on the economic benefits of vocational education and training (VET) at company level, by means of a literature review and meta-analysis based on 62 studies containing, in total, 264 estimated effects of training. Throughout the study the term VET is used to denote employer/enterprise provided training.

Summary of the findings

Does VET have a positive effect on company performance?

On the basis of the evidence collected, we can conclude that VET has a positive influence on the economic performance of firms. Most studies we examined find a positive and significant effect of VET. The average estimated effect of VET is positive. The characteristics of the object of study and the methodology used in it influence the magnitude of the effect found, but they do not generally put the overall result in question.

The positive effect of VET on company performance persists across performance indicators. Most studies we found concentrate on productivity. But for almost all performance indicators (quality, innovation, employment growth, multidimensional indicators), we find more studies concluding that VET has a positive effect than those finding the contrary. Only among those studies which look at profitability and firm costs, do most find an insignificant effect. This result retruns in the meta-regressions we conduct: we find that studies looking at profitability or costs are less likely to find positive and significant effects of VET, all other things being equal.

As clear as the conclusion about the positive effect of VET on company performance is, the evidence available to quantify the effects comparably across studies remains unclear. We came across such a wide variety of performance indicators, VET indicators and model specifications that it is virtually impossible to translate each of the effects estimated into some variable which could be compared across studies. We have made an attempt to compute indicators of effect sizes as comparable as possible across studies, but the small number of valid entries obtained makes the results tentative.

Does the effect of VET on company performance increase with the size of the VET investment?

The same is true of the influence of the level of VET-effort on the estimated effect. VET-effort has been measured in many different ways, and only part of the studies provided enough information to enable the computation of a measure of VET-level comparable across them. Using this comparable measure suggests that the probability of observing positive significant effects of VET increases with the level of VET-effort. However, the small number of observations renders this conclusion tentative.

Influence of the characteristics of the object of study

Most studies did not record the characteristics of the training, treating it as a broad category; they looked at training participation or training expenses, without asking which kind of training they were examining. We found some evidence on particular forms of training, on training fields and on target groups, but it is too scarce to make general conclusions possible. The general picture of positive effects of training remains across training forms and training fields.

The sector of activity offers more. We find evidence, both through descriptive statistics and through the meta-analysis, that studies concentrating on non-manufacturing sectors have a lower probability of observing positive and significant effects of VET. In contrast, studies focusing on manufacturing or on a broad range of sectors find positive and significant effects. Positive effects of VET are found for firms of all sizes, including smaller ones, but we find some evidence, both descriptive and analytical (i.e. based on meta-regressions) that the effects of VET on company performance increase with firm size.

We also examined whether the effects of VET on company performance were greater when VET is integrated in a broader human resources management (HRM) strategy. Only a few studies provided information on this issue. There is only slightly more evidence that the HRM context reinforces the positive effects of VET than there is of no effect from HRM practices.

Influence of the methodology

Most studies correcting for potential endogeneity still find positive and significant effects of VET. In the meta-analysis, correction for endogeneity is not found to affect the probability of finding positive and significant results, which is a surprising result. However, the use of such methods is found to have a negative effect on the size of the estimated effect of VET, which is what one would expect if overlooking potential endogeneity leads to an overestimation of this effect.

How the investment in VET is measured (in number of workers trained, in time spent on training, in training expenses, using a multidimensional index or a dummy) has very little influence on the estimated effect of VET. Similarly, studies that allow investment in training to have a delayed effect on company performance indicators have the same likelihood of finding a positive impact as studies that do not allow for a delayed effect. In the same vein, studies that model the investment in training as a stock of training over time are not found to be more likely to display a positive significant impact of training on company performance indicators than studies that only use contemporaneous investment in training.

Indications for further research

On the basis of these findings, we identify some possibilities to pursue further lines of research, especially since we see several gaps in these studies.

First, there is a clear need to pay more attention to the characteristics of VET. Most of the studies only considered whether training had taken place in a given firm, and how much, but did not register its characteristics. Distinguishing between different training forms, training fields and target groups would make more precise conclusions possible about what works and in which setting. Particularly, more studies on the effects of initial vocational education and training are needed. These effects might be quite different from the effects of continuous training.

Second, the question of what comes first, training or high performance, continues to deserve attention. We find that controlling for endogeneity matters for the size of the estimated effect of VET. This suggests that endogeneity should be considered when estimating the effect of VET on company performance.

In addition, we found many studies of the relationship between VET and productivity or profitability, while other performance indicators received less attention. The influence of VET on a performance indicator such as innovation is an interesting topic for further research. It could be particularly interesting to differentiate between leaders and followers in terms of innovation as the training needs and attitudes towards VET of both groups are likely to differ.

Finally, it is essential to base quantitative estimations of the effect of VET on company performance on a well-defined model. A major problem which we encountered in this study was the lack of comparability between the VET variables used, and consequently between the estimated effects of VET. Ad-hoc estimations too often lead to estimation results not comparable with those of other studies, and therefore lose an important part of their informative value. We can only recommend deriving the model to be estimated from a well-defined production function, to provide for a clear interpretation of the estimated coefficients.

CHAPTER 1
Introduction

1.1. Background

The economic benefits of education have often been studied in the framework of human capital theory (Becker, 1964; Mincer, 1974). Many studies provide empirical estimates of the returns for individuals from an investment in education ([1]). Another strand of the literature attempts to establish and measure the causal link between investment in education and economic growth at national economy level ([2]). But to translate from individual benefits into national economic growth, the effects of educational investment have to appear at the level of firms and economic sectors. The way education investments influence, for instance, productivity and firm or sector growth, is one of the essential ways in which they translate into economic growth, along with other channels such as the development of social capital or health outcomes. The specific role of VET is particularly relevant for firms and economic sectors. One can expect that general education affects national economic growth substantially through 'soft' variables such as social capital, whereas VET has a more direct influence on productivity, and hence on economic benefits which are measurable at company or sector level ([3]).

The benefits of investment in vocational education and training (VET) for firms have been the object of several studies. To date, most studies on the economic benefits of education have used either general variables, such as the number of years spent in initial education, or specific data about training of employees. However, when looking at economic benefits of education at company or sector level, a difference should be made between general and vocational initial education, and measures of training should be included to enable a comparison between the benefits of different types of VET. Knowledge

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([1]) Many are reviewed in Blundell et al. (1999)

([2]) Reviewed in Blundell et al. (1999) and Wilson and Briscoe (2004):

([3]) Here, the notion of 'general education' refers to subjects that are not directly attributable to specific occupations and so is opposed to VET. In human capital theory 'general education' has a very different meaning. There it means education in subjects that are useful for many firms, in contrast to specific training, which is only useful for a particular firm. In this meaning VET is, at least partly, general.

about which kind of training brings the greatest returns, and upon which factors these returns depend is valuable for the future of economic sectors and firms.

The question about the economic benefits of VET to firms and economic sectors is of great practical relevance. At company level, better information about the returns on investment in VET is a useful tool for decision-makers. At sector level, actors involved in the organisation and financing of VET (business organisations, social partners, the State) need to know the extent and nature of the benefits of VET to organise its provision efficiently.

1.2. Purpose of the study and research questions

The purpose of the analysis is to find out whether — and, if yes, to what extent — VET affects company development. Economic activities require both general and more specific skills. Both types can partly be obtained through work experience and informal learning. However, at least for some functions, people must have acquired certain knowledge and skills before they can enter employment or they need additional training once they have entered the workforce. As far as this concerns professional skills, VET is needed to provide workers with them.

The extent to which VET is critical may depend on characteristics of the firm. For instance, process industries may depend greatly on specialised workers who cannot be employed without considerable skills in process technology. Personal services, on the other hand, may be accessible without specific formal skills. The size of the firm is also relevant; skills needs of small firms are different from those of bigger ones. While large firms can have workers with very specific qualifications, small companies require more flexible employees who are able to lend a hand to a wide range of tasks if needed. This is why an analysis of the benefits of VET at company level will provide additional and different information from analysis at macro level. It also has an added-value relative to the analysis of economic returns on education and training at the individual level because, in the absence of a perfectly flexible labour market, the increase in productivity resulting from training is not entirely reflected in workers' wages. It also has an impact on profitability.

The overall research question was formulated as follows: 'What are the net economic benefits of VET for employers and for economic sectors?'

This can be broken down (i.e. for firms) into more specific questions:

(a) What is the influence of VET on the economic performance of firms? More specifically, what is the effect of VET on such indicators of performance as productivity, profitability, innovation and quality?

(b) What are the different effects of different types of VET? What are the different benefits of different types of VET (such as initial versus continuous training, forms and fields of VET)?

Anticipating the results, we indicate that almost all empirical studies using individual company data to investigate the impact of VET on company performance use either productivity and/or profitability as the dependent variable. The number of studies looking at the impact on innovation, for example, is small.

This study is devoted to answering these questions, by analysing the results of extensive literature about the effects of VET on the economic performance of firms.

1.3. Structure of this report

The structure of this report is a follows. Section 2 presents the theoretical framework which forms the basis for the analysis and discusses important methodological issues. Section 3 presents the results of the meta-analysis we conducted to estimate the influence and relative importance of different factors in determining the effects of VET estimated in literature. Finally, Section 4 summarises the findings and formulates recommendations for further research. The data gathering process is detailed in Annex 1 where the interested reader can also find an in-depth description of the data and relative descriptive statistics.

CHAPTER 2
Theoretical framework

2.1. How can VET influence company performance?

2.1.1. Theory

According to human capital theory (Mincer, 1962; Becker, 1962), education and training bring benefits in higher productivity and higher wages. The theory predicts that workers bear the costs of 'general' education and training and that the benefits completely accrue to them. Workers and share the costs and benefits of specific training. Within this context 'general' means that the skills and competences acquired in education and training can be used in several firms and perhaps even several sectors. Specific training provides competences that are company-specific. So, part of VET will generate general human capital and training may be partly or wholly company-specific. However, vocational education may also be partly company-specific. This is particularly true for dual forms of vocational education in which students spend most of their time working for a firm. According to human capital theory, vocational education may bring profits to firms, although some of the benefits will accrue to the students/workers.

However, even if VET were to be completely 'general', firms may benefit from it. Human capital theory, in its original form, lacks some important features. Owing to market imperfections and risk aversion, individuals may be reluctant to invest in 'general' education and training. In practice, both the State and private companies bear part of the costs of 'general' education and training, including VET. Firms may particularly invest in apprenticeship and continuous training ([4]). This implies that the benefits will only partly accrue to workers and that education and training, and particularly VET, may also bring positive returns for companies. Therefore, VET will not only have an impact on productivity, but also on profitability.

The benefits of training for firms can appear in a wide range of other forms of economic performance. First, education and training may have external effects through innovation and spill-over. This is emphasised by the new growth theories

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([4]) Sometimes firms even enable workers to follow formal education. The costs may be shared. If the firm bears the costs completely there is often an arrangement that workers have to pay the costs back to the firm when leaving the firm within a certain period.

(Barro and Sala-I-Martin, 1995). New knowledge and competences embodied in higher educated workers are often transferred to other workers. The same is true for new knowledge that is embedded in new products. A higher share of workers with a VET background may be favourable for innovation and knowledge transfer. Owing to the external effects involved, benefits will not, or only partly, accrue to workers.

Similarly, if VET adds to the skills of workers this may also affect product quality positively. If VET has a stronger impact on product quality and productivity than on wage costs, it will improve competitiveness.

Third, there are not always enough people with the required education to fill labour demand. Young people may choose education based on the current labour market situation, but later, after completing their education, find out that the situation has changed. One might argue that some forms of VET, particularly apprenticeship and continuous training, avoid such a mismatch (or reduce existing mismatch), because the training takes place in the firm and is directly related to its needs.

Although VET may have the positive effects mentioned, this is still no more than a hypothesis that needs testing. Much research has already been done on the effects on the individual firm. We analyse the results of this research and the background to the conclusions.

2.1.2. Determinants of the effect of VET on company performance

Different studies about the effect of VET on company economic performance will find different effects. The aim of this literature review and meta-analysis is to find out in which cases VET has a positive influence on company development. It is, therefore, important to have in mind which factors can have an influence on the estimated effect of VET. These factors can be characteristics of the object of study itself (the firm, the particular training and particular performance chosen). They can also be embedded in the study methodology.

First, the estimated effect of VET will be related to characteristics of the firm, such as size and sector. The country in which the firms studied are located may also influence the results, because of differences in institutional context.

Second, characteristics of the VET are also relevant: the effects of IVET and CVET on company performance would be expected to be different. The effect of VET is also likely to differ across different forms of training (classroom, on-the-job, internal or external), and across different contents or fields of training (e.g. language training, computer training, sales training). The group at which the training is directed is also relevant, because training effectiveness generally differs for people of different age groups and with different educational backgrounds.

The measure of performance chosen as dependent variable in the analysis will also influence the estimated effect of VET. It is to be expected that the effects of VET will not be the same on productivity, profitability, innovation and capacity so it is important to differentiate between studies which focus on different performance indicators.

Finally, the context in which VET is embedded can also play a role in its effectiveness. There is a body of literature investigating whether training is more effective when integrated in more general HRM practices such as quality circles. The influence of such factors on the estimated effects of VET will be examined.

The role of methodology and of the context is addressed in the two following sections.

2.2. Methodological issues

2.2.1. Endogeneity of VET

The studies collected deal with the impact of VET on selected performance variables at company level. The number of workers with a background in vocational education and participation in training may influence company performance. However, company development may also affect investments in training and the demand for workers with a vocational background. We cannot ignore the possibility that we have to deal with a two-way or simultaneous relationship: this means that we do not know whether high levels of VET lead to high company performance, or the reverse, or both. VET is probably an endogenous variable.

There is evidence that firms choose to train their workers in difficult periods, either to 'give them something to do' in times of low demand, or to improve their HRM practice because they notice that they are not doing well (Dearden et al., 2000). In this case, simply applying ordinary least squares (OLS) would lead to an underestimation of the effects of training. However, if firms are restricted in their training investments, and then they invest in periods of higher cash flows, i.e. in better times, the effects of training will be overestimated if endogeneity is not considered.

More generally, if the number of workers with a VET background and the number of workers to be trained affect productivity, and these variables are chosen by the firm in such a way that profits are maximised or costs are minimised, VET and productivity and profitability are, by definition, intertwined.

In empirical studies, it is of crucial importance to try to correct for the endogeneity of VET to avoid biased estimates of its effect. Different strategies can be used. Box 1 presents the different econometric methods available to tackle the problem . In our sample of studies measuring the impact of training on company performance, all the methods mentioned appear. More information is given in the next chapter.

Box 1. **Econometric techniques to correct for endogeneity**

In 50% of the studies considered in this report, researchers deal with panel data from individual firms. Although some of them use OLS, in most more appropriate estimation techniques are used. In several cases panel data techniques (fixed and random effects, and first differencing) are applied. However, the latter techniques only provide a solution to the endogeneity problem in special cases.

Traditionally, endogeneity has been dealt with by using instrumental variables techniques like two-stage least squares and or by applying (full-information) maximum likelihood. Special techniques have been developed for those cases where a dichotomous explanatory variable is endogenous. Particularly, the two-step procedure developed by Heckman must be mentioned. These techniques can, in principle, also be used in case of cross-section data. However, in our sample most studies based on cross-section data use OLS.

The instrumental variables estimator (and the Heckman variant in the case of a dichotomous explanatory variable) are obvious choices in the context of a linear regression model. However, in practice instrumental variables estimators often suffer from heteroskedasticity (Baum et al., 2003), leading to inefficient estimates and making the usual tests for endogeneity and over-identification restrictions invalid. The generalised method of moments (GMM) has been developed to deal with this problem (Hansen, 1982). This method allows for efficient estimation in the case of heteroskedasticity of unknown form. OLS, instrumental variables and maximum likelihood are all special cases of GMM.

GMM often deals with time-invariant specific effects by first-differencing. However, it has been shown that first-differencing GMM can suffer from large finite sample biases. Blundell and Bond (1998) have therefore developed the system GMM estimator. Monte Carlo simulations have shown that the latter estimator behaves quite well in finite samples.

2.2.2. Methodological differences between studies

Both the object of study and how it is studied have an influence on the estimated effect of VET.

First, attention should be paid to the possible endogeneity of VET, i.e. to the fact that investments in VET can be influenced themselves by company performance. Studies which do not consider such effects are likely to over- or underestimate the effects of VET: we have to pay particular attention to the method used by each study to correct for this endogeneity.

It is also important to register whether the estimated effect of training is a direct effect (the effect of VET in *t* on performance in *t*) or some kind of lagged effect (the effect of VET in *t-x* on performance in *t*). Some studies also construct a 'stock' of VET on the base of investments over several earlier years, and estimate the effect of this stock on company performance. The effects of these three kinds of VET indicators should be different.

It is also relevant to know which control variables have been taken up in the analysis. Controlling, or not, for the educational background of the workforce or for the sector of activity of a given firm can have an important influence on the estimated effects of VET. For instance, if higher educated workers get more training and are more productive, not controlling for the share of higher educated workers in the firm may lead to an overestimation of the effects of training, with part of the effect of higher education on productivity attributed to training.

The kind of data used is also crucial. Panel data offer more possibilities to control for the potential endogeneity of training than cross-section data. The influence which the source of the data can have on the estimated effects is also interesting. Using data collected at company level may lead to results different from those obtained using matched employer-employee data. Similarly, using either administrative data from firms or statistical institutes (about financial results, costs of training, etc.) or data collected by surveying individuals (often managers) about how often employees are trained and how well the firm does compared to its competitors may also influence the results. It is also particularly relevant to know how VET has been measured. The estimated effects of the same training programme will be different depending on whether the researcher has looked at the number of workers trained, the time spent in training, the costs of training, or has simply taken up a dummy to indicate use of this training programme in the firm. It also matters for the effect whether the chosen measure is taken up as absolute number (e.g. the costs of training) or as a ratio to some other relevant number (e.g. the share of the training costs in the wage bill). The number of observations used in the analysis is also relevant in that it provides information about how reliable the results of a given study are. A study based on a thousand or more observations will generally be more reliable than a study based on ten companies.

Finally, the form of the model used is important in determining whether the effects estimated are comparable across studies or not. Even in the case of two studies examining the effect of the same type of training on the same performance indicator, the estimated effects are not directly comparable if the first studies take up variables in levels whereas the other uses logarithms. In the second case, the study directly estimates an elasticity, but not in the first case. This is an important aspect to consider when comparing sizes of effects.

In the meta-analysis, we register these different factors systematically to determine their influence on the estimated effect of VET through a statistical analysis. The method used to conduct the meta-analysis is further described in Sections 4.1 and 4.2.

2.3. Role of the HRM context

The hypothesis at the basis of this study is that investing in VET leads to positive returns for firms. Such returns, however, are likely to depend on the context in which the training takes place: VET embedded in more general human resource practices might be expected to amplify its effects. Appropriate HRM practices can improve employee motivation and identification with the employer company, and, therefore, their willingness to learn and to use what they learned in their work.

Table 1 illustrates how HRM practices, of which training is only one, can influence the behaviour of workers and, indirectly, company performance.

Table 1. **Linking HRM and performance**

HRM practices	HRM outcomes	Behaviour outcomes	Performance outcomes
Selection	Commitment	Effort / motivation	*High:*
Training			Productivity
Appraisal	Quality	Cooperation	Quality
Rewards			Innovation
Job design	Flexibility	Involvement	*Low:*
Involvement			Absence
Status and security		Organisational citizenship	Labour turnover
			Conflict
			Customer complaints

Source: Guest (1997).

The idea behind the hypothesis - that HRM practices increase employee motivation and, therefore, performance - is that workers are not just 'rational egoists', but that their behaviour is also influenced by feelings of belonging and loyalty. Identity economics (Akerlof and Kranton, 2000; 2010) states that worker utility is not affected positively simply by the wage they receive and negatively by the effort they have to make to receive the wage. Identity-utility also plays a role, in the sense that if workers identify themselves with the organisation they work in, i.e. if they derive higher identity-utility from their work, they will need less monetary incentive to do their job well. Employers can mobilise these feelings to enhance worker commitment, in general, and in particular to ensure the success of an investment such as training (Cedefop, 2011b).

There are various mechanisms through which HRM practices, and training in particular, can mobilise feelings of loyalty and belonging among employees. Firms can pay more than the market wage to stimulate employees to effort that is higher than that strictly required by their formal function requirements. Investing in training a worker can be considered as the equivalent to an above-market wage. This can be seen as a form of efficiency wage, or a 'gift exchange' between employer and employee (Akerlof, 1984). In this case, employees view the training as a gift from their employer and feel that they have to react by 'giving' their employer full commitment and effort. One way to conceptualise this higher commitment of workers is 'organisational citizenship behaviour' (Organ, 1988). This means that employees act in the interest of the organisation they work for on their own initiative and that they do more than their formal obligations.

Training being perceived as a gift, as something which triggers commitment to the organisation, seems more likely in a context in which much attention is paid to the 'human factor' in the firm and to the relationship of employees to their employer. This leads to the hypothesis that VET will have greater effect when embedded in better developed HRM practices.

CHAPTER 3
Literature review: general picture of the effects of VET on company performance

3.1. Method

In this section, the set of studies on which we base the meta-analysis (Box 2) is described. We first document the search process, and then state the criteria used to select relevant studies.

