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The Cost and Benefits of Work-based Learning

Samuel Mühlemann

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THE COST AND BENEFITS OF WORK-BASED LEARNING

Education Working Paper No. 143

This working paper has been authorised by Andreas Schleicher, Director of the Directorate for Education and Skills, OECD.

Malgorzata Kuczera, Analyst, Directorate for Education and Skills (Malgorzata.Kuczera@oecd.org)
Samuel Mühlemann, Professor for Human Resource Education and Development at the University of Munich (muehlemann@bwl.lmu.de)

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Abstract

Dual apprenticeship training is increasingly seen as an important educational track that provides youth with the skills necessary for a smooth transition into the labour market. However, providing skills at the workplace rather than at (vocational) school comes at a cost for firms that hire such apprentices. Nonetheless, as apprentices become part of a firm's workforce, they also generate a benefit from working productively. This paper provides a theoretical framework and the latest empirical evidence about a firm's costs and benefits that are associated with offering dual apprenticeship training. While many aspects of such training are determined by external factors such as government policies, training regulations, and labour market institutions, firms can still influence many other aspects. The available empirical evidence suggests that there is no single optimal model of dual apprenticeship training. However, given the differences in the institutional setting across countries, adjusting key framework conditions can allow training firms to generate a sufficiently high return on their training investments. The main parameters affecting the cost–benefit ratio are apprentice wages, amount of training provided at the workplace, apprenticeship duration, and the manner in which firms integrate apprentices into the production process (to perform both skilled and unskilled tasks). An important prerequisite to successful apprenticeships, however, is also an adequate supply of suitable apprentices, which in turn (among other factors) depends on the training quality at the workplace, certification of the acquired skills, and future wages and career opportunities from obtaining a vocational qualification.

Résumé

La formation en alternance est de plus en plus considérée comme une filière importante qui dote les jeunes des compétences dont ils ont besoin pour entrer sans difficulté sur le marché du travail. La formation sur le lieu de travail plutôt que dans un établissement d'enseignement (professionnel) a toutefois un coût pour les entreprises qui font appel à des apprentis. Néanmoins, étant donné que les apprentis font partie des effectifs de l'entreprise, ils génèrent aussi des bénéfices en travaillant de façon productive. Le présent document fournit un cadre théorique et les dernières données empiriques sur les coûts et les bénéfices liés au fait, pour les entreprises, de proposer des formations en alternance. Si de nombreux aspects de la formation sont déterminés par des facteurs externes comme les politiques gouvernementales, les réglementations applicables à la formation, et les institutions du marché du travail, les entreprises peuvent encore influencer de nombreux autres aspects. D'après les données empiriques disponibles, il n'existe pas de modèle optimal unique de formation en alternance. Compte tenu des différences des environnements institutionnels entre les pays, le fait d'ajuster certaines conditions clés du cadre permet aux entreprises formatrices de générer un rendement suffisamment élevé de leur investissement dans la formation. Les principaux paramètres qui influencent le rapport coûts-bénéfices sont les salaires des apprentis, le volume de formation fourni sur le lieu de travail, la durée de l'apprentissage, et la façon dont les entreprises intègrent les apprentis dans le processus de production (pour effectuer des tâches à la fois qualifiées et non qualifiées). Une importante condition préalable à la réussite de l'apprentissage, toutefois, est aussi une offre suffisante d'apprentis compétents, laquelle dépend à son tour (entre autres facteurs) de la qualité de la formation sur le lieu de travail, de la validation des compétences acquises, et des perspectives futures de salaire et de carrière qu'offre un diplôme professionnel.

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Abbreviations and acronyms

EUR	Euros
AUD	Australian Dollar
BIBB	Bundesinstitut für Berufsbildung Bonn (Federal Institute for Vocational Education and Training)
IAB	Institut für Arbeitsmarkt- und Berufsforschung (Institute for Employment Research)
VET	Vocational Education and Training
WTO	World Trade Organization

1. INTRODUCTION

Considering the high levels of youth unemployment in Europe, many recent initiatives attempt to increase the number of apprenticeships in several European countries with the aim to improve the labour market outcomes of young individuals (European Commission 2015a,b). In particular, dual apprenticeship training that contains a large component of workplace education is seen as a promising educational pathway so that young individuals can acquire the skills and experience required to successfully obtain adequate jobs after graduation.

However, a necessary requirement for successful apprenticeship schemes is a firm's willingness to invest in apprenticeship training. Thus, while not being the only factor, costs and benefits of such training are an important determinant of a firm's training decision. Moreover, costs and benefits themselves are determined by various factors outside a firm's control, such as government policies, programme design, or institutional and labour market factors, whereas other aspects of apprenticeship training can be influenced by training firms themselves.