Box 2. **What is a meta-analysis?**

Meta-analysis has its origin in health sciences. The original aim of meta-analysis was to extract more reliable information on the effects of a specific treatment by putting together the results of different randomised experiments. In this context, the method used is the same for all studies included, and the influence of the context is minimised by the randomised setting, so that the meta-analysis mainly enables the researcher to increase sample size. In the social sciences, however, randomised experiments are rare, and meta-analyses also have the function of shedding light on the role of different context factors on the measured effect (Kluve, 2010). The methods used to study a given phenomenon in social sciences may also vary a lot, and one additional aim of the meta-analysis is to get more information about how the methodological choices made by the researchers affect the results of the analysis (Stanley, 2001). A large variation in both context factors and methods was observed in literature collected for this report. One particular problem in the meta-analysis is that some crucial context factors, such as the content or the form of the training examined or who received the training, were often not explicitly registered; this limits the number of context factors that could be included in the meta-analysis (i.e, CVET versus IVET, sector, country, company size). Many independent variables included in the present analysis will relate to the method rather than to the context.

Since the effects of VET on company performance found in different studies can be influenced by a wide range of factors (characteristics of the object of study and method adopted) a positive relationship between the presence of VET and company performance cannot be established by simply counting the number of studies which find a positive effects of VET, a procedure sometimes referred to as 'vote counting' (Stanley, 2001). The aim of the meta-analysis is to determine the role and relative importance of these different factors in determining the estimated effects. This is done by pooling together the results of all studies found, to regress the effect of VET on company performance on several relevant explanatory variables. According to Stanley (2001), meta-analysis has some advantages relative to a narrative literature review: it is possible to test statistically which characteristics of the studies matter to the results; it is not necessary to exclude 'low quality' studies a priori, since one can test for the influence of the method used on the results obtained; studies can be weighted according to different methods, and the consequences of the relative weighting strategies can be compared; and it is possible to test statistically for publication bias.

Stanley (2001) describes the meta-analysis method as composed of the following five steps:

1. include all relevant studies. The way we collected literature is described in Section 3.1;
2. choose a summary statistic and reduce the evidence to a common metric. The way the effects of VET found by different studies can be made comparable is addressed Section 4.1, in the paragraph ‘Comparability issues’;
3. choose moderator variables. The moderator variables are the independent variables in the analysis, described in this section. They are the variables from which we expect that they will have an influence on the estimated effect of VET;
4. conduct a meta-regression analysis. The method used to conduct the meta-regression analysis is described in Section 4.1 in the paragraph ‘Estimation method’;
5. subject the meta-regression analysis to specification testing. The results and their robustness are addressed in Sections 4.3 and 4.4.

3.1.1. Search method

We took three successive steps to collect as much as possible literature about the relationship between VET and economic performance of firms.

First, some articles already exist which provide an overview of empirical studies about the benefits of training for employers and firms. Blundell et al. (1999) and Barrett (2001) review studies about the effects of training on company productivity in the framework of a broader overview of benefits of training (including the individual and the macro-level). Hansson et al. (2004) and Bartel (2000) provide a very rich and detailed overview of studies focusing specifically on the benefits of human capital investments for company performance. Such studies provided a natural basis for our literature search: we started with collecting the studies cited in these overviews.

Second, we also looked for additional studies and for the most recent research, which could not have been included in the literature overviews, using keywords in Google Scholar. The search terms we used are presented in Table 2. We conducted searches using combinations of a VET indicator-keyword and a performance-keyword. We also tried adding to these combinations keywords related to the HRM context, such as ‘high performance workplaces’ or HRM, to find studies which relate the effects of VET to the HRM context in which it is embedded.

We used some other features of Google Scholar as our third search step. The ‘related articles’ and ‘cited by’ functions were used on some important articles, such as Bartel (1994), Black and Lynch (1996) and Zwick (2005). These searches were additionally performed limiting the results to recent years only to find more recent research.

Table 2. **Keywords used in the literature search**

VET indicators	Indicators of company performance
VET	company performance
vocational education	company benefits
initial vocational education	enterprise performance
continuous vocational education	productivity
vocational training	profitability
training	profits
on the job training	innovation
off the job training	
human capital investments	
workplace learning	

3.1.2. Inclusion criteria

We used several relevance and usability criteria in the meta-analysis to select studies among literature which came out of the search process.

To be included, studies had to record both the economic performance indicator and VET input. This could be quantified in terms of, for example, proportion of staff trained, training costs, total training days, or at least through qualitative survey questions measuring to what extent a firm makes use of VET (for instance on a Likert scale). One of the consequences of this approach is that most of the selected studies concentrate on formal and non-formal training, but less on informal training; the latter is more difficult to quantify.

The same sort of selection criterion has been used for the influence of the training policy context. We concentrated on studies in which training efforts are quantified, so studies with only some sort of ordinal scale for policy development have not been included ([5]). However, studies combining policy indicators with quantified training in the analysis have been included. More generally, we included many more studies from economics than from HRM, for two main reasons. First, many studies from HRM concern the impact of high productivity workplace or HRM systems. Training is often just one component of these systems (if at all) and its effect is often not estimated separately. Second, many of these studies did not produce estimates of the effects of training usable in our

([5]) In practice, these training policy indicators are highly correlated to company size and sector.

analysis (e.g. share of firms in a given country which indicated that training had improved their performance).

When finding several versions of the same research project, for instance a working paper and a published article, we concentrated on the published article; we used the working paper to provide complementary information when necessary. However, we have also been careful to include research that has not been published in peer reviewed journals, so as to avoid publication bias. We included 18 unpublished working papers in the analysis.

We also systematically excluded some types of study. First, to remain within the scope of the research questions, we excluded studies which examined the effects of VET on productivity at individual, sectoral or national level. Second, we did not include literature examining the effects of VET on turnover and absenteeism, though these are relevant indicators and can have an important effect themselves on company performance. Our focus here, however, is on the size of the direct effect of VET on direct measures of company performance (as named in the Table 2).

Third, we did not consider studies which measure the effect of apprenticeships on company performance during the time of the apprenticeship itself. Such studies are not appropriate to estimating the effect of initial vocational education and training (IVET) on company performance, since training an apprentice also incurs important costs for firms, while the benefits will mainly appear only at a later stage. Therefore, we concentrated on studies in which the effect of the share of workers with an IVET background is measured.

3.1.3. The database

We collected 62 studies, resulting in 264 different estimated effects of VET included in the data set; many studies estimated different models (for different sectors or different VET and performance indicators), and/or took up several training variables in their models. Table 3 shows the distribution of observations across studies. Most studies provided one or two observations in the data set, and only a few provided more than 10 observations.

To get an overview of the results, we summarised the main characteristics and conclusions of the studies in Table A1-A4, in Annex 1. In the following, we give a more general account of the findings of the studies.

Table 3. **Distribution of the number of estimated effects across studies**

Number of estimated effects per study	Number of studies	% of total number of studies
1	15	24
2	16	26
3	5	8
4	7	11
5	5	8
6	4	6
7	2	3
8	2	3
9	1	2
12	2	3
13	1	2
24	1	2
25	1	2
Total	**62**	**100**

3.2. Dependent variable: the effects of VET on performance indicators

3.2.1. Sign and significance

Most studies find that VET has a positive and significant effect on the economic performance of firms. Of all estimated effects included in the database 136 estimated effects of training (i.e. 52.51%) are positive and significant. Of the 62 studies collected, 53 (86.89%) found a positive and significant effect of VET at least once in their estimations. However, this includes all estimation methods, as well as the simplest models which do not correct for potential endogeneity of VET. Only a fifth of the estimated effects are negative and less than a tenth are negative and significant.

Table 4. **Distribution of estimated effects**

Effect found	Observations		Studies	
	Number	% of total	Number	% of total
Negative significant	18	6.95	4	6.56
Negative insignificant	43	16.60	20	32.79
Positive insignificant	62	23.94	28	45.90
Positive significant	136	52.51	53	86.89
Total	**259**	**100.00**	**105**	**172.13**

NB: The total number of studies presented here is higher than 62 because some studies estimate more than one effect.

3.2.2. Comparability of effect sizes

Not only the sign and significance, but also the size of the estimated effects is of interest. However, not all effects estimated in the different studies are directly comparable in terms of size (Section 2.2.2). We observed considerable variety in the types of effects which were estimated. Two types of effects came back regularly across studies. The first type was elasticity: the effect of the log of a measure of training intensity on the log of a measure of company performance. The second type was quasi-elasticity: the effect of a training indicator in levels (e.g. the percentage of workers involved in training) on the log of a measure of performance. These types of effects are found in about two thirds of the studies collected. Elasticities can be computed on the basis of quasi-elasticities, and vice versa, provided we have information on the sample mean of the training indicator used ([6]). This enables us to increase slightly the number of coefficients which are comparable in terms of size. Among the other types of effect estimated, some studies present the marginal effect of a training indicator as estimated in a linear equation (in levels, not in logs), and some present the effects of VET on a constructed performance indicator based on qualitative answers to survey questions.

Table 5. **Types of effects estimated**

Effect found	Observations		Studies	
	Number	% of total	Number	% of total
Elasticity	65	26.10	17	28.81
Quasi-elasticity	101	40.56	23	38.98
Other	83	33.33	27	45.76
Total	**249**	**100.00**	**67**	**113.56**

NB: The total number of studies can be higher than 62 because some studies estimate more than one type of effect.

To obtain effects which are comparable in terms of size, we have to look beyond a particular type of effect (elasticity or quasi-elasticity). First, we had to make sure that all effects get the appropriate sign in our database: a negative estimated effect of VET on scrap rates (Holzer et al., 1993) or on company costs

([6]) If the equation estimated is of the form $\ln(y) = \alpha + \beta x$, the coefficient $\beta = \frac{d\ln(y)}{dx}$ represents a semi-elasticity. The elasticity $\frac{d\ln(y)}{d\ln(x)}$ can be computed as $\frac{d\ln(y)}{d\ln(x)} = \frac{d\ln(y)}{dx/x} = x\frac{d\ln(y)}{dx} = \beta x$

(Kazamaki Ottersten, et al. 1999; Jones et al., 2011) is actually a desirable effect, which should count as positive. For this reason, we multiply the estimated effects in those studies by -1, so that the sign of the estimated effect is in line with that of other studies. A disadvantage of this method is that the resulting effect size can no longer be directly interpreted.

Second, we also had to drop all effects which were only one of many training effects estimated in the same regression. For instance, the coefficient on computer training estimated in a regression in which language training and teamwork training were also included will not be comparable with the coefficient on any training variable taken up as only training indicator in a regression. We registered these effects in our database because they are informative in terms of sign and significance, but we cannot use the estimated size. This way we lose 117 observations in 20 studies. From those studies which estimated the effects of several training indicators in the same regressions, we also included some more general effect of training in our database; this was done when it was available or when it was possible to compute an average effect of training on the basis of the information presented in the article. The latter effect can be compared with 'overall' training effects from other studies. This was possible for 8 of the 20 studies ([7]).

Even after dropping these observations, there are still limitations to the comparability of the remaining effects. The elasticities and quasi-elasticities are still effects of a wide variety of different training indicators, ranging from the share of training costs in a firm's total labour costs to the number of training days received by each trained worker. Several studies estimate effects of dummies (for presence of a particular type of training in a firm) on economic performance. Some estimate the effect of a constructed training variable based on several answers to survey questions about training in the firm. Nevertheless, we have to pool these effects in the analyses below to obtain a sufficient number of observations. However, some training indicators are clearly more informative than others. In general, we consider training indicators which relate the training investment to some measure of labour input in firms (total number of workers, total labour costs, total work hours) as much better than training indicators which

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([7]) The eight studies for which we also have a more general training effect are: Tan and Batra (1996); Holzer et al. (1993); de Kok (2002); Colombo and Stanca (2008); Blandy et al. (2000); Thang (2009); Maliranta and Asplund (2007); Jones et al. (2011). We could not use the estimated effect sizes from the following studies: Aragon-Sanchez et al. (2003); Arvanitis (2005); Ballot et al. (2006); Black and Lynch (1996); Conti (2005); Kurosawa et al. (2005); Ng and Siu (2004); Trouerbach (2009); Turcotte and Rennison (2004); Zwick (2005, 2006, 2007).

do not do so (e.g. dummy indicators, training days per trained worker, (log of) training costs in absolute terms). We pay particular attention to the role played by this aspect in the analysis.

3.2.3. Size of estimated effects

Table 6 presents summary statistics of the estimated effect sizes, for different effect types.

Table 6. **Summary statistics of effect sizes for all VET indicators and all performance indicators pooled together**

Variable	Obs	Mean	Std. Dev.	Min	Max
All effect sizes (excluding effects estimated in regressions with multiple training indicators)	124	0.30	0.93	-0.78	8.08
Quasi-elasticity	42	0.25	0.43	-0.02	2.00
Quasi-elasticity including values calculated from elasticity and sample mean	61	0.29	0.74	-0.06	4.47
Elasticity	33	0.01	0.19	-0.72	0.30
Elasticity including values calculated from quasi-elasticity and sample mean	50	0.02	0.16	-0.72	0.30

Histograms and additional descriptive statistics are included in Annex 2. We observe that the variance of the estimated effects becomes smaller as we move from pooling all effects together to more specific types of effects as elasticities and quasi-elasticities. The variance in estimated effects is smallest for estimated elasticities. The average estimated effect is always positive. The mean quasi-elasticity reported in the Table 6 means that a unit increase in the training variable (which may be share of trained workers, expenditures, etc.) leads to a 0.29% increase in company performance (which may be productivity, profitability, etc.). For elasticities, it is close to zero. The mean elasticity reported here means that a 1% increase in the training variable leads to a 0.02% increase in company performance. The distribution is positively skewed for all types of effects taken together and for quasi-elasticities; it is negatively skewed for elasticities. However, when we include only effects based on a VET indicator related to the total labour input of the firm, which are more reliable, the average estimated effect is positive and the distribution of effects positively skewed for all types of effects (Annex 2). When VET investment is measured in terms of time spent or expenditures, which can also be considered the most precise, and therefore the most reliable method, the average estimated effects are positive (Annex 2).

In Table 7, we also report the estimated effects for more comparable VET indicators. For each VET indicator, we have a much smaller number of observations (see Section 4.3.1), but the interpretation of the estimated effect is clearer. For instance, we find that:

(a) on average, an increase of one percentage point in the share of workers who received training leads to an increase in company performance by 0.16%,

(b) an increase by 1% in the share of labour costs devoted to training is associated with an increase by 0.03% in company performance,

(c) if the time spent on training increases by 1%, company performance will, on average, increase by 0.06%.

Table 7. **Summary statistics of effect sizes for different VET indicators and all performance indicators pooled together**

Variable	Obs	Mean	Std. Dev.	Min	Max
Share of workers who received training					
Quasi-elasticity including values calculated from elasticity and sample mean	10	0.16	0.10	0.04	0.31
Elasticity including values calculated from quasi-elasticity and sample mean	10	0.05	0.05	0.01	0.17
Share of labour costs spent on training					
Quasi-elasticity including values calculated from elasticity and sample mean	4	1.84	2.21	0.01	4.47
Elasticity including values calculated from quasi-elasticity and sample mean	4	0.03	0.03	0.00	0.07
Euros spent on training per worker					
Quasi-elasticity including values calculated from elasticity and sample mean	8	0.00	0.00	0.00	0.00
Elasticity including values calculated from quasi-elasticity and sample mean	8	0.05	0.06	0.00	0.17
Hours spent in training per worker					
Quasi-elasticity including values calculated from elasticity and sample mean	9	0.00	0.01	-0.02	0.03
Elasticity including values calculated from quasi-elasticity and sample mean	9	0.00	0.02	-0.04	0.03
Number of workers (level)					
Elasticity	5	-0.22	0.44	-0.72	0.15
Training expenditures (level)					
Elasticity	4	0.08	0.15	0.00	0.30
Time spent on training (level)					
Elasticity	7	0.06	0.04	0.01	0.12

Obviously, those average effects have to be treated with great caution, given the very limited number of observations on which they are based.

This evidence is obviously not enough to conclude that VET has a positive effect on company economic performance. For instance, if all studies finding a positive effect did not control for the potential endogeneity of VET, we can no longer reach such a conclusion. In the remainder of the study, we will, therefore, examine how the estimated effects of VET vary across several characteristics of the studies collected.

3.3. Control variables: correction for potential endogeneity of VET

Table 8 presents an inventory of the methods used to correct for potential endogeneity of VET. Estimations which did not control for potential endogeneity of VET are registered under ‘ols’ and ‘maximum likelihood’ (e.g. logit or probit without correction for endogeneity). The other categories contain estimations which did control for VET endogeneity. Slightly more than half of the studies (34) found used some method to correct (at least partially) for the potential endogeneity of VET: 19 studies used methods involving instrumental variables (IV, Heckman or most often GMM), and 15 studies used panel data to correct for unobserved company characteristics (by estimating fixed-effects or random-effects model or models in first differences). Thirty-nine studies did not try to correct for the potential endogeneity of VET: they estimated simple linear models or simple logit or probit models. These studies provided 127 (264-133-4) point estimates of the effect of training on company performance.

Table 8. **Number of studies correcting for potential endogeneity of VET**

Correction for endogeneity	Observations		Studies	
	Number	% of total	Number	% of total
Ols	133	50.38	36	58.06
Maximum likelihood	4	1.52	3	4.84
Fixed effects	31	11.74	8	12.90
Random effects	2	0.76	2	3.23
First differences	17	6.44	5	8.06
Gmm	15	5.68	6	9.68
Gmm sys	31	11.74	7	11.29
Instrumental variables	18	6.82	3	4.84
Heckman	13	4.92	3	4.84
Total	**264**	**100.00**	**73**	**117.74**

NB: The total number of studies can be higher than 62 because some studies use more than one method.

Whether a study corrected for the endogeneity of VET or not does not seem to have a tremendous effect on the results, at least in qualitative terms ([8]).The proportion of positive and significant effects is highest among studies using instrumental variables. Studies which used panel methods, however, less often found positive and significant effects of VET ([9]). Still, when weighting the different effects with weights inversely proportional to the number of times that the study they are found in appears in the data set (to avoid giving too much weight to a study which provides a great number of effects), one finds that most studies estimate a positive and significant effect of VET on company performance, both among studies which did not correct for endogeneity and those which used instrumental variables.

Table 9. **Distribution of estimated effects across methods for correcting for endogeneity**

	Negative		Positive		Total
	Significant	Insignificant	Significant	Insignificant	
Unweighted					
No correction for endogeneity	12.21	19.08	22.14	46.56	100
Panel method	2.00	20.00	38.00	40.00	100
Instrumental variables	1.28	10.26	17.95	70.51	100
Total	**6.95**	**16.60**	**23.94**	**52.51**	**100**
Weighted					
No correction for endogeneity	5.46	14.62	15.81	64.11	100
Panel method	3.48	13.54	28.51	54.47	100
Instrumental variables	1.51	13.66	14.50	70.33	100
Total	**3.70**	**14.09**	**17.35**	**64.85**	**100**

3.4. Control variables: different forms of economic performance

The studies collected dealt with a wide range of performance indicators. Most studied the effects of VET on productivity, which was measured in terms of value

([8]) The influence of the estimation method on the size of the estimated effect is addressed in the meta-analysis below.

([9]) There is, however, evidence that fixed-effects may not be the best method to estimate production functions, because taking first or mean differences exacerbates the effect of possible measurement error on the estimated coefficients. This is particularly problematic for highly persistent variables such as capital and training (Griliches and Hausman 1986).

added, gross production or output or sales volumes (in levels or per workers). Most of these focused on productivity in levels, but several studied the effect of VET on productivity growth. Other studies focused on total factor productivity ([10]). The second most examined indicator of company performance was profitability. Product quality, as measured by variables as scrap rates, rates of good pieces, attractiveness of a store as rated by its employees, etc., was also used to measure company performance in some studies. Some other studies focused on a multidimensional indicator of company performance: this was most often an indicator constructed on the basis of answers to qualitative survey questions about different aspects of the productivity of the firm. Three studies examined the effects of VET on innovation, as measured by the number of patents applied for, a dummy for the introduction of a new product, or a dummy for the introduction of innovative practices in the firm. Finally, two studies concentrated on the costs born by the firm, and one on employment growth as an indicator of company development.

Table 10. **Distribution of performance indicators**

Performance indicator	Observations		Studies	
	Number	% of total	Number	% of total
Productivity	163	61.74	42	67.74
Total factor productivity	5	1.89	3	4.84
Profitability	54	20.45	14	22.58
Quality	12	4.55	6	9.68
Multidimensional	8	3.03	5	8.06
Innovation	5	1.89	3	4.84
Company costs	13	4.92	2	3.23
Employment	4	1.52	1	1.61
Total	**264**	**100.00**	**76**	**122.58**

NB: The total number of studies can be higher than 62 because some studies focus on more than one performance indicator.

When the effects are broken down by performance indicator (Table 11), most positive and significant effects are for productivity, innovation, employment growth and multidimensional performance indicators. For quality, profitability and company costs, the evidence is less clear cut. When the different effects are

([10]) Total factor productivity measures reflect output net of the contribution of some combined set of inputs (usually capital and labour). A change in total factor productivity reflects the change in output that cannot be accounted for by the change in the stock of capital and employment. It reflects the contemporaneous influence of various factors: technological progress, innovativeness, economies of scale, managerial skill, and changes in the organisation of production.

weighted (as described above), most positive and significant effects are also found for quality and profitability, but not for company costs. However, the number of observations is so small that caution is advised. Overall, VET seems to have a positive and significant effect on a broad range of indicators for company performance.

Table 11. **Distribution of effects per performance indicator**

	Negative		Positive		Total
	Significant	Insignificant	Insignificant	Significant	
Unweighted					
Productivity	4.32	17.28	22.84	55.56	100
Total factor productivity	0.00	0.00	0.00	100.00	100
Quality	0.00	16.67	33.33	50.00	100
Profitability	20.37	16.67	20.37	42.59	100
Innovation	0.00	0.00	0.00	100.00	100
Company costs	0.00	25.00	75.00	0.00	100
Employment growth	0.00	0.00	33.33	66.67	100
Multidimensional	0.00	14.29	0.00	85.71	100
Total	**6.95**	**16.60**	**23.94**	**52.51**	**100**
Weighted					
Productivity	2.49	15.11	19.70	62.70	100
Total factor productivity	0.00	0.00	0.00	100.00	100
Quality	0.00	11.46	17.71	70.83	100
Profitability	13.92	14.50	20.12	51.46	100
Innovation	0.00	0.00	0.00	100.00	100
Company costs	0.00	25.00	75.00	0.00	100
Employment growth	0.00	0.00	33.33	66.67	100
Multidimensional	0.00	22.73	0.00	77.27	100
Total	**3.70**	**14.09**	**17.35**	**64.85**	**100**

3.5. Control variables: forms of training

3.5.1. CVET versus IVET

The distinction between initial vocational education and training (IVET) and continuous vocational education and training (CVET) is important. We tried to find studies examining the effects of both kinds of VET on the economic performance of firms. We found few studies on the effects of IVET, though there are several on the costs and benefits of apprenticeship training. However, for an adequate picture of the effects of IVET on company economic performance, it is more appropriate to have an idea of the benefits to firms in terms of, for example, the productivity of those workers who have completed apprenticeship training. Unfortunately, most studies on productivity by the composition of the workforce only focus on education level and have no coverage of the vocational aspect. In the end, we found only five studies which explicitly examined the effect of IVET on company economic performance: Baker and Thompson (1995); Leiponen (2000); Jones (2001); Hempell (2003) and Zwick (2007).

Table 12. **Distribution of CVET versus IVET**

	Observations		Studies	
	Number	% of total	Number	% of total
CVET	256	96.97	58	93.55
IVET	8	3.03	5	8.06
Total	**264**	**100.00**	**63**	**101.61**

Overall, there is more evidence of a positive effect of IVET on company performance than of a negative one, but the available evidence is limited and not very strong (Box 3).

Box 3. **Effects of IVET on company performance: main results from literature**

Jones (2001) finds that the effect of the share of workers having received IVET has a positive and significant effect on productivity in the manufacturing sector in Ghana. She even finds evidence that workers with vocational education are more productive than those with secondary education, despite the fact that the latter have received more years of education. She does not, however, correct for potential endogeneity of IVET.

Baker and Thompson (1995) find that GP practices which train future GPs in the UK are also significantly more likely to introduce innovative methods. The direction of the causality relation is, however, not determined in this study. The other three studies used advanced methods (GMM) to correct for the potential endogeneity of VET.

Hempell (2003) finds positive and significant effects of the share of workers with vocational education on value added of firms in the business-related and distribution services sector in Germany. Interestingly, he finds no significant effect of CVET on value added, but a cross-term of investment in training with the share of workers having received vocational education has a positive and significant effect. This suggests synergies between IVET and CVET.

Leiponen (2000) estimates the effect of the share of workers with a technical or natural scientific degree (vocational or higher) on the net profit margin of manufacturing firms in Finland. The estimated effect is positive and insignificant, but becomes significant when only higher degrees are considered.

Zwick (2007) finds that the share of employees with a secondary vocational degree has, on average, a negative and significant effect on profits per employee in firms of all sectors in Germany. This conclusion is independent of the estimated method used (OLS, panel data methods or GMM).

3.5.2. Form of training

In general, the literature examined contained very little information about the form of the training studied. This is clear from the size of the 'unknown' categories in Table 13.

Table 13. **Distribution of different forms of training examined**

	Observations		Studies	
	Number	% of total	Number	% of total
Training form				
On the job	10	3.82	8	12.90
Classroom	45	17.18	10	16.13
Informal	2	0.76	1	1.61
Combination	2	0.76	2	3.23
Other	9	3.44	3	4.84
Unknown	194	74.05	48	77.42
Total	**262**	**100.00**	**72**	**116.13**
Internal versus external training				
Internal	19	7.22	6	9.68
External	17	6.46	6	9.68
Combination	1	0.38	1	1.61
Unknown	226	85.93	61	98.39
Total	**263**	**100.00**	**74**	**119.35**
Instructor				
Internal	4	1.52	2	3.23
External	17	6.44	3	4.84
Unknown	243	92.05	61	98.39
Total	**264**	**100.00**	**66**	**106.45**

NB: The total number of studies can be higher than 62 because some studies focus on more than one form of training.

All studies concentrated on employer-provided training, or at least we suppose so from the fact that data on training participation were obtained from employers: this was not generally made explicit. Most studies did not explicitly address the training in terms of formal, non-formal and informal. However, to have some sort of measurable effect, it is crucial that VET input has been registered. This means that informal training has not been included in the studies, because it is more difficult to quantify; only one study explicitly addressed informal training. Aspects of training which were sometimes registered in the studies we found are presented in Table 13. We classified the different forms encountered into: training on the job (including such activities as watching others and job rotation); classroom training (including quality circles, seminars and talks); informal training; and other (including training leave, distance learning).

Even when grouping the information in such broad categories, the number of observations for each category remains very small.

Some studies also registered whether the training examined was external or internal. This included aspects such as whether the training group was exclusively composed of employees of the firm or also of other persons, or whether the training was company-specific or more general. Some studies registered whether the instructor of the training was external or internal to the firm.

The estimated effects of on-the-job training are generally positive. It seems that correcting for potential endogeneity of VET leads to less positive estimated effects of on-the-job training. However, the limited number of studies found and the great variation in countries examined and methods used makes firm conclusions difficult (Box 4).

Box 4. **Effects of on-the-job training on company performance: main results from literature**

Barron et al. (1989) and Blandy et al. (2000) both find positive and significant effects of on-the-job training for new employees on productivity growth, the former in the US and the latter in Australia. Yang et al. (2010) estimate a positive and significant effect of on-the-job training on total factor productivity in the electronics sector in China. Aragon-Sanchez et al. (2003) conclude that on-the-job training has a positive and significant effect on benefits and profitability in several EU countries. However, most studies do not control for the potential endogeneity of VET. Kurosawa et al. (2005) find a negative and insignificant effect of on-the-job training on value added in the manufacturing sector in Japan. They all estimate pooled OLS models, except for Yang et al. (2010) who estimate a random effects model.

Studies which use more reliable methods find less significant effects. Dostie (2010), using both a fixed-effects and a GMM method, finds positive but insignificant effects of on-the-job training on production in Canada. Zwick (2005), who estimates a fixed-effects model, finds negative and weakly significant effects of on-the-job training on value added of firms in Germany. Turcotte and Rennison (2004) is the only example of a pooled OLS estimation finding negative and insignificant effects of on-the-job training on value added per worker.

The evidence about the effects of classroom training on company performance is also positive. The link between the estimated effects and the estimation method is less clear here. Studies using only OLS find both positive significant and less clear effects (e.g. Turcotte and Rennison, 2004; versus Harel and Tzafrir, 1999), and the same is true of studies using GMM (e.g. Dostie, 2010; versus Konings and Vanormelingen, 2010). Overall, there is evidence that classroom training has a positive effect on company performance (Box 5).

Box 5. **Effects of classroom training on company performance: main results from literature**

Konings and Vanormelingen (2010) find that training has a positive and significant effect on value added in Belgium. Harel and Tzafrir (1999) also estimate positive and significant effects of 'systematic and formal' training on perceived organisational and market performance of firms in the public and private sector in Israel. Murray and Raffaele (1997) conclude that classroom-provided quality training had positive and significant impact on the quality of products in vitreous china production facilities in the US.

Three studies find less clear-cut evidence. Turcotte and Rennison (2004) find positive but insignificant effect of in-class training on value added per worker in Canada. Dostie (2010) finds positive effects of classroom training on production in the same country. They are significant in a standard fixed effects model, but insignificant when the model is estimated with GMM. Zwick (2005) estimates the effects on value added of different classroom courses in Germany. He finds that formal external courses have a positive and significant effect. Formal internal courses also have a positive significant effect, but only for a one-year lagged training variable, not for the two-year lag. Seminars and talks are found to have no significant effect. Quality circles have a positive estimated effect on value added, but this is only significant for a two-year lagged indicator.

Van de Wiele (2010) finds positive and significant effects of formal training which does not take place on the job on over- or underperformance of firms relative to others in terms of productivity in Belgium, in manufacturing and services. Kurosawa et al. (2005) find a positive and significant (at the 10% level) effect of 'off-the-job' training on value added in Japan in manufacturing. Trouerbach (2009) only finds insignificant effects of 'off-the-job' training on productivity and service quality in Dutch pharmacies.

Two studies examine the effects of training consisting of both on-the-job and classroom activities. They both find positive and significant effects on productivity, the one for Canada (Dostie, 2010), and the other one for Ghana (Jones, 2001).

Only Trouerbach (2009) explicitly investigates the effect of informal training (i.e. percentage of working time spent on instructive tasks). She finds no significant effect on performance in Dutch pharmacies.

Other forms of training also feature. Aragon-Sanchez et al. (2003) find that the granting of a training leave to workers has a negative and significant effect on company benefits, and no clear effect on sales, and that distance learning has a negative and significant effect on profitability and benefits. This result can probably be explained by the fact that they estimate the effects of training in the same year as it takes place, and that training leave and distance learning are likely to be used for longer-lasting courses, the effects of which are likely to appear later. Zwick (2005) finds a positive but insignificant effect of self-induced learning on value added in German firms.

3.5.3. Internal versus external training

There is no evidence that external training would be better than internal training or vice versa: both seem to have generally positive effects on company economic performance. Literature indicates a majority of positive significant effects for both internal and external training (Box 6).

Box 6. **Effects of external and internal training on company performance: main results from literature**

Aragon-Sanchez et al. (2003) find that training inside the company by an outside trainer has a positive and significant effect on sales volume and benefits, that training outside the company has a positive significant effect on sales, and that training inside the company by an in-house trainer has a positive significant effect on benefits. Barrett and O'Connell (2001) conclude that general training has a positive significant effect on the production of firms in manufacturing, construction and private services in Ireland, however, they find no significant effect of company-specific training. Böheim et al. (2009) estimate a positive significant effect of in-house training on production per hour worked in Austrian firms, and a positive but insignificant effect of external training. Zwick (2005) concludes that formal external courses have a positive significant effect on value added; formal internal course also are found to have a positive and significant effect, but only for one-year lagged values, not for two-year lags. Finally, Konings and Vanormelingen (2010) find positive and significant effects of training at a specific training place (not on the workplace or self-study), which can be considered external training. Jones et al. (2011) find no significant effect of training on the performance of Finnish banks, neither general nor bank-specific. Maliranta and Asplund (2007) find positive and significant effects of both internal and external training on productivity and profitability in Finland, but only for firms which implemented process innovation. Finally, Bryan (2006) finds positive and significant effects of in-house training on sales growth in British manufacturing. External management training has no effect on short-term sales growth, but a positive and significant effect on long-term survival of the firm.

3.5.4. Content of training

The content of the training examined was mostly not recorded in the studies we found.

Table 14. **Number of studies which recorded training content**

Was content of training recorded?	Observations		Studies	
	Number	% of total	Number	% of total
no	223	84.47	53	85.48
yes	41	15.53	13	20.97
Total	**264**	**100.00**	**66**	**106.45**

NB: The total number of studies can be higher than 62 because some studies estimate both effects which consider the content of training and effects which do not.

In those studies which explicitly named the fields of the training examined, a great variety of fields was observed: the one which received most attention in literature was ‘soft’ skills. The evidence is mixed as regards the effect of training for ‘soft skills’: there is generally as much evidence of positive effects as of no effect (Box 7). This may be partially explained by the fact that the effects of this kind of training only appear in the longer term, and therefore could not be captured in the setting of the studies named above.

Box 7. **Effect of training in ‘soft skills’ on company performance: main results from literature**

Böheim et al. (2009) find that the share of training hours spent on personal skills (cooperation, interview training, etc.) has a positive and significant effect on production. Dostie (2010) also finds some positive effects on production of team-building activities. However, he finds no significant effect of managerial training, and even negative effects of training in group decision-making/problem-solving and orientation for new employees, although he corrects for the potential endogeneity of training in the estimation method. Black and Lynch (1996) find no significant effect of teamwork training and managerial training on sales in the US. Ng and Siu (2004) find positive and significant effects of managerial training on the productivity of Chinese manufacturing firms. Bryan (2006) examines the effect of management training in the British manufacturing sector, and finds no significant effect on short-term sales growth, but a positive and significant effect on long term survival.

Computer training is also a field that received much attention in literature. The evidence about the effects of computer training on company performance is mixed (Box 8).

Box 8. **Effect of computer training on company performance: main results from literature**

Turcotte and Rennison (2004) find positive and significant effects from computer training on value added per worker in Canada. Dostie (2010) also finds for Canada that training in computer software has a positive significant effect on production. However he finds no significant effect of training on computer hardware. Arvanitis (2005) finds a positive and significant effect of computer training on productivity in Switzerland. Black and Lynch (1996) estimate positive effects of computer training on sales, but these are only weakly significant (at the 10% level) in the non-manufacturing sectors, and not significant in the manufacturing sectors in the US. Finally, Böheim et al. (2009) finds a negative and significant effect on production of the share of training hours spent on IT training.

The effects of training in sales and marketing are also examined in several studies. Based on limited evidence, it seems that training in sales and marketing has positive effects on company economic performance (Box 9).

Box 9. **Effect of training in sales on company performance: main results from literature**

Dostie (2010) finds that training in sales and marketing has a positive effect on production. Russell et al. (1985) also find that training in basic sales procedures has a positive and significant effect on sales volumes per employee in the retail sector in the US. Böheim et al. (2009) find some positive effects on production of the share of training hours spent on marketing training. Only Aragon-Sanchez et al. (2003) find negative and significant effects of training in sales techniques on profits and profitability of firms. This may be related to the fact that they do not correct for the potential endogeneity of training.

Three studies examine the effects of VET received in a technical field. Evidence on the effects of such training is very limited and the results not very positive (Box 10).

Box 10. **Effect of technical training on company performance: main results from literature**

Böheim et al. (2009) look at the effects of the share of training hours spent on technical training. Leiponen (2000) estimates the effects of the share of workers holding a technical or natural scientific degree in manufacturing firms in Finland. Ng and Siu (2004) estimate the effect of technical training on productivity in manufacturing in China. Böheim et al. (2009) and Ng and Siu (2004) find no significant effect. Leiponen (2000) finds a positive effect, but it is only significant for higher degrees.

Several studies only look at the content of the training to focus on training directly related to company production. It is not a very surprising result that training directly related to production has a positive effect on company economic performance (Box 11).

Box 11. **Effect of training directly related to company production on company performance: main results from literature**

Lyau and Pucel (1995) concentrate on training directly related to production (no fire safety or language training) in auto parts manufacturing in Taiwan, and find a positive and significant effect on value added per worker. Dostie (2010) finds positive and significant effects of professional training (when received in the classroom). Aragon-Sanchez et al. (2003) find that the transmission of specific skills has a positive and significant effect on sales. Murray and Raffaele (1997) also find positive and significant effects of a specific quality training programme on product quality. Ng and Siu (2004) find that job-related training has a significant positive impact on productivity in manufacturing firms in China.

3.5.5. Overview effects by type of VET

Table 15 summarises the evidence presented above. Most types of VET are found to have positive effects on company performance, except for informal learning, training in soft skills, computer training, and technical training. However, the number of studies collected for each type of training is so limited that caution in making firm conclusions is required.

Table 15. **Overview of effects found for different types of VET**

Type of training	Number of studies	Effect found
IVET	5	More positive than negative
On-the-job	7	Rather positive effects, correcting for endogeneity leads to less positive effects
Classroom/off-the-job	9	Rather positive effects, not sensitive to correction for endogeneity
Combination of on-the-job and classroom training	2	Positive significant effects
Informal learning	1	No significant effect
Internal (or company-specific) training	6	Majority of positive effects
External (or general) training	5	Majority of positive effects
Soft skills	5	Mixed evidence
Computer training	5	Mixed evidence
Sales and marketing	4	Positive effects
Technical training	3	Mostly insignificant
Job-related	5	All positive significant

3.5.6. Target group of training

Most of the studies examined did not pay explicit attention to who received the training. Of those studies which did, three concentrated exclusively on a particular target group and four examined how the effects of training differed across target groups.

Table 16. **Number of studies which recorded target group**

Target group recorded	Observations		Studies	
	Number	% of total	Number	% of total
No	231	87.5	57	91.94
Yes	33	12.5	7	12.90
Total	**264**	**100.00**	**64**	**104.84**

NB: The total number of studies can be higher than 62 because some studies estimate both effects which consider the target group of training and effects which do not.

On the basis of the available evidence, it is difficult to determine which groups benefit most from training (Box 12).

Box 12. **Effects of the training of different target groups on company performance: main results from literature**

Barron et al. (1989) and Blandy et al. (2000) concentrate on training given to new employees, finding positive and significant effects. Delery and Doty (1996) concentrate on loan officers, because of their central function in the banking sector which is the object of their study. They find no significant effect of the training provided.

Ballot et al. (2001) examine the effects of the training stock received by different occupational groups in France and Sweden. They conclude that the effects of training are positive and significant for both managers and non-managers, and for technicians. The effect is only insignificant for the category 'other'. Trouerbach (2009) finds no significant effect of training in Dutch pharmacies, neither for assistants nor for support staff. Colombo and Stanca (2008) also estimate the effects of training for different occupations in Italy. They find positive and significant effects of training for workers and blue-collar workers, and no significant effects for clerks, white collar workers and executives. This is consistent with the hypothesis that training benefits most those who have received less initial education. However, Tan and Batra (1996), examining the effects of training in various non-OECD countries, find positive significant effects for the skilled, and no effect for the unskilled.

3.5.7. Training investment measurement

The estimated effect of VET may also depend on how the training investment is measured. The indicator used most often was the number of workers trained. Other indicators were training expenses, the time spent in training, or an indicator variable registering whether a given form of training took place in a given firm. A limited number of studies constructed a multidimensional training indicator using answers to survey questions on the training efforts of the firm.

Table 17. **Distribution of VET indicators**

	Observations		Studies	
	Number	% of total	Number	% of total
Number of workers trained	74	28.03	27	43.55
Time spent in training	57	21.59	17	27.42
Expenditures	66	25.00	22	35.48
Indicator variable	49	18.56	14	22.58
Multidimensional indicator	18	6.82	7	11.29
Total	**264**	**100.00**	**87**	**140.32**

Every VET indicator indicates a majority of positive and significant effects, except for VET measured in terms of time spent in training, where most estimated effects are insignificant. This is true for both weighted and unweighted percentages.

Table 18. **Distribution of estimated effects by VET indicator**

	Negative		Positive		Total
	Significant	Insignificant	insignificant	Significant	
Unweighted					
N of workers trained	6.76	13.51	20.27	59.46	100
Time spent in training	1.79	33.93	30.36	33.93	100
Expenditure	6.25	12.50	32.81	48.44	100
Dummy	14.58	12.50	14.58	58.33	100
Multidimensional indicator	5.88	0.00	11.76	82.35	100
Total	**6.95**	**16.60**	**23.94**	**52.51**	**100**
Weighted					
N of workers trained	7.84	12.81	17.14	62.21	100
Time spent in training	0.37	29.79	23.26	46.58	100
Expenditure	2.60	8.78	23.94	64.68	100
Dummy	2.60	14.80	8.06	74.54	100
Multidimensional indicator	0.75	0.00	7.46	91.79	100
Total	**3.70**	**14.09**	**17.35**	**64.85**	**100**

3.5.8. Direct versus lagged effect of VET

It may take time before the effects of training on company performance become visible. Therefore, the time elapsed between measurement of training and measurement of performance in the studies may also have an influence on the estimated effect of VET. More than half of the studies computed the effect of training on economic performance over the short term, i.e. both variables were measured in the same year. Several studies used lagged training variables, often from the year before and sometimes from earlier years. Nine studies estimated the effect of a stock of training, resulting from investment in training in a series of preceding years.

Table 19. **Distribution of estimation periods**

Performance indicator	Observations		Studies	
	Number	% of total	Number	% of total
Short term	169	64.02	39	62.90
Lagged effect	57	21.59	21	33.87
Stock effect	38	14.39	9	14.52
Total	**264**	**100.00**	**69**	**111.29**

Most estimated effects are positive and significant for all estimation periods. In the unweighted counts, there appears to be mainly insignificant effects of training stocks, which is surprising. However, when the percentages are weighted to avoid overrepresentation of studies which report many estimated effects, this result disappears. Still, the share of positive and significant effects is highest for lagged effects, and not for stock effects, as expected. However, the number of observations is too small to be conclusive.

Table 20. **Distribution of estimated effects by estimation period**

	Negative		Positive		Total
	Significant	Insignificant	Significant	Insignificant	
Unweighted					
Short term	10.30	12.73	19.39	57.58	100
Lagged effect	1.75	19.30	22.81	56.14	100
Stock effect	0.00	29.73	45.95	24.32	100
Total	**6.95**	**16.60**	**23.94**	**52.51**	**100**
Weighted					
Short term	5.48	15.62	17.98	60.91	100
Lagged effect	1.50	12.56	12.20	73.74	100
Stock effect	0.00	10.11	25.84	64.04	100
Total	**3.70**	**14.09**	**17.35**	**64.85**	**100**

3.5.9. Interaction between VET and HRM

Our analysis concentrates on company investments in VET, excluding studies which examine the effects of more general HRM policies. However, the extent to which HRM policy can help reinforce VET effects is of great interest for our study. A non-negligible number of studies (23) take up HRM practices as control variables in the analysis. It is not always possible, however, to determine how HRM policy influences the effects of VET.