The purpose of this paper is to discuss the determinants of the costs and benefits of apprenticeship training, and the effects of these factors on both the demand for, and the supply of, apprentices. The apprenticeship market follows the same basic economic principles as a labour market for skilled workers. However, even though apprentice wages are often the highest training cost component, instructor salaries and other expenditures for training equipment may be equally important sometimes, and hence, non-wage labour costs for apprentices are relatively more important compared to unskilled or skilled labour. Moreover, apprentices typically spend a substantial fraction of their time away from the workplace to attend vocational school or other courses, and have a low initial productivity in skilled tasks. Finally, the supply of apprentices may not as strongly depend on apprentice wages compared to how skilled labour supply depends on skilled worker wages, because apprenticeship training typically lasts only three or four years. Thus, the supply of apprentices is also largely influenced by expected future wages and career opportunities after graduation. Consequently, individuals might be willing to accept a low apprentice wage during the apprenticeship period, as long as they expect sufficiently high future benefits associated with successfully acquired vocational qualification.

The empirical evidence about the costs and benefits of apprenticeship training is rather scarce, and large-scale firm-level representative surveys are limited to Germany and Switzerland. Nonetheless, the available evidence suggests that there is a large heterogeneity with respect to costs and benefits of apprenticeship training, not only across countries and training occupations, but also within a particular training occupation. Depending on the labour market situation, apprenticeship training must generate short-run returns to firms, particularly when labour mobility is high, so that expected post-training benefits from training apprentices are low. Conversely, firms might be willing to invest in training when they expect to be able to retain suitable apprentices as skilled workers, thereby improving the match quality and saving on future hiring and firing costs. While it is difficult to estimate the expected returns to apprenticeship training for firms located in countries that currently do not have an established dual vocational education and training (VET) system, this paper's results should help to assess the potential costs and benefits of apprenticeship training under different hypothetical scenarios.

The remainder of this paper is organized as follows. Section 2 discusses the theoretical background, components of the cost–benefit model, and empirical evidence on the returns to apprenticeship training for firms. Section 3 provides the additional empirical evidence on how different factors affect the costs and benefits of apprenticeship training. Section 4 concludes.

2. COSTS AND BENEFITS OF APPRENTICESHIP TRAINING TO COMPANIES

This section discusses the theoretical framework underlying the costs and benefits of apprenticeship training, the related measurement methods, the factors influencing the different cost components, and the effects of such costs and benefits on a firm's demand for apprentices.

2.1. Theoretical framework

Related literature

The costs and benefits of apprenticeship training are an important determinant of a firm's decision to take on apprentices because it is at its own discretion to offer apprenticeships. According to the classical human capital theory (Becker, 1962), apprenticeship training may be classified as general or firm-specific human capital. In the case of competitive labour markets, a firm would never make a net investment in general skills, as individuals require a wage that is equal to their value of their productivity. Thus, a firm would not be able to extract any profit after training, because an employee could simply quit and work for a different firm that offers a wage (i.e. the *outside option*) equal to the value of the employee's productivity. However, in the case of firm-specific human capital, both the firm and the worker share the costs and the returns associated with an investment in apprenticeship training. The reason for such sharing is the hold-up problem that would give either party an incentive to claim all the benefits in the post-training period.[1]

Dual apprenticeship training is a special type of training, as apprentices are hired specifically for the period of the apprenticeship programme, and the apprenticeship contract expires automatically after the end of training. Lindley (1975) discusses the two main motives as to why a firm would be willing to take on apprentices: (i) production motive, and (ii) investment motive (see also Merrilees, 1983). For the first motive, the relevance of the costs and benefits of apprenticeship training are immediately clear: if a firm's main motive is to use apprentices for production during the apprenticeship period and does not wish to subsequently retain the graduated apprentices, then a firm would never hire an apprentice if the expected training costs exceed the expected training benefits. A similar logic applies if the firm expects that most apprentices will leave the firm voluntarily after training, for example, to pursue further studies or to go on and work for a different firm. Consequently, when a firm trains according to the production motive, apprentice pay must adjust so that the productive contribution of the apprentice covers a firm's training expenditures.

Regarding the investment-oriented training motive, the training benefits do not necessarily need to outweigh the training costs in the short-run, as long as a firm can expect sufficiently high post-training benefits. There are many potential sources for post-training benefits. The first important post-training benefit is related to savings on hiring costs for future skilled workers. Stevens (1994) models the training decision of the firm as an investment in the future skilled workforce, when firms first invest in the training for young people. However, by successfully retaining apprentices as skilled workers, a firm can subsequently save on recruitment costs for skilled workers. Obviously, this kind of post-training benefit will only be of relevance if there is in fact a scarcity of skilled workers in the external labour market. As long as the firm can easily hire suitable and experienced workers at low costs, the (net) costs of

[1] Given that a firm were to finance all of the specific training, a worker could simply quit when not being granted a wage increase after training. Conversely, if the worker makes the investment, the firm has no incentives to offer higher pay after training, as firm-specific human capital does not raise the worker's outside option (because firm-specific human capital can – by definition – only be used productively in the firm where it was acquired).

apprenticeship training may exceed the costs of external hiring. However, in times of skilled worker shortages – within particular industries or in general due to, for example, demographic change – this type of post-training benefit can be substantial.