Table 21 **Effects of the interaction between VET and HRM**

Performance indicator	Observations		Studies	
	Number	% of total	Number	% of total
Negative	2	0.76	1	1.61
No effect	4	1.52	3	4.84
Positive	12	4.55	5	8.06
Not applicable	246	93.18	58	93.55
Total	**264**	**100.00**	**67**	**108.06**

Information was found In eight studies. The general finding is only slightly more evidence of the positive effects of VET on company performance being enhanced in presence of appropriate HRM strategies than of the HRM context having no effect. Still, the evidence available is limited (Box 13).

Box 13. **Interaction between VET and HRM: main effects from literature**

Russell et al. (1985) estimate the effect of cross-terms of training investment with measures of supervisory support and merchandising support, and find no significant effects of those cross terms on sales per employee in the retail sector in the US. This suggests that the effect of VET is not dependent on the HRM context. The other studies, however, all find evidence of an interaction between training and HRM. Bartel (1989) concludes that the effect of training on output per worker in the US is no longer significant when one controls for an HRM practice consisting of screening employees through formal test before hiring. Screening and training are positively correlated; it seems that firms are rather more productive because they screen their employees than because of their training investments. Delaney and Huselid (1996) also examine the effect of the interaction between training and staffing selectivity. They find no effect of this interaction on company performance, except for organisational performance, where it has a positive and weakly significant effect (10% level) in one case. In any case, the introduction of this interaction term does not affect the effect of training very much. Thang (2009) includes in his estimation cross-terms of training with indicators of different company strategies (cost strategy, quality strategy, flexibility strategy). He finds no significant effect, neither of training nor of the cross-terms. The only exception is the cross-term with quality strategy in the manufacturing sector. This suggests that training is only effective in this sector when combined with a quality strategy.

Several other studies which examine the role played by HRM on the effects of training find evidence of positive synergies. Aragon-Sanchez et al. (2003) find evidence that the HRM context matters: a variable indicating that training actions are isolated rather than included in a training plan has a negative, weakly significant (10% level) effect on sales, while cooperation in training with other firms is found to have a positive and significant effect on both benefits and profitability. Several studies even conclude that VET is only effective in the presence of a broader HRM strategy. Cosh et al. (2000) find that the effect of training on employment growth is only significant in firms which also use total quality management or quality circles. De Kok (2002) includes a cross-term of training with training support per working day in analysing the determinants of productivity in manufacturing in the Netherlands. This cross-term has a positive and significant effect, whereas the number of training days alone has not. He concludes that training only has effect when accompanied by training support. Nikandrou et al. (2008), analysing the determinants of perceived company performance in 14 European countries, find that training in itself has no significant effect on company performance, but that a cross-term of employee training with strategy formalisation (i.e. the degree to which the firm’s strategy is formalised) has a positive and significant effect. This suggests that training only has effect in the context of a clearly formalised company strategy. However, a cross-term of employee training with the strategic character of HRM (i.e. the degree to which HRM plays a strategic role in the firm’s policy) is not found to have any significant effect.

3.6. Control variables: characteristics of the firm

3.6.1. Sector of activity

More than half of the studies we found included all (for profit) sectors of the economy in their analysis. Three quarters of those studies include controls for the sector in the analysis, which seems an appropriate strategy, given that most studies look at very broad parts of the economy. Many studies concentrated on manufacturing sectors; few examined the services sector. Four studies also examined manufacturing and all other sectors as well.

Table 22. **Distribution of sectors of activities**

Sector of activity	Observations		Studies	
	Number	% of total	Number	% of total
All	113	47.28	32	52.46
Manufacturing	63	26.36	24	39.34
Services	48	20.08	9	14.75
All but manufacturing	15	6.28	4	6.56
Total	**239**	**100.00**	**69**	**113.11**

The effects of VET are mostly found to be positive and significant in the studies looking at the whole of the economy and manufacturing. Studies examining the effects of VET in services sectors and all sectors other than manufacturing more often find insignificant and negative effects. However, these sectors have been studied much less, which makes the comparison with manufacturing and the whole economy unbalanced.

Table 23. **Distribution of effects of VET by sector**

	Negative		Positive		Total
	Significant	Insignificant	Significant	Insignificant	
Unweighted					
All	3.60	13.51	20.72	62.16	100
Manufacturing	0.00	11.48	26.23	62.30	100
Services	4.26	31.91	42.55	21.28	100
All but manufacturing	0.00	40.00	20.00	40.00	100
Total	**2.56**	**18.38**	**26.50**	**52.56**	**100**
Weighted					
All	4.16	11.73	15.78	68.33	100
Manufacturing	0.00	12.29	18.43	69.28	100
Services	6.41	24.57	22.86	46.15	100
All but manufacturing	0.00	37.50	17.50	45.00	100
Total	**2.96**	**14.33**	**17.64**	**65.07**	**100**

3.6.2. Company size

About half (26) of all the studies we found consider all kinds of companies, without consideration of size. Five studies included only firms below a given size. From this limited evidence it is difficult to conclude anything about the specific effects of VET for small firms, except that they appear rather positive (Box 14).

Box 14. **Effects of VET in smaller firms: main results from literature**

Baker and Thompson (1995) examine GP practices, which are generally small organisations, and find positive and significant effects of VET on innovation. Bryan (2006) looks at firms with less than 100 workers in the UK, and finds positive and significant effects of training on sales growth. Aragon-Sanchez et al. (2003) studied only firms with up to 250 workers. They examine the effects of several training variables, finding mainly positive and significant effects. Cosh et al. (2000) and Holzer et al. (1993) include only firms with less than 500 workers. The former finds mixed evidence (from insignificant to positive significant) of the effects of training on employment growth. The latter finds a positive and significant effect of training on product quality in manufacturing firms in the US.

A bigger number of studies (28) had a minimum size as limit for the inclusion of firms in their research. We observed major variation in this lower bound, from two workers to 500. The correlation between the lower bound in a study and a scale qualifying the effect found in the study (ranging from 1 for negative significant to 4 for positive significant) is positive (0.12). This correlation is significant at the 10% level. This suggests that training has a higher probability of bringing significant positive effects in bigger firms.

Table 24. **Distribution of lower bounds for company size**

Lower bound for company size	Observations		Studies	
	Number	% of total	Number	% of total
Not applicable	143	54.17	36	58.06
2	15	5.68	2	3.23
5	10	3.79	3	4.84
10	42	15.91	4	6.45
20	28	10.61	6	9.68
50	3	1.14	2	3.23
100	13	4.92	5	8.06
200	5	1.89	3	4.84
250	1	0.38	1	1.61
500	2	0.76	1	1.61
200 biggest manufacturing Firms in Sweden	2	0.76	1	1.61
Total	**264**	**100.00**	**64**	**103.23**

Most studies (44) control for the size of the firm (in terms of labour input) in the analysis. This is a desirable strategy, especially in studies which include firms of very different sizes.

3.6.3. Country

The country in which a firm is situated may also be relevant to the effects of VET. Literature that we found examined a broad range of different countries (26), with the consequence that the evidence for each country is limited. A significant group of studies (11) examined the effects of VET in the US. France and Germany were each addressed in five of the studies we found. Three studies pooled data from several countries in their analysis.

Table 25. **Countries examined in the studies**

	Unweighted (number of observations)	Weighted (number of studies)
Australia	6	2
Austria	10	2
Belgium	21	3
Canada	8	2
China	7	3
Columbia	3	0.2308
Finland	29	3
France	13	4.9
Germany	14	5
Ghana	1	1
Indonesia	3	0.2308
Ireland	5	1
Israel	2	1
Italy	9	2
Japan	2	1
Malaysia	7	1.231
Mexico	3	0.2308
Netherlands	16	3
Portugal	1	1
Spain	3	2
Sweden	6	2.1
Switzerland	2	1
Taiwan	5	1.077
UK	18	4
US	34	11
Vietnam	8	1
several countries	28	3
Total	**264**	**62**

NB: Some countries are only one of several countries examined in one study. In this case, they weigh less than 1 in the weighted counts.

CHAPTER 4
Meta-analysis: background and determinants of the effects of VET and workplace training on company performance indicators

4.1. Empirical strategy

The discussion of the empirical results is organised around two main hypotheses, taking the constraint imposed by the data into due consideration:

Hypothesis 1: When is the relationship between VET and company performance measures more likely to be positive?

Hypothesis 2: Does the (positive) impact of VET on company performance vary with the intensity of the investment in VET (share of employees trained, expenditure, and time spent in training)?

Comparability issues between the impacts of VET are at the base of these formulations.

There is a great degree of heterogeneity between studies, with problems illustrated by the following example: it is, at best, difficult to compare the effect of on-the-job training on productivity with the effect of computer training on innovation capacity.

To work around this issue this study took a broad view on the impact of VET. Only the sign (and significance) of the impact of VET on the performance measure would be registered, regardless of the actual measure of company performance (profits, innovation capacity, value added per worker) and of the actual measure of VET (monetary measure of training cost, share of the workforce trained).

In the simplest test of hypotheses, an indicator variable signalling a positive VET impact is used as the dependent variable and regressed against the independent variables (introduced in Sections 3.3-3.6) for hypothesis 1, adding a measure of the intensity of the investments in training when dealing with hypothesis 2.

Given that, most of the time, the dependent variables register only the presence of a positive (and significant) impact of VET on company performance, the workhorse model of the analysis is the binary logit model. The estimation of a limited dependent variable model on a small number of observations (n=204) might deliver unreliable coefficient, so the results of the logit were compared with those from a linear probability model, which is less demanding. The linear probability model was used for robustness and not as the main model because more than 10% of the predicted outcomes were either bigger than 1 or smaller than 0 ([11]).

In a third modelling exercise, the impacts of VET on performance indicators were organised into three groups: negative significant effects, non-significant effects (both positive and negative), and positive significant effects. In the assignment procedure priority was given to the significance level. It can happen that the absolute value of a positive non-significant coefficient is larger than the absolute value of a positive significant coefficient. However, since the former cannot be (statistically) distinguished from zero, while the latter can be assumed to be larger than zero, the positive but significant effect will be ranked as larger than the positive but non significant effect. This must be kept in mind when the results of the multinomial logit models used for the estimations are discussed.

A smaller sample of studies measured the impact of VET on performance indicators by means of quasi-elasticities. Since the impact measures are relatively homogenous in this sub-sample, the binary dependent variable was changed into an ordinary variable (representing the quasi elasticity, the effect of VET on the relevant performance indicators) so that an estimate of the impact of control variable on the size of the impact of VET on the performance indicator could be obtained (by means of ordinary least squares).

Three different strategies were used to account for the heterogeneity of the studies. The first one treats all observations in the same way; these are not weighted (all have the same weight) and the standard errors are computed in a standard manner.

Some studies contribute to the database estimates of the effects of VET resulting from very different estimation techniques and referring to different VET indicators. To avoid the result of the meta-analysis being excessively influenced by these very heterogeneous studies, we assign to each observation from a given study a weight inversely proportional to the total number of observations in the database derived from this same study; this reduces the importance of studies containing many different estimates from many different models.

The final modelling strategy accounts for the fact that all the results (the impacts of VET on performance indicators) contained in a given study are likely

([11]) Kluve (2010) also estimates probit models with few observations (ranging from 70 to 137) in his meta-analysis of the effects of active labour market programmes.

to be influenced by similar unobservable factors (the variance of the disturbances of results from a given study is correlated), by computing clustered standard errors (each study is a cluster).

4.2. Hypothesis 1: factors influencing the probability of a positive impact of VET on company performance indicators

In this section, we test the first hypothesis: what factors increase the likelihood of a positive impact of VET on company performance indicators? We first estimate a general model for the probability of observing a positive and significant effect of VET on company performance. We then focus on the size of the estimated effect.

4.2.1. Probability of finding a positive and significant effect

Table 26 presents the results of the estimation of a binary logit model with the probability that the estimated effect of VET is positive and significant as a dependent variable.

Studies focussing on IVET (apprentices) appear more often to find positive and significant effects on company performance. The same is true of studies with a higher lower bound for the size of firms, i.e. examining bigger firms. Studies examining non-manufacturing sectors have less probability of finding positive and significant effects of VET; however, such results should be treated with caution because of the well-known difficulties in measuring productivity in the service industries. Focusing on the manufacturing sector has a positive but insignificant effect on this probability. Whether the study took place in an OECD country or not does not appear to affect the results.

Ideally, we would have to conduct the analysis for sub-samples of the data, for different kinds of company performance. However, most observations included in the Table 26 (127) come from studies examining the impact of VET on productivity: the observations left to examine the effects of VET on other performance indicators are too few to permit estimation of a model. To be able to say something about the effect of VET on different indicators for company performance, we have included dummies recording on which kind of performance indicator each of the collected effects has been estimated. Productivity is the reference category. The dummy for innovation has been dropped because it perfectly predicted success, i.e. a positive and significant result. In all estimations, the effect of the profitability dummy (effect of VET estimated on costs or profits) is negative and significant. There is a lower probability of observing a positive and significant effect of VET on profitability than on productivity, all other things being equal. The effect of the quality dummy is also negative in several estimations. Studies based on a multidimensional indicator of company performance also appear to find less positive significant VET effects. The dummy for studies examining employment growth has no significant effect.

The methodology used to estimate the effects of VET on performance indicators does not tend to influence the probability of finding a positive and significant impact. Whether studies correct for the potential endogeneity of VET or not does not seem to have a significant impact on the (qualitative) results. This is a rather surprising finding, though it shows that studies correcting for the endogeneity of VET do not find significantly less positive and significant effects of VET, all other things being equal. The effect of the time elapsed between measurement of training and of performance is not precisely estimated and nedither is the way the VET investment is measured: the dummies registering whether the VET variable was measured before the performance variable (lagged VET) and whether the variable was a constructed stock of VET (stock of VET) do not have significant effects. On the contrary, when the incidence of the training investment is measured by means of an indicator variable (i.e. a Likert scale) the probability of a positive and significant impact is increased (relative to when the training investment is measured in terms of people participating in it). Three out of four studies which use an absolute VET indicator, i.e. which do not relate VET investment to some measure of company size, are found to have a smaller probability of finding significant and positive effects of VET. In all of our estimations, we find that measuring performance subjectively increases the probability of finding positive and significant effects of VET.

The control variables included in the model also matter. Controlling for labour input in a firm significantly lowers the probability of finding a positive significant effect of VET. Including controls for the tenure of employees has also a negative and significant effect on the probability of a positive and significant impact. Controlling for the educational and occupation structure of the workforce and for the sector of activities of firms does not matter for the estimated effect of VET. Finally, the number of waves used in the analysis has a positive and significant effect on the probability of observing a positive and significant effect. This suggests that having better data, in the form of a long panel, increases the chance of finding a positive effect of VET on company performance. Analyses based on large data sets (including a higher number of firms), an indicator of data quality and reliability of the estimates, have a higher probability of a finding a positive and significant impact of training on company performance indicators, but it is only significant in the model with clustered standard errors.

These conclusions are robust to a change in the specification of the dependent variable (equal to 1 if the estimated effect of VET is positive and significant, 0 if the effect is insignificant, and -1 for a negative significant effect) and estimation method (an ordered logit) as shown in Table 27.

4.2.2. Effect size

We are obviously not only interested in the sign and significance of the estimated effect, but also in its size. Unfortunately, the number of comparable effect sizes found in literature is very limited. The maximum number of comparable effects was provided by quasi-elasticities. Table 28 presents the results of estimating a linear model with the size of the quasi-elasticity as a dependent variable.

First we have to stress that the few observations available for the estimation of this model limit the reliability of the results presented here. The dummies for quality and multidimensional indicators were dropped because of collinearity. Also, the quasi-elasticities included in this regression are based on a very broad range of different training indicators.

There is weak evidence that studies conducted in non-manufacturing sectors find smaller VET effects: the effect is only significant at 10% level in the unweighted model. The lower the minimum company size in the database of firms used by the analyses, the smaller the estimated impact of VET (only significant in the weighted model). This contrasts with the positive influence of this variable on the probability of observing a positive and significant VET effect.

As far as the methodology of the study is concerned, methods used to correct for endogeneity (instrumental variables and panel) are both found to have a negative and significant effect on the size of the VET effect.

How VET is measured matters not only for the probability of finding a positive significant effect, but also for the size of this effect: relative to measuring VET in terms of participating workers, measuring it in terms of expenditure has a positive influence on the size of the impact of VET, and using a multidimensional indicator a negative one. Using a measure of VET which is not related to an indicator of company size not only has a negative influence on the probability of finding a positive effect, but also on the size of the effect. The controls adopted in the study also have an influence on the size of the estimated effect: controlling for labour input, for educational structure of the workforce and for tenure of the workers are found to have a positive effect. Controlling for the sector of activity of the firm has a positive effect on effect size: not controlling for the sector may lead to an underestimation of the effect of VET if lower performing sectors train less. The more control variables are included in the model, the smaller the estimated effect of VET, which is a logical result. Finally, studies based on more firms and/or using longer panels find higher effects of VET, all other things being equal.

Table 26. **Binomial logit model for the probability that the estimated effect of VET is positive and significant**

	Unweighted			Weighted			Clustered standard errors		
Sample size	204			204			204		
Pseudo R2	0.4091			0.4394			0.4091		
LR of Wald test stat	115.42			67.22			186.63		
P-value test	0.000			0.000			0.000		
	coeff.	**z**	**P>|z|**	**coeff.**	**z**	**P>|z|**	**coeff.**	**z**	**P>|z|**
Performance indicator (productivity is reference)									
Profitability	-3.2114	-3.07	0.002	-4.7219	-4.58	0.000	-3.2114	-4.17	0.000
Quality	-1.6814	-1.31	0.189	-1.6105	-1.06	0.287	-1.6814	-1.82	0.068
Employment	-0.7641	-0.48	0.631	-0.7977	-0.40	0.691	-0.7641	-0.62	0.536
Multidimensional	-1.9754	-1.21	0.226	-3.1285	-2.50	0.013	-1.9754	-1.55	0.121
IVET (CVET is reference)	1.6095	1.36	0.174	3.4101	3.17	0.002	1.6095	1.96	0.051
Sector (all sectors is reference)									
Non-manufacturing	-1.3900	-1.74	0.082	-1.7147	-2.04	0.042	-1.3900	-1.27	0.204
Manufacturing	0.3859	0.53	0.597	0.5834	0.74	0.461	0.3859	0.42	0.671
Non-OECD country	0.2380	0.32	0.746	-0.0022	0.00	0.998	0.2380	0.50	0.617
Lower size bound	0.0092	1.52	0.128	0.0130	2.51	0.012	0.0092	2.27	0.023
Estimation method (no correction for endogeneity is reference)									
Panel	-0.6365	-0.83	0.404	-1.2142	-1.55	0.121	-0.6365	-1.39	0.164
Instrumental variables	0.0474	0.06	0.953	-1.2731	-1.31	0.189	0.0474	0.06	0.953
Position in time of the VET variable (no lag is reference)									
Lagged VET	0.0753	0.10	0.924	-0.0493	-0.06	0.952	0.0753	0.12	0.905
Stock of VET	-0.3990	-0.45	0.653	-0.2508	-0.28	0.778	-0.3990	-0.83	0.407
Way VET is measured (n of workers trained is reference)									
VET time	0.5839	0.75	0.452	0.9667	1.13	0.259	0.5839	0.82	0.413
VET expenditure	0.8023	1.15	0.251	1.4393	1.87	0.062	0.8023	1.26	0.206
VET dummy	2.2362	2.16	0.031	4.2590	3.24	0.001	2.2362	2.01	0.045
VET multidimensional	2.1507	1.63	0.103	3.9850	2.33	0.020	2.1507	1.32	0.188

	coeff.	z	P>|z|	coeff.	z	P>|z|	coeff.	z	P>|z|
VET absolute	-0.7395	-1.09	0.274	-1.3891	-1.90	0.057	-0.7395	-1.06	0.291
Subjective performance	2.2084	1.96	0.050	2.5698	2.65	0.008	2.2084	2.54	0.011
Control variables included in the model									
Labour input	-1.8624	-1.95	0.051	-2.1035	-2.34	0.019	-1.8624	-3.57	0.000
Educational structure	-0.4360	-0.61	0.544	-0.3164	-0.42	0.671	-0.4360	-0.65	0.515
Occupational structure	-0.1012	-0.14	0.892	0.3533	0.51	0.607	-0.1012	-0.17	0.866
Tenure	-1.5459	-1.97	0.049	-1.8606	-1.90	0.058	-1.5459	-1.69	0.091
Sector	0.4993	0.78	0.435	0.8481	1.22	0.221	0.4993	0.70	0.484
No of control variables	-0.0227	-0.81	0.417	-0.0488	-1.84	0.065	-0.0227	-1.44	0.149
No of firms	0.0001	1.37	0.171	0.0001	1.52	0.128	0.0001	1.92	0.055
No of waves	0.2557	1.74	0.081	0.4293	2.78	0.005	0.2557	1.76	0.079
Constant	1.4726	1.18	0.238	1.6951	1.38	0.168	1.4726	1.29	0.196

Table 27. **Ordered logit model for the qualitative effect of VET**

	Unweighted			Weighted			Clustered standard errors		
Sample size	204			204			204		
Pseudo R2	0.3922			0.4286			0.3922		
LR of Wald test stat	126.06			75.99			234.78		
P-value test	0.000			0.000			0.000		
	coeff.	z	P>|z|	coeff.	z	P>|z|	coeff.	z	P>|z|
Performance indicator (productivity is reference)									
Profitability	-3.7397	-3.58	0.000	-5.2550	-5.19	0.000	-3.7397	-4.30	0.000
Quality	-2.1832	-1.75	0.080	-2.1518	-1.53	0.126	-2.1832	-2.10	0.036
Employment	-1.2772	-0.84	0.401	-1.2435	-0.68	0.494	-1.2772	-1.10	0.271
Multidimensional	-2.7287	-1.67	0.096	-3.6094	-2.82	0.005	-2.7287	-2.08	0.038
IVET (CVET is reference)	-0.3650	-0.35	0.723	1.6888	1.69	0.091	-0.3650	-0.31	0.759
Sector (all sectors is reference)									
Non-manufacturing	-1.3022	-1.72	0.085	-1.5185	-1.98	0.048	-1.3022	-1.12	0.262

	coeff.	z	P>|z|	coeff.	z	P>|z|	coeff.	z	P>|z|
Manufacturing	0.7792	1.11	0.268	1.0335	1.38	0.168	0.7792	0.90	0.367
Non-OECD country	0.0896	0.13	0.899	0.2990	0.37	0.713	0.0896	0.15	0.884
Lower size bound	0.0081	1.41	0.159	0.0124	2.31	0.021	0.0081	1.69	0.091
Estimation method (no correction for endogeneity is reference)									
Panel	-0.3827	-0.55	0.580	-1.0354	-1.53	0.125	-0.3827	-1.23	0.217
Instrumental variables	0.4217	0.60	0.549	-0.6158	-0.80	0.425	0.4217	0.73	0.467
Position in time of the VET variable (no lag is reference)									
Lagged VET	0.3687	0.50	0.617	0.4003	0.54	0.592	0.3687	0.62	0.537
Stock of VET	0.2598	0.31	0.755	0.6482	0.75	0.455	0.2598	0.40	0.689
Way VET is measured (n of workers trained is reference)									
VET time	0.8191	1.14	0.253	1.1823	1.40	0.160	0.8191	1.28	0.201
VET expenditure	0.9372	1.42	0.156	1.2822	1.70	0.090	0.9372	1.50	0.134
VET dummy	2.3594	2.52	0.012	4.0960	3.35	0.001	2.3594	2.19	0.028
VET multidimensional	1.9698	1.54	0.123	3.6204	2.25	0.024	1.9698	1.25	0.211
VET absolute	-1.0841	-1.68	0.093	-1.7108	-2.43	0.015	-1.0841	-1.51	0.131
Subjective performance	2.7393	2.50	0.012	2.9519	2.88	0.004	2.7393	2.60	0.009
Control variables included in the model									
Labour input	-2.9375	-3.08	0.002	-3.2795	-3.99	0.000	-2.9375	-4.48	0.000
Educational structure	-0.5173	-0.75	0.452	-0.7080	-0.96	0.339	-0.5173	-0.83	0.405
Occupational structure	-0.5377	-0.77	0.444	-0.2425	-0.37	0.709	-0.5377	-0.90	0.370
Tenure	-1.4819	-2.17	0.030	-1.5283	-2.01	0.044	-1.4819	-1.77	0.076
Sector	0.9955	1.59	0.111	0.9796	1.51	0.131	0.9955	1.10	0.273
No of control variables	-0.0099	-0.37	0.709	-0.0161	-0.60	0.550	-0.0099	-0.49	0.621
No of firms	0.0001	1.14	0.255	0.0000	1.33	0.184	0.0001	2.02	0.044
No of waves	0.2479	1.83	0.067	0.3773	2.76	0.006	0.2479	1.71	0.086

Table 28. **Linear regression for the size of the estimated quasi-elasticities**

	Unweighted			Weighted			Clustered standard errors		
Sample size	57			57			57		
R2	0.7322			0.8538			0.7322		
F-test	3.64			1159.23			218.15		
p-value of the test	0.0004			0.000			0.000		
	coeff.	z	P>|z|	coeff.	z	P>|z|	coeff.	z	P>|z|
Performance indicator (productivity is reference)									
Profitability	-0.0112	-0.02	0.987	-0.6836	-0.69	0.493	-0.0112	-0.01	0.994
Employment	0.3008	0.62	0.539	0.6904	0.84	0.409	0.3008	0.70	0.495
IVET (CVET is reference)	0.5038	0.80	0.428	0.2446	0.61	0.546	0.5038	1.28	0.217
Sector (all sectors is reference)									
Non-manufacturing	-0.7182	-1.79	0.083	-0.5420	-1.12	0.270	-0.7182	-1.36	0.188
Manufacturing	-0.5533	-1.43	0.162	-0.3480	-0.73	0.473	-0.5533	-1.13	0.273
Non-OECD country	-0.1332	-0.31	0.757	-0.4992	-1.14	0.262	-0.1332	-0.51	0.613
Lower size bound	-0.0012	-1.68	0.102	-0.0015	-2.17	0.037	-0.0012	-1.24	0.230
Estimation method (no correction for endogeneity is reference)									
Panel	-2.1476	-5.15	0.000	-2.4362	-3.41	0.002	-2.1476	-1.98	0.062
Instrumental variables	-2.2521	-5.13	0.000	-2.6979	-3.50	0.001	-2.2521	-1.97	0.064
Position in time of the VET variable (no lag is reference)									
Lagged VET	-1.0560	-2.66	0.012	-1.4342	-2.89	0.007	-1.0560	-1.68	0.108
Stock of VET	0.0165	0.04	0.968	-0.2093	-0.49	0.626	0.0165	0.04	0.968
Way VET is measured (n of workers trained is reference)									
VET time	0.6195	1.62	0.114	0.6043	1.61	0.116	0.6195	1.43	0.168
VET expenditure	0.7496	2.20	0.035	0.9216	2.42	0.021	0.7496	1.59	0.129
VET dummy	0.7826	1.15	0.259	0.7609	1.16	0.255	0.7826	1.20	0.246
VET multidimensional	-1.8232	-1.20	0.237	-2.6470	-1.81	0.080	-1.8232	-0.85	0.406
VET absolute	-0.7250	-1.92	0.064	-0.9823	-2.35	0.025	-0.7250	-1.58	0.131

	coeff.	z	P>|z|	coeff.	z	P>|z|	coeff.	z	P>|z|
Control variables included in the model									
Labour input	1.7431	2.59	0.014	2.0920	3.13	0.004	1.7431	1.80	0.087
Educational structure	0.5940	1.55	0.132	1.1024	2.23	0.033	0.5940	0.92	0.368
Occupational structure	0.4057	0.91	0.371	0.1557	0.49	0.627	0.4057	0.88	0.388
Tenure	1.8748	1.64	0.110	2.5397	1.83	0.076	1.8748	0.89	0.384
Sector	1.0115	3.34	0.002	1.1390	3.17	0.003	1.0115	2.39	0.027
No of control variables	-0.0665	-4.10	0.000	-0.0802	-3.07	0.004	-0.0665	-1.72	0.101
No of firms	0.0000	1.60	0.118	0.0000	2.50	0.018	0.0000	0.99	0.336
No of waves	0.2357	3.14	0.004	0.2470	2.25	0.031	0.2357	1.67	0.111
Constant	-0.4468	-0.72	0.479	-0.4960	-0.73	0.470	-0.4468	-1.08	0.294

4.3. Hypothesis 2: effect of the level of the VET variable on company performance

In this section we investigate if and how the level of investment in VET influences its impact on performance. Hypothesis 2 states that the effect of VET on company performance increases with the extent of VET. This hypothesis could be further refined by replacing the linear relationship between the extent of VET and the returns on VET with a non-linear relationship (either a U-shaped relationship or that the returns on investment decrease above a certain threshold). To test this hypothesis, we will relate the size of the returns on VET in a given study to a measure of the extent of VET in the study. Studies with a relatively large average investment in VET (captured by the average investment in training in the study) should also find large returns on the training investments (captured by the size of the coefficient on the investment in VET variable).

4.3.1. Measurement of the level of the VET variable

The collection of the means of variables measuring VET is subject to two main problems: the use of 'absolute' VET variables in some studies, and the lack of appropriate descriptive statistics in others. The first problem is that 120 of our collected estimated effects, coming from 35 studies, are based on VET variables which are 'absolute', meaning that they are not assessed relative to the size of the firm in which the training has taken place. One kind of study records only whether training has taken place in a firm, by means of a dummy, without paying attention to the extent of the training. This can be the case for all of the estimated effects in a study or for only part of them. For such studies, the means of the training variables are not interpretable in terms of the level of investment in VET. A second study type measures investment in VET by means of qualitative variables, often based on Likert scales in survey questions. The resulting training variable used in the estimation can be the index number chosen by the respondent on the scale, or a variable constructed using a factor analysis based on the answers to several qualitative questions. Each of the variables computed in this way represents a level of investment in VET but the means are not comparable among studies because they are based on different qualitative questions. Consequently, they are not usable in a meta-regression. A third study type quantifies the investment in VET, in terms of time or money spent, or in terms of number of workers trained, but does not relate this indicator to an indicator of company size. For instance, some studies estimate the effect of the time spent on training per trained employee (Aragon-Sanchez et al., 2003; Gallié and Legros, 2007; Addison and Belfield, 2008) or of the amount spent on training per trained employee (Gallié and Legros, 2007; Van de Wiele, 2010). This obtains a measure of training intensity for those who receive training and of its effect, but not of the overall VET effort of a firm. Other studies only look at the effect of the total VET effort: they only take up total time devoted to training without relating it to total working time (Barron et al., 1989; Blandy et al., 2000; de Kok, 2002; Nikandrou et al., 2008), or the (log of) the level of training expenditures, without relating it to total labour costs (Boon and van der Eijken, 1998; Hempell, 2003; Konings and Vanormelingen, 2010; Kurosawa et al., 2005; Lyau and Pucel, 1995; Ng and Siu, 2004; Thang, 2009). Other studies only take up in their model the (log of) number of workers trained in a given firm, rather than the share of workers who received training (Black and Lynch 1996; 2001; Jones, 2001; Ismail, 2009). It would not be meaningful to use the means of these variables in a meta-regression because they are not comparable among studies/firms: 10 trained workers may be a high investment for one firm and a small effort for another. Table A6, in Annex 2, gives an overview of the studies which use (among others) ‘absolute’ measures of VET, by type of VET indicator.

The second problem is that even studies using training variables which can be related to some indicator of company size do not always report the mean of the variable we would need to include in our meta-regression. Some report descriptive statistics for sub-samples which are not the same as the sub-samples used in the estimation (e.g. they report only separate means for training and non-training firms, or for different sub-sectors); they do not provide enough information for calculation of the relevant mean (Almeida and Carneiro, 2009; Konings and Vanormelingen, 2010; Konings, 2008; Addison and Belfield, 2008; Bryan, 2006; de Kok, 2002; Tan and Batra, 1996). Some do not report descriptive statistics at all for the training variable (D’Arcimoles, 1997; Leiponen, 2000; Aragon-Sanchez et al., 2003).

This means that we lose many observations when we want to include the level of VET as regressor in our meta-analysis. In the end, we have been able to collect 83 ‘meaningful’ mean values of VET variables, from 24 studies.

4.3.2. Influence of the level of the VET variable on the probability of finding a positive and significant effect

The 83 meaningful mean values of VET variables which we collected belonged to five different categories: share of total working time spent on VET, share of workers participating in VET, share of total labour costs spent on VET, euros spent per worker on VET, and hours spent per worker on VET. Mean values themselves cannot be put together directly in a regression, because they are not comparable. We first tried taking up an interaction term of the mean values with a dummy indicating to which category the mean value belongs. None of the interaction terms was significant, and the *p*-values were very high. As an alternative, we put the mean values on a common three-item scale: low, medium and high investment in VET. To define this scale, we computed for each category the 33rd and the 66th percentile of the distribution of mean values. Values which were below the 33rd percentile were categorised as 'low effort', values between the 33rd and the 66th percentile as 'medium', and values above the 66th percentile as 'high'. Table 29 presents the results of the estimation of a binary logit model including the dummies for low and high investment in VET as regressors. Table 30 presents the results of an ordered logit.

The number of regressors included in the model is smaller than in the basic model because the number of observations is considerably smaller. Even so, most estimated effects are found to be insignificant. The estimated effect of the level of VET is insignificant as well, though the coefficients have the expected sign in most estimations (except for the weighted ones): negative for low investment and positive for high investment. This suggests that the probability of finding a positive and significant effect of VET increases with the level of VET effort. Further, the estimated effect of IVET is negative and significant in the unweighted ordered logit, which is in contradiction with the result from the basic model. The lower bound for company size has a positive and significant effect in the ordered logit, which is consistent with previous results. The use of instrumental variables is found to have a positive and significant effect in several estimations, which is surprising. Finally, measuring VET as a stock has a negative and significant effect on the probability of observing a positive and significant effect of VET; one would have expected the contrary. The limited number of observations, and the fact that several results are in contradiction with the basic model, indicate that the estimations presented here have to be taken with great caution.

4.3.3. Influence of the level of the VET variable on the estimated effect size

Table 31 presents the estimation results of a linear model in which the effect of the level of VET effort on the size of the estimated effect of VET is measured.

Relative to studies in which the mean VET-effort is average, studies with low VET-efforts and studies with high investment in VET both find smaller effect sizes. This is consistent with the hypothesis that the relationship between investment in VET and return is inversely U-shaped, with low returns for lowest and highest levels of investment, and an optimum somewhere in between. This result, however, is not significant, except for high VET-effort in the model with clustered standard errors (at 10% level). Given the very limited number of observations, it is not possible to base conclusions on this result. Studies looking at IVET are found to find significantly higher effects than others. This is consistent with the results from Section 4.4.1. We also find that studies looking at bigger firms find bigger effects of VET. This result is in contradiction with the model presented in Section 4.3.2, but consistent with the results from models with qualitative dependent variables (Sections 4.3.1 and 4.4.2). In this model, we find that studies concentrating on non-manufacturing sectors find larger VET effects, which contradicts results to this point. As far as the estimation method is concerned, only measuring VET as a stock is found to have a significant influence on the size of the estimated effect of VET. This is a negative one, which is in conflict with what one would expect. Just as in Section 4.4.2, the results presented here cannot be for fixed conclusions but should rather be considered as an illustration of what obtained when trying to measure the influence of the level of VET on the estimated effect size, and of the difficulties of the exercise.

Table 29. **Binomial logit model for the probability that the estimated effect of VET is positive and significant, including the level of VET as a regressor**

	Unweighted			Weighted			Clustered standard errors		
Sample size	83			83			83		
Pseudo R2	0.3428			0.2383			0.3428		
LR of Wald test stat	38.24			7.01			23.05		
p-value test	0.000			0.7936			0.0174		
	coeff.	z	P>|z|	coeff.	z	P>|z|	coeff.	z	P>|z|
Level of VET (VET medium is reference)									
VET low	-0.3367	-0.44	0.659	-0.0906	-0.11	0.910	-0.3367	-0.52	0.600
VET high	0.2690	0.23	0.816	-0.1456	-0.15	0.884	0.2690	0.34	0.731
IVET (CVET is reference)	-0.7452	-0.45	0.655	-0.2381	-0.16	0.870	-0.7452	-0.29	0.775
Sector (all sectors is reference)									
Non manufacturing	0.5532	0.34	0.732	1.9931	1.06	0.291	0.5532	0.34	0.730
Manufacturing	1.0431	0.73	0.464	1.6315	1.26	0.209	1.0431	0.89	0.374
Lower size bound	0.0696	1.13	0.258	0.0790	1.10	0.272	0.0696	1.53	0.127
Estimation method (no correction for endogeneity is reference)									
Panel	0.3235	0.34	0.732	0.8283	0.84	0.400	0.3235	0.44	0.659
Instrumental variables	1.0438	1.19	0.233	1.6871	1.69	0.091	1.0438	1.54	0.124
Position in time of the VET variable (no lag is reference)									
Lagged VET	0.3167	0.39	0.696	0.7075	0.78	0.436	0.3167	0.39	0.694
Stock of VET	-3.8471	-2.15	0.032	-2.8107	-1.64	0.102	-3.8471	-2.15	0.032
Subjective performance	-13.4136	-1.13	0.259	-14.3024	-1.05	0.293	-13.4136	-1.64	0.100
Constant	-0.7677	-0.82	0.414	-1.3539	-1.33	0.183	-0.7677	-0.78	0.437

Table 30. **Ordered logit model for the qualitative effect of VET, including the level of VET as a regressor**

	Unweighted			Weighted			Clustered standard errors		
Sample size	83			83			83		
Pseudo R2	0.2953			0.2326			0.2953		
LR of Wald test stat	41.18			26.92			39.36		
p-value test	0.000			0.0047			0.000		
	coeff.	z	P>|z|	coeff.	z	P>|z|	coeff.	z	P>|z|
Level of VET (VET medium is reference)									
VET low	-0.0257	-0.04	0.971	0.2969	0.39	0.695	-0.0257	-0.04	0.967
VET high	0.0752	0.09	0.929	-0.2993	-0.37	0.712	0.0752	0.19	0.848
IVET (CVET is reference)	-5.6980	-3.23	0.001	-2.6000	-0.96	0.336	-5.6980	-1.48	0.138
Sector (all sectors is reference)									
Non manufacturing	0.7210	0.58	0.565	1.6769	1.33	0.184	0.7210	0.72	0.475
Manufacturing	0.9025	0.70	0.482	1.4394	1.10	0.270	0.9025	0.87	0.386
Lower size bound	0.0242	1.74	0.083	0.0276	2.60	0.009	0.0242	2.87	0.004
Estimation method (no correction for endogeneity is reference)									
Panel	0.5682	0.69	0.489	0.6946	0.83	0.408	0.5682	0.92	0.357
Instrumental variables	0.9069	1.27	0.203	1.4165	1.89	0.058	0.9069	2.05	0.040
Position in time of the VET variable (no lag is reference)									
Lagged VET	0.3186	0.42	0.674	0.6001	0.74	0.458	0.3186	0.45	0.649
Stock of VET	-3.0082	-2.18	0.029	-1.3748	-1.19	0.234	-3.0082	-1.88	0.060
Subjective performance	-3.9027	-1.60	0.109	-3.8524	-2.50	0.012	-3.9027	-2.05	0.040

NB: Ancillary parameters not shown.

Table 31. **Linear regression for the size of the estimated quasi-elasticities, including the level of VET as regressor**

	Unweighted			Weighted			Clustered standard errors		
Sample size	31			31			31		
R2	0.9147			0.8961			0.9147		
F-test	21.44			14.91			55.20		
p-value of the test	0.000			0.000			0.000		
	coeff.	**z**	**P>|z|**	**coeff.**	**z**	**P>|z|**	**coeff.**	**z**	**P>|z|**
Level of VET (VET medium is reference)									
VET low	-0.2841	-1.17	0.255	-0.5187	-1.61	0.123	-0.2841	-1.83	0.095
VET high	-0.1837	-0.74	0.468	-0.2530	-1.27	0.218	-0.1837	-1.34	0.206
IVET (CVET is reference)	0.2924	0.80	0.431	0.3674	3.24	0.004	0.2924	6.07	0.000
Sector (all sectors is reference)									
Non-manufacturing	6.9598	8.37	0.000	7.0900	4.53	0.000	6.9598	10.70	0.000
Manufacturing	0.1115	0.40	0.691	0.0080	0.04	0.967	0.1115	0.49	0.636
Lower size bound	0.0067	7.42	0.000	0.0069	4.33	0.000	0.0067	7.45	0.000
Estimation method (no correction for endogeneity is reference)									
Panel	0.0667	0.27	0.786	0.1996	0.65	0.522	0.0667	0.47	0.646
Instrumental variables	0.0450	0.16	0.876	0.0255	0.10	0.924	0.0450	0.32	0.757
Position in time of the VET variable (no lag is reference)									
Lagged VET	0.1445	0.65	0.526	0.3835	1.29	0.211	0.1445	0.92	0.376
Stock of VET	-6.8981	-8.61	0.000	-6.9450	-4.55	0.000	-6.8981	-9.72	0.000
Constant	0.0658	0.21	0.833	-0.0048	-0.02	0.987	0.0658	0.45	0.658

CHAPTER 5
Conclusions and indications for further research

The report investigated the relationship between training and productivity gains by systematically analysing the empirical relationship between these two variables as found in 62 studies using meta-analysis. The study was made difficult by the heterogeneity in the performance indicator used (productivity, sales, revenues, profits) and in the training indicators (training participation, training days, training expenses). Also, most studies did not record the type of training, which is treated as a very general category; they record training participation or expenses, but not the kind of training they examine (whether informal or formal, school based or workplace based).

These shortcomings notwithstanding, as far as the sector of activity is concerned, it was found, both through descriptive statistics and through the meta-analysis, that studies concentrating on non-manufacturing sectors have a lower probability of observing positive and significant effects of VET. Similarly, most studies focusing on manufacturing or on a broad range of sectors find positive and significant effects. A caveat is in order, however, since productivity measurement is particularly difficult in service industries. Positive effects of VET are found for firms of all sizes, including smaller ones, but we find some evidence, both descriptive and analytical (i.e. based on meta-regressions) that the effects of VET on company performance increase with company size.

While only a limited number of studies provided information on the integration of VET in a broader HRM strategy, the HRM context seems to reinforce the positive effects of VET on performance indicators.

Finally, only a fraction of the studies collected (resulting in a small number of observations) provided enough information to enable the computation of a measure of VET-level comparable across studies. The results of these estimations suggest that the probability of observing positive significant effects of VET increases with the level of VET-effort but the number of observations was too small to estimate the effect precisely.

We now turn to the main research question in the report:

5.1. Does VET have a positive effect on company performance?

On the basis of the evidence collected, we can conclude that VET has a positive influence on the economic performance of firms. Most studies we examined find a positive and significant effect of VET. The average estimated effect of VET is positive. The characteristics of the object of study and the methodology used by a study influence the effect found, but they do not generally put this result in question.

The positive effect of VET on company performance persists across performance indicators. Most studies we found concentrate on productivity. But for almost every performance indicator (quality, innovation, employment growth, multidimensional indicators), we find more studies concluding that VET has a positive effect than studies finding the contrary. Only when looking at profitability and company costs do most studies find an insignificant effect. This result is echoed in the meta-regressions: we find that studies looking at profitability or costs are less likely to find positive and significant effects of VET, all other things being equal.

Though the conclusion about the positive effect of VET on company performance is clear, the evidence available to quantify the effects in a comparable way across studies is unclear. The studies displayed a high level of heterogeneity in the performance indicators, VET indicators and model specifications that made comparison across studies very difficult. Considerable effort and ingenuity have been devoted to computing indicators of effect sizes as comparable as possible across studies. This effort has often come at the cost of precision (in the sense that the resulting estimation samples were small), so the models were not able to produce precise estimates of the size of the impact of training on performance measures.

5.2. Indications for further research

On the basis of these findings, we identify several possibilities to develop further research.

First, there is a clear need to pay more attention to the characteristics of VET when looking at its effect on company performance. Most of the studies we found only considered whether training had taken place in a firm, and how much, but did not register the type of training (formal or informal). Making a distinction between different training forms, training fields and target groups would make more precise conclusions possible about what works, and could therefore lead to better practical recommendations.

Second, many studies focused on the relationship between VET and productivity or profitability, but other performance indicators received less attention. The influence of VET on aspects such as job satisfaction, absenteeism levels and innovation is an interesting topic for further research. In particular, it could be interesting to investigate differences in training needs and attitudes towards training between leaders and followers in terms of innovation.

Third, most of the studies focused on the contemporaneous relationship between training and productivity. However, it is likely that the full impact of training on productivity will develop over time: this is a concept akin to the importance of learning-by-doing that resulted in the development of the learning curve. To obtain a more precise description of the way training affects productivity it would be useful to develop measures of the stock of VET (or skills) available at the firm.

Finally, the importance of basing quantitative estimations of the effect of VET on company performance on a well-defined model cannot be overstated. A major problem encountered in this study was the lack of comparability between the VET variables used, and consequently between the estimated effects of VET. Ad-hoc estimations too often lead to estimation results which are not comparable with those of other studies, and therefore lose an important part of their informative value. We recommend deriving the model to be estimated from a clear production function, to provide for a clear interpretation of the estimated coefficients.

List of abbreviations

CVET	continuous vocational education and training
GMM	generalised method of moments
HRM	human resource management
IVET	initial vocational education and training
OLS	ordinary least squares
VET	vocational education and training

References

Addison, J.T.; Belfield, C.R. (2008). *Unions, training and firm performance* (IZA Discussion paper, No 3294).

Akerlof, G.A. (1984). Gift exchange and efficiency-wage theory: four views. *American economic review*, Vol. 74, No 2, p. 79-83.

Akerlof, G.A.; Kranton, R.E. (2000). Economics and identity. *Quarterly journal of economics*, Vol. 115, No 3, p. 715-753.

Akerlof, G.A.; Kranton, R.E. (2010). *Identity economics: how our identities shape our work, wages and well-being.* Princeton University Press.

Akhtar, S. et al. (2008). Strategic HRM practices and their impacts on company performance in Chinese enterprises. *Human resource management*, Vol. 47, No 1, p. 15-32.

Alba-Ramirez, A. (1994). Formal training, temporary contracts, productivity and wages in Spain. *Oxford bulletin of economics and statistics*, Vol. 56, No 2, p. 151-70.

Almeida, R.; Carneiro, P. (2009). The return to firm investments in human capital. *Labour economics*, Vol. 16, No 1, p. 97-106.

Aragon-Sanchez, A. et al. (2003). Effects of training on business results. *International journal of human resource management*, Vol. 14, No 6, p. 956-980.

Arvanitis, S. (2005). Computerisation, workplace organisation, skilled labour and firm productivity: evidence for the Swiss business sector. *Economics of innovation and new technology*, Vol. 14, No 4, p. 225-249.

Baker, R.; Thompson, J. (1995). Innovation in general practice: is the gap between training and non-training practices getting wider? *British journal of general practice*; Vol. 45, No 395, p. 297-300.

Ballot, G. et al. (2001). Firms' human capital, R&D and performance: a study on French and Swedish firms. *Labour economics*, Vol. 8, No 2, p. 443-462.

Ballot, G. et al. (2006). Who benefits from training and R&D, the firm or the workers. *British journal of industrial relations*, Vol. 44, Issue 3, p. 473-495.

Barrett, A. (2001). Economic performance of education and training: costs and benefits. In Descy, P.; Tessaring, M. (eds). *Training in Europe: second report on vocational training research in Europe 2000: background report. Volume II*. Luxembourg: Publications Office of the European Union, p. 383-404.

Barrett, A.; O'Connell, P. (2001). Does training generally work? The returns to in-company training. *Industrial and labor relations review*, Vol. 54, No 3, p. 647-662.

Barro, R.J.; Sala-i-Martin, X. (1995). *Economic growth.* McGraw-Hill College.

Barron, J.M. et al. (1989). Job matching and on-the-job training. *Journal of labor economics*, Vol. 7, p. 1-19.

Bartel, A.P. (1989). Formal employee training programmes and their impact on labour productivity: evidence from a human resource survey. Cambridge: National Bureau of Economic Research (NBER working paper No 3026).

Bartel, A.P. (1994). Productivity gains from the implementation of employee training programmes. *Industrial relations: a journal of economy and society*, Vol. 33, Issue 4, p. 411-425.

Bartel, A.P. (2000). Measuring the employer's return on investments in training: evidence from the literature. *Industrial relations: a journal of economy and society,* Vol. 39, Issue 3, p. 502-524.

Bassi, L.J. et al. (2001). *Human capital investments and firm performance.* Washington, DC: Human Capital Dynamics, Inc. (Mimeo).

Bauernschuster, S. et al. (2008). *The impact of continuous training on a firm's innovations*. (CESifo Working paper).

Baum, C.F. et al.(2003). Instrumental variables and GMM: estimation and testing. *Stata journal*, Vol. 3, No 1, p. 1-31.

Becker, G.S. (1962). Investment in human capital: a theoretical analysis. *Journal of political economy*, Vol. 70, Issue 5, p. 9-49.

Becker, G.S. (1964, 1993). *Human capital: a theoretical analysis with special reference to education.* Columbia University.

Bishop, J.H. (1989). *On-the-job training of new hires*. (CAHRS Working paper series; No 401).

Black, S.E.; Lynch, L.M. (1996). Human-capital investments and productivity. *American economic review*, Vol. 86, Issue 2, p. 263-267.

Black, S.E.; Lynch, L.M. (2001). How to compete: the impact of workplace practices and information technology on productivity. *Review of economics and statistics*, Vol. 18, No 3, p. 434-445.

Blandy, R. et al. (2000). Does training pay? Evidence from Australian enterprises. In: Smith, A. (ed.). *Return on investment in training: research readings*. Adelaide: NCVER, p. 61-70.

Blundell, R.; Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, Vol. 87, Issue 1, p. 115-143.

Blundell, R.; et al. (1999). Human capital investment: the returns from education and training to the individual, the firm and the economy. *Fiscal studies*, Vol. 20, No 1, p. 1-23.

Böheim, R.; et al. (2009). *Employer-provided training in Austria: productivity, wages and wage inequality*. Linz: Austrian Center for Labor Economics and the Analysis of the Welfare State (Working paper, No 0927).

Boon, M.; van der Eijken, B. (1998). Employee training and productivity in Dutch manufacturing firms. Netherlands official statistics, No 13, p. 19-24.

Bryan, J. (2006). Training and performance in small firms. *International small business journal*, Vol. 24, No 6, p. 635-660.

Carriou, Y.; Jeger, F. (1997). La formation continue dans les entreprises et son retour sur investissement [Continuing education in organisations and return on investment]. *Économie et statistique*, Vol. 303, p. 45-58.

Cedefop (2011a). *Learning while working: success stories of workplace learning in Europe*. Luxembourg: Publications Office of the European Union.

Cedefop (2011b). *The anatomy of the wider benefits of VET in the workplace*. Luxembourg: Publications Office of the European Union (Research paper; No 12).

Colombo, E.; Stanca, L. (2008). *The impact of training on productivity: evidence from a large panel of firms*. University of Milano-Bicocca, Department of Economics (Working papers, No 134).

Conti, G. (2005). Training, productivity and wages in Italy. *Labour economics*, Vol. 12, No 4, p. 557-576.

Cosh, A. et al. (2000). *The relationship between training and employment growth in small and medium-sized enterprises*. Sheffield: Department for Education and Employment (Research report; No 245).

D'Arcimoles, C.H. (1997). Human resource policies and company performance: a quantitative approach using longitudinal data. *Organization studies*, Vol. 18, No 5, p. 857-874.

Danvila Del Valle, I.D.; Sastre Castillo, M.A. (2009). Human capital and sustainable competitive advantage: an analysis of the relationship between training and performance. *International entrepreneurship and management journal*, Vol. 5, No 2, p. 139-163.

de Kok, J. (2002). The impact of firm-provided training on production: testing for firm-size effects. *International small business journal*, Vol. 20, Issue 3, p. 271-295.

Dearden, L. et al. (2000). *Who gains when workers train? Training and corporate productivity in a panel of British industries.* London: Institute for Fiscal Studies (IFS working paper; 00/04).

Delaney, J. T.; Huselid, M.A. (1996). The impact of human resource management practices on perceptions of organisational performance. *Academy of management journal*, Vol. 39, p. 949-969.

Delery, J.E.; Doty, D.H. (1996). Modes of theorising in strategic human resource management: tests of universalistic, contingency, and configurational performance predictions. *Academy of management journal*, Vol. 39, p. 802-835.

Dostie, B. (2010). Estimating the returns to firm-sponsored on-the-job and classroom training. Bonn: Institute for the Study of Labor (IZA Discussion papers; 5258).

Gallié, E.P.; Legros, D. (2007). Vocational training and innovation. Paris: IMRI (Working paper, No 2007/01)

Griliches, Z.; Hausman, J. (1986). Errors in variables in panel data. *Journal of econometrics*, Vol. 31, No 1, p. 93-118.

Guerrero, S.; Barraud-Didier, V. (2004). High-involvement practices and performance of French firms. *International journal of human resource management*, Vol. 15, p. 1410-1425.

Guest (1997). Human resource management and performance: a review and research agenda. *International journal of human resource management*, Vol. 8, Issue 3, p. 263-276.

Hansen, L. (1982). Large sample properties of generalised method of moment estimators. *Econometrica*, Vol. 50, Issue 4, p. 1029-1054.

Hansson, B. (2007). Company-based determinants of training and the impact of training on company performance: results from an international HRM survey. *Personnel review*, Vol. 36, No 2, p. 311-331.

Hansson, B. et al. (2004). The impact of human capital and human capital investment on company performance. Evidence from literature and European survey results. In: Cedefop; Descy, P.; Tessaring, M. (eds). *Impact of education and training: third report on vocational training research in Europe: background report*. Luxembourg: Publications Office, 2004 (Cedefop reference series; 54).

Harel, G.; Tzafrir, S. (1999). The effect of HRM practices on the perceptions of organisational and market performance in the firm. *Human resource management*, Vol. 38, Issue 3, p. 185-199.

Hempell, T. (2003). *Do computers call for training? Firm-level evidence on complementarities between ICT and human capital*. Mannheim: Centre for European Economic Research (ZEW Discussion paper 03-20).

Holzer, H.J. et al. (1993). Are training subsidies for firms effective? The Michigan experience. *Industrial and labor relations review*, Vol 46, No 4, p. 625-636.

Ismail, R. (2009). The impact of human capital attainment on output and labour productivity of Malay firms. *Journal of international management*, Vol. 4, No 1, p. 221-230.

Jones, P. (2001). Are educated workers really more productive? *Journal of development economics*, Vol. 64, Issue 1, p. 57-79.

Jones, D. et al. (2011). The effects of general and firm-specific training on wages and performance: evidence from banking. *Oxford economic papers* (first published online 19 April 2011).

Kazamaki Ottersten, E. et al. (1999). Evaluating firm training, effects on performance and labour demand. *Applied economic letters*, No 6, p. 431-437.

Kluve (2010). The effectiveness of European active labour market programmes. *Labour economics*, Vol. 17, No 6, p. 904-918.

Konings, J. (2008). *The impact of training on productivity and wages: evidence from Belgian firm level panel data*. LICOS, Centre for Institutions and Economic Performance (Discussion paper series, 197/2008).

Konings, J.; Vanormelingen, S. (2010). *The impact of training on productivity and wages: firm level evidence*. Bonn: IZA, Institute for the Study of Labor (Discussion paper series, No 4731).

Kurosawa, M. et al. (2005). *Productivity, training and human resource management practices-disentangling complex interactions using a survey of Japanese manufacturing firms*. Kyoto: National Graduate Institute for Policy Studies.

Leiponen, A. (2000). Competencies, innovation and profitability of firms. *Economics of innovation and new technology*, Vol. 9, Issue 1, p. 1-24.

Loundes, J. (1999). *Labour productivity in Australian workplaces: evidence from the AWIRS*. Melbourne: Institute of Applied Economic and Social Research (Working paper, No 19/99).

Lyau, N.M.; Pucel, D.J. (1995). Economic return on training investment at the organisation level. *Performance improvement quarterly*, Vol. 8, Issue 3, p. 68-79.

Mahlberg, B. et al. (2009). Firm productivity, workforce age and vocational training in Austria. In: Kuhn, M.; Ochsen, C. *Labour markets and demographic change*. Wiesbaden: VS Verlag, p. 58-84.

Maliranta, M.; Asplund, R. (2007). *Training and hiring strategies to improve firm performance*. Helsinki: ETLA (Discussion paper, No 1105).

Mincer, J. (1962). On-the-job training: costs, returns and some implications. *Journal of political economy*, Vol. 70, No 5, p. 50-79.

Mincer, J. (1974). *Schooling, experience and earnings.* Cambridge, MA: NBER, National Bureau of Economic Research.

Murray, B.; Raffaele, G.C. (1997). Single-site, results-level evaluation of quality awareness training. *Human resource development quarterly*, Vol. 8, Issue 3, p. 229-245.

Ng, Y.C.; Siu, N.Y.M. (2004). Training and enterprise performance in transition: evidence from China. *International journal of human resource management*, Vol 15, Issue 4-5, 878-894.

Nikandrou, I. et al. (2008). Training and firm performance in Europe: the impact of national and organisational characteristics. *International journal of human resource management*, Vol. 19, No 11, p. 2057-2078.

Organ, D.W. (1988). *Organizational citizenship behaviour: the good soldier syndrome*. Lexington, MA: Lexington Books.

Russell, J.S. et al. (1985). Organisational performance and organisational level training and support. *Personnel psychology*, Vol. 38, Issue 4, p. 849-863.

Stanley, T.D. (2001). Wheat from chaff: meta-analysis as quantitative literature review. *Journal of economic perspectives*, Vol. 15, No 3, p. 131-150.

Tan, H.; Batra, G. (1996). *Enterprise training in developing countries: incidence, productivity effects, and policy implications*. Washington, DC: PSD Department Monograph, World Bank.

Thang, N.N. (2009). Human resource training, organisational strategy and firm performance in emerging economies: the case of Vietnam. Faculty of Economics and Business Administration, Ghent University (PhD thesis).

Trouerbach, L. (2009). *Training and organisational performance in Dutch pharmacies*. Maastricht University (Master's thesis).

Turcotte, J.; Rennison, L.W. (2004). The Link between technology use, human capital, productivity and wages: firm-level evidence. *International productivity monitor*, Vol. 9, p. 25-36.

Van de Wiele, P. (2010). The impact of training participation and training costs on firm productivity in Belgium. *International Journal of Human Resource Management*, Vol. 21, Issue 4, p. 582-599.

Wilson, R.A.; Briscoe, G. (2004). The impact of human capital on economic growth. In: Cedefop, Descy, P.; Tessaring, M. (eds). *Impact of education and training: third report on vocational training research in Europe: background report.* Luxembourg: Publications Office of the European Union (Cedefop reference series, No 54).

Yang, C.H. et al. (2010). R&D, human capital investment and productivity: firm-level evidence from China's electronics industry. *China and world economy*, Vol. 18, Issue 5, p. 72-89.

Zwick, T. (2005). Continuing vocational training forms and establishment productivity in Germany. *German economic review*, Vol. 6, Issue 2, p. 155-184.

Zwick, T. (2006). The impact of training intensity on establishment productivity. *Industrial relations: a journal of economy and society*, Vol. 45, No 1, p. 26-46.

Zwick, T. (2007). Apprenticeship training in Germany — investment or productivity driven? *Zeitschrift für Arbeitsmarktforschung*, Vol. 40 (2/3), p. 193-204.

ANNEX 1

Data description and overview of literature

Table A1. **Overview of the studies dealing with the effects of VET on productivity**

Reference	Country // Economic sector(s)	Forms of VET // Types of VET	Indicator for VET efforts // Target group	Data type	Correction for endogeneity	Measure ment period	Performance indicator(s)	Vet: effect// sign // significance
Almeida and Carneiro (2009)	PT // manufacturing	CVET formal // -	training stock (based on human capital function, based on among others mount of training per employee) // large firms (more than 100 employees)	firm-level panel data	lagged; OLS first difference; instrumental variable system GMM estimator	lagged values	log value added (based on production function)	coeff: 0.0006; coeff: 0.0013; an increase in training per employee of 10 hours per year increases current productivity with 0.6% coeff: 0.0006 // all 3 positive // all three sig.
Ballot et al. (2006)	FR, SE // manufacturing	CVET // all	1) training stock per employee (cumulated expenditure on training, considering separations, 2) training expenditure per employee // all employees (large firms)	firm-level panel data	yes, using GMM-SYS	1987-1993	1) productivity, 2) wages	elasticity training on productivity is 0,173 (training variable in log). Elasticity training on wages is 0,131. Elasticity training on productivity is 0,054. Elasticity training on wages is 0,061. // + // sig.
Ballot et al. (2001)	FR, SE // all/unspecified	CVET formal //	training stock (computed by cumulating flows of annual training expenditures over seven years); training stock (computed by cumulating flows of hours of training over seven years) // all employees; managers; non-managers; tech personnel	firm-level panel data	fixed effects; random effects; GMM; GMM-SYS	within same year	log value added (Cobb Douglas production function)	production function: coeff: -0.118-0.951 // 17 positive, 7 negative // 11 sig. of which 1 negative coeff.
Colombo and Stanca (2008)	IT // all; services; non-services; manufacturing	CVET formal //	training intensity (number of employees taking training); effective training (duration of training considered) // all; white collar; blue collar; executives; clerks; workers	firm-level panel data	RE; FE; GMM; GMM-SYS	within same year; effect t-1, t-2; effect t-2, t-3; training predetermine d; training endogenous	log value added (Cobb-Douglas production equations)	production function coeffs. Vary from 0.01-0.202 // 22 positive, 1 negative // 14 sig. all positive

Conti (2005)	IT // all	CVET // -	train (= flow(t) + stock(t-1)) = proportion of trained workers in an industry // -	panel data, training on indiv. level, firm performance on firm level, but both aggregated to industry level	FE; first difference GMM; "full two-step GMM system estimator"	within same year; lagged	log value added; change in log value added	coeff: -0.424-0.451 // 13 positive, 1 negative // 1 insig.
Dostie (2010)	CA // Private sector	formal classroom training; formal on the job training // various (with specific analysis to measure specific covariates for certain types)	proportion employees in classroom training; proportion employees on the job training // all employees	Panel data	Yes. Unobserved productivity shock causing endogeneity is tackled by using GMM methods (Blundell and Bond, 1999) and Arellano and Bond, 1991). Second source self-selection based on expected returns is tackled by establishment fixed effects	within same year	production (production function)	those who undertook classroom training 3,5-11% more productive. // "+ // Significance differs among specifications
Hempell (2003)	DE // business-related and distribution services (excl. bank and insurance, for unreliable productivity measures)	CVET and IVET // -	expenditures on training (including costs of foregone working hours); intangible training stock constructed using longitudinal character of the data // all employees	firm-level panel data	fixed-effects model; two-step SYS-GMM estimator	longer run, because estimates effect of a training stock rather than of expenditures on training in a given year	log value added	1-point increase in share with voc. educ. leads to 0.3146 increase in log value added (sample mean = 0.55) // + // share with vocational educ. 5%; training * share graduates insig; training * share with voc. educ. 10%
Black and Lynch (2001)	US // all but over sample manufacturing and 100+ employees	CVET // -	log number of employees currently in training // public sector employees, not-for-profit institutions and corporate headquarters excludes	cross-section data	GMM	within same year	labour productivity (3 different Cobb Douglas production functions)	coeff: -0.004; -0.003; -0.002 // all negative // all insignificant
Tan and Batra (1996)	CO, ID, MY, MX, TW // all/unspecified	CVET: formal, CVET internal formal, CVET external formal //	dummy if firm reports in investments in internal formal/external training or positive training expenditures; instrument: estimated training; training indicator weighted by fraction of workers trained // all employees; skilled; unskilled	firm-level cross-section data	IV (instrument: probit estimate of training based on firm size, exports, age, multi-plant status, education, proportion of skilled labour, % value of automatic machinery, quality control, proportion of female workers and unionisation)	within same year	log value added (Cobb Douglas production function)	coeff: -0.858-1.454 // 23 positive; 11 negative // 17 out of 34 sig. of which 1 negative coeff.
Zwick (2006)	DE // all	CVET formal //	training intensity (employees trained divided by number of employees in the establishment);	firm-level (establishment level) panel data	fixed effects estimation, Durbin-Wu-Hausman; IV	effects of training 1, 2, 3 and 4 years ago	log value added	coeff: 0.097-0.761 // all positive // 3 out of 4 sig.

			apprenticeship training; training intensity instrument // all					
Konings (2008)	BE // manufacturing and non-manufacturing	CVET // -	share of workers who received training // all employees	firm-level panel data	firm fixed-effects; Olley-Pakes (1996) approach for estimating total factor productivity, to control for simultaneity between productivity and the choice of input factors	within same year	productivity (output per worker); total factor productivity	coeff: 0.235 (marg. Effect of share trained workers on log productivity; article computes effect also using capital-labour ratio) (sample mean: 0.42 in training firms) // + // sig (1%)
Böheim et al. (2009)	AT // firms with at least 20 employees	1) continuous training 2) apprentices 3) white collar versus blue collar // 1) field of training 2) in-house versus external 3) type of (external training institution	a) training costs per employee b) share of different fields of training in total training hours c) training hours external and internal (logs) d) share of external training hours by type of institution e) fraction of apprentices // all employees in companies with at least 20 workers	cross-section; panel (two data points). With two data points is the same as estimating in first differences	fixed effects (with two data points is the same as estimating in first differences)	1999 and 2005	1) log (production per hour worked	elasticity of costs per training is 0,039; Training in personal skills is most effective, followed by language training; effect IT training is less than average; External training by other companies is relatively effective; by schools ineffective; training by private providers holds an intermediary position; The share of apprentices has a significant negative effect on productivity // + // sig
Boon and van der Eijken (1998)	NL // manufacturing	CVET: formal // all types (?)	human capital stock, based on training expenditures // all employees (firms with more than 5 employees)	firm-level pooled (panel) data; firm-level panel data	fixed effects; random effects	within same year	log real gross output; log real value added	elasticity (coeff: 0.004-0.071) // + // half of estimations sig
Zwick (2005)	DE // all/unspecified	CVET // formal external courses; formal internal courses; on-the-job; seminars and talks; job rotation; self-induced learning; quality circles	offered yes/no // -	firm-level panel data	FE; selection correction term (based on estimated training decision of firm)	lagged effect t-1; lagged effect t-2	log value added	formal external courses positive significant effect; rest depends on estimation // + // 5%
de Kok (2002)	NL // manufacturing	CVET // -	log of nr of firm-provided training days; training support per working day; training days per working day // all employees	firm-level panel data	not really; fixed-effects model estimated as OLS on first differences to obtain robust standard errors	within same year	log of gross production	training * training support per working day coeff: 0.083 // + // training and training * training days per working day insig; training * training support per working day sign.
Yang et al. (2010)	CN // electronics (code: 40)	CVET // on-the-job	training intensity (= ratio of on-the-job training expenditure to wage expenditure (%)) // -	firm-level panel data	RE	within same year	in TFP index (total factor productivity function index, based on value added, wage payment and capital stock)	coeff: 0.014 // + // 1%

Bartel (1994)	US // all/unspecified	CVET formal // -	percentage of firm's occupational groups for which a of formal training programme exists; change in training index (% businesses that implemented a training programme in period) // -	firm-level cross-section data; firm-level panel data	lagged effect	within same year; lagged effect (effect of implementing a training programme in 1984, 1985 1986 on productivity in 1986)	log value added (based on Cobb Douglas production function); percent change in labour productivity (based on Cobb Douglas production function)	coeff: 0.01; coeff: 0.01; coeff: 0.41; coeff: 0.39 // all positive // only lagged effects (panel data) sig.
Jones (2001)	GH // manufacturing	vocational training // classroom study alternated each 6 months with on-the-job training	number of workers // all	firm-level panel data	lagging of 2 other variables: capital stock and firm size)	within same year	log value added (value added calculated as profits plus the wage bill)	value added coeff: 0.721 // + // 5%
Konings and Vanormelingen (2010)	BE // NACE A to K; manufacturing; non-manufacturing	Continuous training paid by firms to their employees; formal training: not at the workplace or self-study, has to be at specific training place. // all	share of trained workers; average training costs // all employees	firm-level panel data	control for unobserved influences on productivity by estimating these; joint estimation of production function and unobserved productivity via two-step procedure and iteration (method by Ackerberger, Caves and Frazer, 2006); estimate of TFP included in wage equation; firm fixed-effects	within same year	value added	coeff: 0.243 effect of a 1-point rise in share of workers trained on log value added // + // sig (1%)
Kazamaki Ottersten et al. (1999)	SE // machine tool industry (SNI 382)	CVET // -	share of training expenditures in the wage bill, in % // all employees (firms out of the 200 largest manufacturing firms in Sweden)	firm-level panel data	no; estimation by maximum likelihood; firm-specific parameters for some variables, but not for training! Paper rather concerned with form of the production function than with possible endogeneity of training…	within same year	company costs; total factor productivity	average elasticity long run total costs with respect to training: -0.043; average elasticity TFP with respect to training: 0.067. // + // unknown (no standard errors computed)
Turcotte and Rennison (2004)	CA // all/unspecified	CVET formal // on-the-job; in class	share of workers trained // all	firm-level cross-section data	nonlinear least squares (to consider the potential causality)	within same year	log value added per worker function	function: coeff: -0.035-0.355 // 2 positive, 2 negative // 1% pos. coeff. sig.
Alba-Ramirez (1994)	ES // Non-agricultural large firms (more than 200 employees)	CVET // all	percentage workers that have attended training courses; computed for junior and senior employees // all employees (firms with more than 10 employees)	cross-section	no	1988	1) productivity, 2) wages	elasticity training of senior employees on productivity is 0,04; Elasticity training of junior employees on productivity is -0,00; Elasticity training senior employees on wages is 0,02; Elasticity training of junior employees on wages is 0,006 // + // all positive effects sig.

Aragon-Sanchez et al. (2003)	UK, NL, PT, FI, ES	CVET; various forms // various training activities	number of training hours per worker; percentage of trained workers; total expenditure on training as a share of sales volume // all (companies with 10 to 250 workers)	firm-level cross-section	no (linear step-wise regression)	within same year (and one year later in some cases)	log sales volume; log benefits before interest and taxes; log profitability (benefit before taxes / sales)*100	lots of estimations, 13 + and 11 - // all sig. //
Barrett and O'Connell (2001)	IE // manufacturing, construction and private services; only firms with more than 10 employees	General and firm-specific training // all	1) Trainees/total employment 2) Training days/total employment 3) Training expenditure/total employment // all employees (firms with more than 10 employees)	firm-level panel data (two points in time)	no	1993 and 1995	first difference in labour productivity	trainees/employment elasticity on productivity is 0,039 =0,394*0,099; training days/employment elasticity is: 0,027; training expenditure/wage sum elasticity is 0,009; general training days/employment elasticity is 0,027; specific training days elasticity is:-0,016 // mostly positive // 3 out of 4 positive effects sig. Rest insig.
Barron et al. (1989)	US // all/unspecified	CVET: formal // on-the-job	log of hours of training in first 3 months // new employees	firm-level cross-section data	no	within same year	rate of (firm) productivity growth	10% increase in training is associated with a 3% increase in productivity // + // 1%
Bartel (1989)	US // equivalent of NACE A to K	CVET // -	share of the 7 occupational groups for which training is provided; share of occupations for which training assessed based on an indicator of productivity // all (divided into 7 occupational groups)	firm-level cross-section	unclear	within same year	output per worker	coeff: 0.17; coeff: 0.20 // + // sig (10%) (N.B.: no longer sig when control for screening of employees through formal test before hiring; use of screening and training positively correlated)
Bassi et al. (2001)	US // all/unspecified	CVET formal //	training expenditures/ employee // all	firm-level panel data	no	effects of training 1 year ago	sales/employee; income/employee; tobin's q/employee; stock market return (%)	coeff: -0.092-0.044 // 3 out of 4 positive // 3 out of 4 sig. of which 1 negative coeff.
Bishop (1989)	US // all/unspecified	CVET formal and informal in first 3 months // by supervisors; by co-workers; training by watching others	hours spent training; training intensity squared (sum of 4 indicators, weighted by costlines) // last hired 'typical' employee	cross-section data	no	within same year	logged productivity growth of worker in first 2 years; linear measure of productivity growth of worker in first 2 years; linear measure of productivity growth of worker	coeff: -0.049-0.149 // 12 positive, 3 negative // all sig
Black and Lynch (1996)	US // manufacturing; non-manufacturing	CVET +% of formal training that occurs off the job, // CVET + computer training, teamwork training, supervisor training	total number of workers trained in year of study and 3 years before,% of formal training that occurs off the job, computer training, teamwork training, supervisor training // all	firm-level cross-section	no	within same year + 3 years later	productivity (dollar value of sales)	most effects insignificant, except % formal training outside working hours in manufacturing sector and computer training in non manufacturing // - // insig

			employees (firms with more than 20 employees)					
Blandy et al. (2000)	AU // all/unspecified	CVET // on-the-job	log of hours of training in first three months; training quantity (index based on several interview questions about expenditures, hours of training and proportion of employees etc) and training quality (index based on several interview questions) // new employees	firm-level cross-section data	no	within same year	productivity growth; profitability index (1-7) (perceived)	10% increase in training is associated with an increase in productivity growth of 1% in Australia // + // 4 out of 5 sig.
Carriou and Jeger (1997)	FR // NACE A to K	CVET // -	expenditures on training relative to salaries; expenditures on training relative to salaries, and square term to allow for possible saturation // all (companies with 50 workers or more)	firm-level cross-section	unclear	effect of training expenditures in year preceding measurement of value added	value added	average coeff. = 2 (effect of 1-point increase in training expenditures rate on log value added) (sample mean not reported); optimal training expenditure rate = 4% // + // sig in most years
D'Arcimoles (1997)	FR // manufacturing (industrial firms)	CVET // all	share of training expenses in total wage sum; change/evolution Share of training expenses in total wage sum // all employees	firm-level panel data (training info from older waves, but analysis cross-section); firm-level panel data (change 87-89)	no (OLS)	separate analyses for effects of training 1, 2, 3, 4 and 5 years ago	profitability return on capital: operating result/total assets); level of productivity (added value/total staff); evolution productivity and profitability in two year period	simple functional form (no logs), but several lags. No sample means. Coefficient varies from 0 to 42 for several lags // + // mostly sig.
Lyau and Pucel (1995)	TW // auto parts manufacturing firms	CVET (IVET explicitly excluded) // employer-sponsored activities, only activities directly related to production (i.e. no fire safety and language training)	direct costs of training; total costs of training (including trainer and trainee salaries during training) // all employees (large and medium sized firms)	firm-level cross-section	no	within same year	sales per worker	elasticity: 0.01-0.12 // + // sales per worker insig; value added per worker sig.
Mahlberg et al. (2009)	AT // NACE C to K	CVET // -	share of employees who received training; share of training hours in total hours worked; share of training expenses in total personnel costs // all employees	cross-section, matched firm-employee data	no; OLS estimation (problem not only with endogeneity of training, but also with survivor bias and selection bias)	two years later (training measured in CVETS 1999, value added in 2001)	value added per employee	coeff: 0.08 when sector dummies included, 0.16 when sector dummies left out (marginal effect of share of trained workers on log value added per employee); sample mean = 0.22 // + // insig when sector dummies included, sig when sector dummies left out
Ismail (2009)	MI // manufacturing; services	CVET // -	number of workers who attended training // all	firm-level cross-section	no	within same year	output; productivity (output per worker)	elasticity: 0.148 // effect on output + and insig; effect on productivity - and insig //

Russell et al. (1985)	US // retail	CVET // training in basic sales procedures	percentage of personnel trained (and training emphasis as perceived by employees) // all employees	cross-section	unclear	within same year	sales volume per employee (also subjective measure of evaluation of store image by employees, but not included here)	coeff: 0.4 // + // sig
Bryan (2006)	UK // manufacturing	in-house training and external management training	proportion of employees trained (classes) // all employees	firm-level cross-section	no	separate analysis for short-term and long-term effects	annual turnover growth	positive significant
Trouerbach (2009)	NL // pharmacies	formal training and informal learning	number of training received per employee // share of working time spent on instructive activities	firm-level panel	no	lagged effect (two years)	number of prescriptions processed per worker	insignificant
Van de Wiele (2010)	BE // manufacturing, trades and services	CVET // formal training, not on-the-job	share of workers who received training, costs per person trained, share of labour costs spent on training // all employees	firm-data, panel	yes (estimates effect of training on firm fixed-effect in production function)	lagged effect (one year)	over- or underperformance of firm in terms of productivity (fixed effect from estimated production function)	mostly significant (1% level)
Kurosawa et al. (2005)	JP// manufacturing	off-the-job and on-the-job training	log of costs of on-the-job training, hours of on-the-job training per production staff	firm-level panel	no, OLS	lagged	log real value added	off-the-job training pos. sig. (10%) on-the-job training insig.
Maliranta and Asplund (2007)	FI // all sectors	CVET, both internal and external training	time spent on training per employee// all employees	matched employer-employee data, panel	no	effect of a training stock ($\Delta y = f(t)$)	productivity growth (value added per person)	effect of training positive and significant only for firms with process innovation
Ng and Siu (2004)	CN // manufacturing	CVET, technical training and managerial training	log of total expenditures on training	firm-level cross-section	no, OLS	lagged (one year)	log sales	positive significant effect of managerial training, no significant effect of technical training.
Arvanitis (2005)	CH// all sectors	CVET	share of employees receiving job-related training, dummy for strong orientation of training towards computer training // all employees	firm-level cross-section	no, OLS	direct effect	log sales per employee	positive significant effect
Thang (2009)	VN// manufacturing, non-manufacturing	CVET	total training costs	firm-level panel	no (OLS)	direct effect	output per worker	positive sig. in manufacturing, insig. in non-manufacturing

Table A2. **Overview of the studies dealing with the effects of VET on profitability**

Reference	Country // Economic sector(s)	Forms of VET // Types of VET	Indicator for VET efforts // Target group	Data type	Correction for endogeneity	Measurement period	Performance indicator(s)	Vet: effect// sign // significance
Zwick (2007)	GE // All sectors	Secondary education, professional degree // initial education	share of workers with secondary education, professional degree // all employees	cross-section; panel	no; Fixed effects; GMM	1997-2003	profits per employee	elasticity is -0,028; elasticity is -0,025 // - // sig
Leiponen (2000)	FI // manufacturing	IVET // technical or natural scientific degree (vocational or higher)	share of employees with a technical or natural scientific degree (vocational or higher) // all employees	firm-level panel data	Arellano-Bond: dynamic model with fixed-effects and lagged variables as instrumental variables	within same year	profitability (net profit margin)	technical education is positive but insignificant; only higher technical education has positive significant effect on profitability // technical educ +; higher technical educ + // technical educ insig; higher technical educ sig.
Aragon-Sanchez et al. (2003)	UK, NL, PT, FI, ES	CVET; various forms // various training activities	number of training hours per worker; percentage of trained workers; total expenditure on training as a share of sales volume // all (companies with 10 to 250 workers)	firm-level cross-section	no (linear step-wise regression)	within same year (and one year later in some cases)	log sales volume; log benefits before interest and taxes; log profitability (benefit before taxes / sales)*100	lots of estimations, 13 + and 11 - // all sig. //
Delery and Doty (1996)	US // banking industry	CVET // both formal and informal	availability / use of training programmes as assessed by HR manager (measure constructed from factor analysis) // only loan officers, because crucial to all banks	firm cross-section	no	within same year	return on average assets; return on equity	0 // - // insig
Bassi et al., (2001)	US // all/unspecified	CVET formal //	training expenditures/employee // all	firm-level panel data	no	effects of training 1 year ago	sales/employee; income/employee; Tobin's q/employee; stock market return (%)	coeff: -0.092-0.044 // 3 out of 4 positive // 3 out of 4 sig. of which 1 negative coeff.
D'Arcimoles (1997)	FR // manufacturing (industrial firms)	not clear, but because this is about expenses, there is a chance that it only concerns formal training // all	Share of training expenses in total wage sum; Change/evolution Share of training expenses in total wage sum // All employees	firm-level panel data (training info from older waves, but analysis cross-section); firm-level panel data (change 87-89)	no (OLS)	separate analyses for effects of training 1, 2, 3, 4 and 5 years ago	profitability return on capital: operating result/total assets); Level of productivity (added value/total staff); evolution productivity and profitability in two year period	simple functional form (no logs), but several lags. No sample means. Coefficient varies from 0 to 42 for several lags // + // mostly sig.
Maliranta and Asplund (2007)	FI // all sectors	CVET, both internal and external training	time spent on training per employee // all employees	matched employer-employee data, panel	no	effect of a training stock ($\Delta y = f(t)$)	profitability growth (value added per labour compensation)	effect of training positive and significant only for firms with process innovation
Jones et al. (2011)	FI // banking sector	CVET, general versus specific	training costs per employee, training days per employee // all employees	firm-level panel	fixed-effects and GMM SYS		profits	insignificant
Danvila del Valle and Sastre	ES // security	CVET	one indicator based on: different training courses given, number of hours of	firm-level panel	no	lagged	income (earnings before interests, tax,	positive, highly significant

Castillo (2009)	services		attendance per year per employee, and annual investment in training per employee				depreciation and amortisation/number of employees)	

Table A3. **Overview of the studies dealing with the effects of VET on perceived performance**

Reference	Country // Economic sector(s)	Forms of VET // Types of VET	Indicator for VET efforts // Target group	Data type	Correction for endogeneity	Measurement period	Performance indicator(s)	Vet: effect// sign // significance
Loundes (1999)	AU // all/unspecified	CVET formal // -	dummy formal training in last year // workplaces with more than 20 employees	cross-section data	-	somewhat lagged (training last year, compared to current productivity)	perceived level of productivity (labour productivity compared to competitors); perceived productivity growth (current labour productivity compared to two years ago)	coeff: 0.14; coef: 0.21 // both positive // only effect on perceived productivity growth sig.
Nikandrou et al. (2008)	14 European countries // industry and services	CVET // -	number of days spent on training by different categories of personnel (also: training formalisation, HR involvement, Training Needs Analysis, Training Evaluation) // all employees	firm-level cross-section	no [focus is on hierarchical linear modelling to test the influence of moderating cultural variables]	within same year	perceived performance (constructed out of: perception of quality, productivity, profitability, timing of the product on the market, innovation)	correlation between employee training and firm performance pos. sig.; employee training itself insig. In the regression; employee training * humane orientation pos. sig. at 10% level; employee training * national expenditure on education has neg. effect, not very sig. // - // insig
Akhtar et al. (2008)	CN // manufacturing + services	CVET // -	availability / use of training programmes as assessed by HR manager (measure constructed from factor analysis) // all	firm cross-section	no	within same year	product/service performance as assessed by managers (compare performance to that of competitors over last 3 years); financial performance as assessed by managers (compare performance to that of competitors over last 3 years)	coeff: 0.28; coeff: 0.15 // + // sig (1%)
Guerrero and Barraud-Didier (2004)	FR // all	CVET // -	availability / use of training programmes as assessed by HR manager (measure constructed from factor analysis) // all (large firms)	cross-section	no	within same year	social and organisational performance as assessed by manager (based on work climate, attendance, productivity, quality)	0.094 // + // sig (10%)
Harel and Tzafrir (1999)	IL // private and public sector at least 200 employees. (public sector not included in profitability analysis)	systematic and formal training // all	share of employees which received formal training in past year (scale) // all employees	firm-level cross-section	no	direct effect (training in past year)	perceived organisational performance (quality of programmes/products); scale; perceived market performance (profitability); scale	// + // sig (5%)
Hansson (2007)	various countries (27) // private sector (at least 200 employees)	not clear to what extent also includes	share of training expenses in total wage sum; Proportion workers trained in last year; Written training policy or not; Systematic training	cross-section	No. Because prior profit is control variable, to certain extent explanation of	within same year	top 10% companies of sectors in scores on profitability (perceptions). Because prior profit is control variable (perceptions and classes),	// + // share of training expenses in total wage sum sig. Rest insig.

		informal // all	need analysis or not // All employees		change in profit. Moreover, first training indicator is only weakly determined by prior profit (separate analysis)		to certain extent explanation of change in profit.	
Blandy et al. (2000)	AU // all/unspecified	CVET // on-the-job	log of hours of training in first 3 months; training quantity (index based on several interview questions about expenditures, hours of training and proportion of employees etc) and training quality (index based on several interview questions) // new employees	firm-level cross-section data	no	within same year	productivity growth; profitability index (1-7) (perceived)	10% increase in training is associated with an increase in productivity growth of 1% in Australia // + // 4 out of 5 sig.
Trouerbach (2009)	NL // pharmacies	formal training and informal learning	number of training received per employee // share of working time spent on instructive activities	firm-level panel	no	lagged effect (two years)	perceived service quality relative to others (Likert scale)	insignificant
Addison and Belfield (2008)	UK // all sectors	CVET, off-the-job training	incidence dummy, scale indicating share of workers trained, scale indicating duration of training for trained employees	firm-level cross-section	instrumental variable	direct effect	dummy variable for above average labour productivity, as estimated by manager	mostly positive sig.
Delaney and Huselid (1996)	US // for profit and not for profit	formal training	one constructed training indicator, with underlying elements (including participation) // all employees	firm-level cross-section	no	direct effect	organisational performance and market performance	positive significant

Table A4. **Overview of the studies dealing with other performance indicators (innovation, wages, employment, quality and costs)**

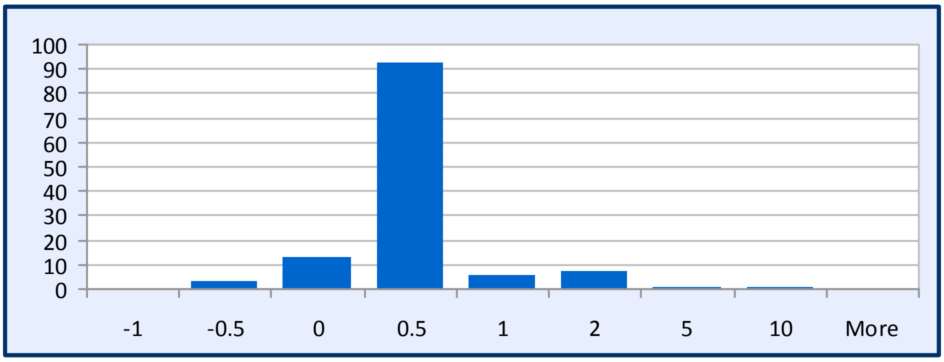
Reference	Country // Economic sector(s)	Forms of VET // Types of VET	Indicator for VET efforts // Target group	Data type	Correction for endogeneity	Measure ment period	Performance indicator(s)	Vet: effect// sign // significance
Bauernschuster et al. (2008)	DE // private-sector business	CVET // -	continuous training 1997, 1998, 2000: dummy if firm continuously encouraged training by partly financing the training or releasing the employee from work; continuous training instrumented by the existence of a union contract and a works council // -	firm-level panel data are transform ed to cross-section by defining variables that span more than one	lag training variable, and they do not consider training at a single year but focus on the continuity in training. Also a lagged innovation variable for controlling for continuously innovation; instrumental variable regression. A lagged innovation variable for controlling for continuously innovation	lagged	innovation 1999-2001: dummy if firm introduced a new product/service, newly adopted a product/service or enhanced an existing product/service	coeff: -0.6696602 -0.2451723 // 2 out of 4 positive // only positive effects sig.

				year.				
Gallié and Legros (2007)	FR // intermediate goods, capital good, food goods	CVET // -	(1) training expenditure per trained employee; (2) number of training hours per trained employee; (3) rate of participation in training // all employees	firm-level panel data	quasi-differenced GMM estimator (i.e. kind of GMM dynamic model with fixed-effects)	within same year	innovation: number of patents applied for	1% more expenditure per employee leads to 0.16 patents more; 1% more training hours per employee leads to 0.03 more patents; 1% more participation in training leads to 0.11 more patents // + // sig.
Baker and Thompson (1995)	UK // GP practices	IVET	participation of the practice in the training scheme (dummy)	firm-level panel data	no (logistic regression)	change after 8 years	presence of a range of features in the practice at the end of the period (marriage counsellor, patient participation group, audit, collaborative research, computer, diagnostic index, practice research, library, workload analysis, diabetes clinic, elderly patient screening, sigmoidoscope	positive significant
Ballot et al. (2006)	FR, SE // manufacturing	all // all	1) training stock per employee (cumulated expenditure on training, considering separations, 2) training expenditure per employee // all employees (large firms)	firm-level panel data	yes, using GMM-SYS	1987-1993	1) productivity, 2) wages	Elasticity training on productivity is 0,173 (training variable in log). Elasticity training on wages is 0,131. Elasticity training on productivity is 0,054. Elasticity training on wages is 0,061. // + // sig.
Alba-Ramirez (1994)	ES // non-agricultural large firms (more than 200 employees)	all // all	Percentage workers that have attended training courses; computed for junior and senior employees // all employees (firms with more than 10 employees)	cross-section	no	1988	1) productivity, 2) wages	elasticity training of senior employees on productivity is 0,04; elasticity training of junior employees on productivity is -0,00; elasticity training senior employees on wages is 0,02; elasticity training of junior employees on wages is 0,006 // + // all positive effects sig.
Cosh et al. (2000)	UK // equivalent of NACE A to K	CVET // -	dummy for training firm; training expenditures as a percentage of total sales // all (SME's)	firm-level (short) panel	yes; control in the model for propensity to undertake training (Heckman: include residuals from a probit model to explain the chance to train in one or two of the both periods)	training at the beginning of period where growth measured	employment growth (log of ratio of opening and closing size)	marginal effect of training dummy on log growth // + // insig/sig
Murray and Raffaele (1997)	US // vitreous china production facility	CVET // Crosby quality training programme	dummy for post-training intervention // managers, salaried employees, hourly employees	firm-level panel data	fixed-effects model estimated by GLS	over 5 years following training intervention	quality of products: percentage of good pieces following a production process (greenware)	coeff: 4.84 (the training intervention increased the percentage of good quality pieces by 4.84%) // + // sig (1%)
Holzer et al. (1993)	US // manufacturing companies with up to 500 employees	CVET // -	log of hours trained per employee; change in training; lag change in training // all	firm-level cross-section	unclear	within same year; within same year +	scrap rate	coeff: -0.68 (effect of marginal increase in log of hours trained per employee on delta log(scrap rate); coeff: -0.076; coeff: 0.052 // + (a

	implementing some type of new technology					one year later		negative coeff. on scrap rate means a positive effect on performance!); +; - // only log of hours trained per employee sig(5%)
Danvila del Valle and Sastre Castillo (2009)	ES// security services	CVET	one indicator based on: different training courses given, number of hours of attendance per year per employee, and annual investment in training per employee	firm-level panel	no	lagged	customer loyalty in terms of months	positive, highly significant
Kazamaki Ottersten et al. (1999)	SE // machine tool industry (SNI 382)	CVET // -	share of training expenditures in the wage bill, in% // all employees (firms out of the 200 largest manufacturing firms in Sweden)	firm-level panel data	estimation by maximum likelihood; firm-specific parameters for some variables, but not for training! Paper rather concerned with form of the production function than with possible endogeneity of training	within same year	company costs; total factor productivity	average elasticity long run total costs with respect to training: -0.043; average elasticity TFP with respect to training: 0.067. // + // unknown (no standard errors computed)
Jones et al. (2011)	FI // banking sector	CVET, general versus specific	training costs per employee, training days per employee // all employees	firm-level panel	fixed-effects and GMM SYS		costs	insignificant

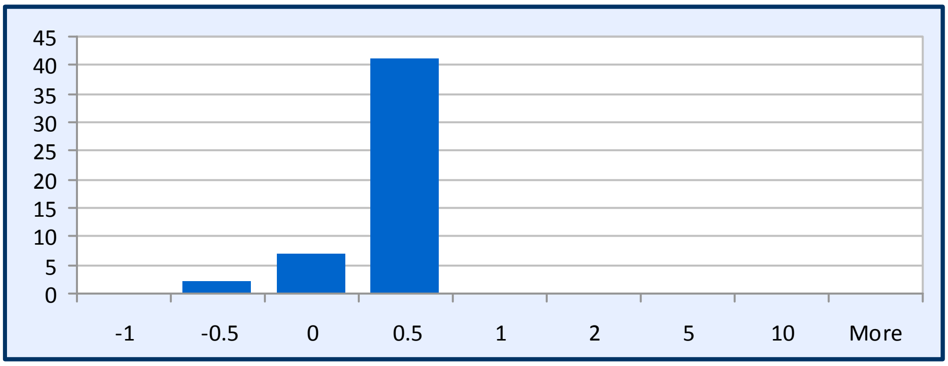
ANNEX 2
Descriptive statistics

Figure A 1 **Histogram of estimated effect sizes**



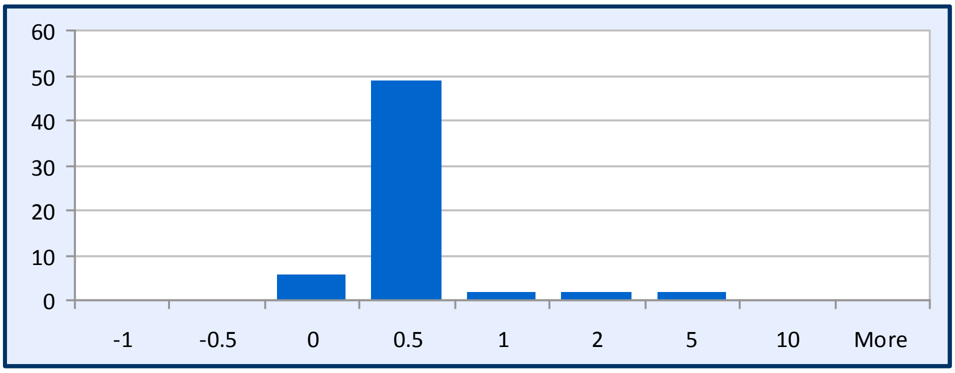
NB: effects estimated in regressions with multiple training indicators excluded.

Figure A 2 **Histogram of estimated elasticities**



NB: effects estimated in regressions with multiple training indicators excluded; elasticities computed on the basis of quasi-elasticities and sample means included.

Figure A 3 **Histogram of estimated quasi-elasticities**



NB: effects estimated in regressions with multiple training indicators excluded; quasi-elasticities computed on the basis of elasticities and sample means included.

Table A5. **Estimated effects of VET by type of training indicator**

Variable	Obs	Mean	Std. Dev.	Min	Max
VET indicator not related to total labour input					
All effect sizes (excluding effects estimated in regressions with multiple training indicators)	58	0.39	1.24	-0.78	8.08
Quasi-elasticity	13	0.29	0.22	0.03	0.72
Quasi-elasticity including values calculated from elasticity and sample mean	16	0.23	0.23	-0.06	0.72
Elasticity	16	-0.02	0.28	-0.72	0.30
Elasticity including values calculated from quasi-elasticity and sample mean	18	-0.01	0.26	-0.72	0.30
VET indicator related to total labour input					
All effect sizes (excluding effects estimated in regressions with multiple training indicators)	66	0.21	0.50	-0.09	2.00
Quasi-elasticity	29	0.23	0.50	-0.02	2.00
Quasi-elasticity including values calculated from elasticity and sample mean	45	0.31	0.86	-0.02	4.47
Elasticity	17	0.03	0.05	-0.04	0.17
Elasticity including values calculated from quasi-elasticity and sample mean	32	0.03	0.05	-0.04	0.17
VET indicator based on number of workers trained					
All effect sizes (excluding effects estimated in regressions with multiple training indicators)	35	0.10	0.27	-0.72	0.80
Quasi-elasticity	21	0.16	0.16	0.02	0.72
Quasi-elasticity including values calculated from elasticity and sample mean	21	0.16	0.16	0.02	0.72
Elasticity	5	-0.22	0.44	-0.72	0.15
Elasticity including values calculated from quasi-elasticity and sample mean	16	-0.03	0.26	-0.72	0.17
VET indicator based on time spent training					
All effect sizes (excluding effects estimated in regressions with multiple training indicators)	22	0.01	0.21	-0.78	0.34
Quasi-elasticity	4	0.01	0.02	-0.02	0.03
Quasi-elasticity including values calculated from elasticity and sample mean	12	0.00	0.01	-0.02	0.03
Elasticity	11	0.03	0.09	-0.04	0.30
Elasticity including values calculated from quasi-elasticity and sample mean	14	0.03	0.08	-0.04	0.30
VET indicator based on training expenditures					
All effect sizes (excluding effects estimated in regressions with multiple training indicators)	44	0.27	0.60	-0.17	2.00
Quasi-elasticity	8	0.55	0.90	0.01	2.00
Quasi-elasticity including values calculated from elasticity and sample mean	19	0.61	1.27	-0.06	4.47
Elasticity	17	0.06	0.05	0.00	0.17
Elasticity including values calculated from quasi-elasticity and sample mean	19	0.05	0.05	0.00	0.17
VET indicator is a dummy					
All effect sizes (excl. effects estimated in regressions with multiple training indicators)	18	1.08	2.06	0.00	8.08
Quasi-elasticity	7	0.33	0.21	0.03	0.71

Quasi-elasticity including values calculated from elasticity and sample mean	7	0.33	0.21	0.03	0.71
Elasticity	0				
Elasticity including values calculated from quasi-elasticity and sample mean	1	0.03		0.03	0.03
Multidimensional VET indicator based on survey questions					
All effect sizes (excl. effects estimated in regressions with multiple training indicators)	5	0.33	0.24	0.09	0.66
Quasi-elasticity	2	0.19	0.03	0.17	0.21
Quasi-elasticity including values calculated from elasticity and sample mean	2	0.19	0.03	0.17	0.21
Elasticity	0				
Elasticity including values calculated from quasi-elasticity and sample mean	0				

Table A6. **Overview of studies using 'absolute' indicators of VET**

Reference	workers	time	Expen-diture	dummy	Multi-dimen-sional	Total
Addison and Belfield (2008)	0	4	0	4	0	8
Akhtar et al. (2008)	0	0	0	2	0	2
Aragon-Sanchez et al. (2003)	0	2	1	14	4	21
Arvanitis (2005)	0	0	0	1	0	1
Baker and Thompson (1995)	0	0	0	1	0	1
Barron et al. (1989)	0	1	0	0	0	1
Bartel (1989)	0	0	0	0	2	2
Bartel (1994)	0	0	0	1	0	1
Bauernschuster et al. (2008)	0	0	0	1	0	1
Black and Lynch (1996)	4	2	0	6	0	12
Black and Lynch (2001)	1	0	0	0	0	1
Blandy et al. (2000)	0	1	0	0	4	5
Boon and van der Eijken (1998)	0	0	2	0	0	2
Cosh et al. (2000)	0	0	0	3	0	3
Danvila del Valle and Sastre Castillo (2009)	0	0	0	0	2	2
de Kok (2002)	0	4	0	0	0	4
Delaney and Huselid (1996)	0	0	0	0	2	2
Delery and Doty (1996)	0	0	0	1	0	1
Gallié and Legros (2007)	0	1	1	0	0	2
Guerrero and Barraud-Didier (2004)	0	0	0	0	1	1
Hempell (2003)	0	0	1	0	0	1
Jones (2001)	1	0	0	0	0	1
Konings and Vanormelingen (2010)	0	0	3	0	0	3
Kurosawa et al. (2005)	0	0	1	0	0	1
Loundes (1999)	0	0	0	1	0	1
Lyau and Pucel (1995)	0	0	4	0	0	4
Murray and Raffaele (1997)	0	0	0	2	0	2
Ng and Siu (2004)	0	0	4	0	0	4
Nikandrou et al. (2008)	0	1	0	0	0	1
Ismail (2009)	4	0	0	0	0	4
Russell et al. (1985)	0	0	0	0	3	3
Tan and Batra (1996)	0	0	0	5	0	5
Thang (2009)	0	0	8	0	0	8
Zwick (2005)	0	0	0	7	0	7
Van de Wiele (2010)	0	0	2	0	0	2
Total	10	16	27	49	18	120

ANNEX 3
Codes used in the meta-analysis

Variables	Codes (*Notes*)		
Reference	author + date		
Country	EU codes		
N firms	n		
N waves	n	*In the case of panel data*	
N observations	n	*If different from firms, e.g. in panel data*	
Characteristics of firms			
Economic sector(s)	1 = all; 2 = manufacturing; 3 = services; 4 = all but manufacturing		
Size firms lower bound	0 = not applicable; n		
Size firms higher bound	n; 999999 = not applicable		
Characteristics of VET			
IVET versus CVET	1 = CVET; 2 = IVET		
Training form	1 = on the job; 2 = classroom training; 3 = informal training 4 = other; 9 = unknown		
Internal versus external	1 = internal 2 = external 9 = unknown	*Internal = participants all employees of the same firm (or firm-specific training)* *External = participants from different firms (or general training).*	
Instructor	1 = Peers; 2 = internal trainer/supervisor; 3 = external trainer; 9 = unknown		
Content of training specified	1 = Yes; 0 = No		
Content of training	Text	as accurate as possible	
Indicator for VET efforts	1 = number of workers trained 2 = time spent in training (hours or days) 3 = training expenditures 4 = dummy for training intervention / presence of training in the firm 5 = multidimensional indicator	*(multidimensional indicator: to account for indicators constructed on the base of answers to several survey questions related to different dimensions of training)*	
VET indicator based on subjective data	1 = Yes; 0 = No		
VET indicator absolute	1 = Yes	*other studies in which VET indicator not related to firm as a whole (e.g. VET indicator taken up as level, as expenditures or time per trained employee, as constructed variable from answer to different questions, etc.)*	
	0 = No	*studies in which VET indicator related to some measure related to the firm as a whole (total nr of employees, total working time, total wage costs, sales volume, etc.)*	
Target group specified	1 = Yes; 0 = No		
Target group	text	*as accurate as possible*	
Characteristics of the model			
data type	1 = cross-section; 2 = panel data		
data source	1 = firm-level data; 2 = matched employer-employee data		

Variables	**Codes (*Notes*)**	
estimation method (correction for endogeneity of training)	0 = OLS 1 = fixed effects 2 = model in first differences 3 = GMM 4 = GMM SYS 5 = instrumental variables 6 = Heckman 7 = maximum Likelihood 8 = random effects	*In case of a combination (e.g. GMM and fixed-effects), choose the method most relevant to control for endogeneity (in that case: GMM).*
correction for endogeneity of training	1 = Yes; 0 = No	*(to be sure)*
measurement period	1 = short term	*y = f(t) or ∆y = f(∆t)*
	2 = lagged effect (effect of training in t-x on performance in t)	*yt= f(tt-x)*
	3 = effect of a training stock in t (sum of training in preceding years) on performance in t)	*y = f(stock of t) or ∆y = f(t) or yt=f(tt, tt-x)*
control for labour input	1 = Yes; 0 = No	*If dependent variable is y/l, counts as control for labour input*
control for capital input	1 = Yes; 0 = No	
control for materials / intermediate costs	1 = Yes; 0 = No	
control for education level workforce	1 = Yes; 0 = No	*If study conducted only for a very specific sector, can be counted as control for sector.*
control for occupational structure workforce	1 = Yes; 0 = No	
control for tenure workforce	1 = Yes; 0 = No	
control for innovation / RandD	1 = Yes; 0 = No	
control for HRM policy indicators	1 = Yes; 0 = No	
control for sector dummies	1 = Yes; 0 = No	
number of control variables	number	*Fixed-effects do not count as control variables*
performance indicator	1 = productivity (value added, gross production, sales, productivity growth, etc.) 2 = total factor productivity 3 = quality (scrap rates or shares of good pieces) 4 = profitability 5 = innovation (nr of patents applied for, introduction of a new product, etc.) 6 = firm costs 7 = employment growth 8 = multidimensional indicator	*Estimate effect of VET on total factor productivity is also a way of controlling for endogeneity of VET* *Multidimensional indicator: to account for indicators constructed on the base of answers to several survey questions related to different dimensions of performance*
performance indicator based on subjective data	1 = Yes; 0 = No	

Characteristics of effect of VET		
sign effect	1 = positive; 0 = negative	
significance effect	1 = significant; 0 = insignificant	*Possibility to construct one variable with 4 categories: neg sig, neg insig, pos insig, pos sig and to run ordered logit*
significance level	1 = 1% level; 5 = 5% level; 10 = 10% level	
size effect	coefficient	
type effect	1 = elasticity: marginal effect of log training indicator on log performance indicator 2 = quasi-elasticity: marginal effect of training share (in total costs, employment, working time) on log performance indicator 3 = other marginal effect of training on performance indicator	
explanation type effect	text	*if 3 above, specify interpretation of the marginal effect*
sample mean training	sample mean training indicator	*to compute alternative effect sizes…*
average effect	1 = Yes; 0 = No	*Is the reported coefficient / effect an average effect computed*

Variables	Codes	(*Notes*)
		on the basis of the effects of different training varialbes?
one out of many	1 = Yes; 0 = No	*Is the reported coefficient / effect the coefficient on one of many training variables taken up together in a single model? (to check comparability with coefficients on training in general…)*
interaction with HRM considered	1 = Yes; 0 = No	
how HRM considered	text	*as accurate as possible*
interaction with HRM	*1 = embedding training in HRM policy fosters positive effect of training* *0 = embedding training in HRM policy has no effect* *-1 = embedding training in HRM policy hampers positive effects of training* *9 = not applicable*	

European Centre for the Development of Vocational Training

The impact of vocational education and training on company performance

Luxembourg:
Publications Office of the European Union

2011 – VI, 97 p. – 21 x 29.7 cm

ISBN 978-92-896-0893-0
ISSN 1831-5860
doi:10.2801/37083
Cat. No: TI-BC-11-011-EN-N

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The impact of vocational education and training on company performance

This study is a meta-analysis of the evidence available in literature on the economic benefits of VET at company level. It is based on 62 studies and 264 estimated effects, covering many different company performance and training indicators. The meta-analysis concludes that VET has a positive and significant effect on the economic performance of firms. This result is valid for most performance indicators and VET indicators, and is also robust to the methodology used in the studies. Evidence on the effects of different types of training is limited because this aspect is not recorded in most of the studies. Similarly, a clear relationship between size of investment and size of the effect on productivity was hard to establish for the limited comparability of the VET variables and estimated effects collected.

TI-BC-11-011-EN-N

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