The second type of post-training benefit arises if firms can select better qualified individuals as skilled workers. Because of asymmetric information, a firm will always take time to assess whether an individual's skills and abilities, personality traits, etc. are a good match with its job requirements.[2] Thus, by the end of a three- or four-year apprenticeship programme, the firm's knowledge about an individual apprentice is considerably higher compared to the situation where external candidates are interviewed in the selection process (even when considering more sophisticated hiring procedures, such as assessment centres).

There are many additional potential post-training benefits. Acemoglu and Pischke (1998, 1999) argue that because of information asymmetries, firms might be able to extract rent from training by paying a wage that is lower than the value of the employee's productivity, as outside firms cannot accurately determine an employee's productivity. Owing to mobility and job search costs, employees who receive training will thus remain with the training firm, even though there might be other employers who would be willing to offer higher pay.[3] Blatter et al. (2016) show for Switzerland that the separation rate is substantially lower in training firms (10.2%) than in non-training firms (14.7%), indicating that training firms may indeed be able to reduce turnover. Moreover, apprenticeship training may serve as a signal of good work climate. Backes-Gellner and Tuor (2010) show that German firms offering apprenticeships have a higher recruitment success from the external labour market compared to non-training firms, as reflected in a lower job vacancy rate for skilled blue-collar workers.

Taking a different view on human capital, Lazear (2009) argues that there is no firm-specific human capital, as it may be very hard to imagine skills that are completely irrelevant to any other employer. Instead, Lazear claims that it is the specific combination of general skills that can make them de-facto firm-specific. Based on the BIBB/IAB qualification and career surveys and BIBB cost–benefit surveys, Geel et al. (2011) provide evidence that German firms make a higher net investment in occupations that require specific combinations of general skills. Moreover, individuals in such occupations are less likely to subsequently change occupations. Related to the transferability of skills acquired during apprenticeship training, Fitzenberger et al. (2015) for Germany, and Müller and Schweri (2015) for Switzerland, find that apprenticeship training is sufficiently general so that individuals can switch employer and occupation without experiencing large wage penalties. Furthermore, Pfeifer et al. (2011) calculate based on the German cost–benefit survey in 2007 that the firm-specific component of apprenticeship training is on average about 12%. Thus, while apprenticeship training includes some firm-specific components (that may differ across occupations), most of the accumulated human capital during an apprenticeship is useful in other firms as well.

Measuring the costs and benefits of apprenticeship training

Calculating the costs of apprenticeship training is less challenging compared to quantifying the training benefits. Table 1 summarises the main components of a firm's training expenditures: (i) labour

[2] Lange (2007) shows that it takes three years for a firm to reduce the initial expectation error regarding the ability of a new hire by 50%. Thus, as apprenticeships typically last between three and four years, it is a valuable screening device for a firm.

[3] Pfeifer (2015) shows for Germany that firms with a more compressed wage structure are more likely to completely finance general training courses of their employees (rather than just some fraction of training costs). Pfeifer et al. (2011) show that the starting wages of external hires exceed the starting wages of former apprentices in the same firm by only 1%. Thus, most gains from apprenticeship training would likely result from a potentially higher ability of former apprentices, and not due to wage differences of internal vs. external hires.

costs for apprentices, (ii) labour costs for instructors, and (iii) costs for material and infrastructure. The remaining cost factors are listed under (iv) other costs.

Table 1: Training costs from the firm's perspective

(i) Labour costs for apprentices	(ii) Labour costs for instructors	(iii) Costs for material and infrastructure	(iv) Other costs
Apprentice pay	Full-time instructors pay	Expenses for work station used for non-productive activities *(e.g. machines, computers, tools, exercise equipment)*	Learning and teaching material (e.g. software, books), working equipment, protective clothing, etc.
Irregular wage payments *(Bonus, performance pay, 13th /14th monthly salary, etc.)*	Part-time instructors pay	Training centre	External training courses, training-related fees to professional associations, training funds, etc.
Other employer contributions *(e.g. according to tariff agreements in Germany, travel costs reimbursements, compensation for food, or living expenditures)*	External instructor fees	Within-firm formal training courses *(away from the workplace in separate classrooms)*	Administrative and recruitment costs for apprentices

In dual apprenticeship systems, such as those of Germany or Switzerland, apprentices sign a training contract and receive a monthly salary during the entire training period, even though they spend time away from the workplace to attend vocational school or external training courses. Some firms also offer irregular wage payments, such as 13th or 14th monthly salaries, Christmas bonuses, or pay for performance (e.g. for good grades in vocational school). Moreover, some firms may provide financial assistance for travel expenses, living arrangements, or subsidised lunches.

Labour costs for apprentice instructors constitute the second main cost component of apprenticeship training. In the German and Swiss cost–benefit surveys, firms were asked to report the number of instruction hours that prevented instructors from carrying out their regular duties at the workplace. Such a distinction is particularly important for part-time instructors, who perform skilled work in the firm when not engaging in training activities. Thus, if apprentices simply watch an instructor perform certain tasks, the corresponding time is not viewed as instruction time that is costly to the firm (because the instructor would have been equally productive without an apprentice watching). However, if the instructor stops regular work activities, or slows down the work process, then the corresponding time is cost-relevant for

the firm. In addition, some firms hire external training instructors to teach certain skills at the workplace; this cost is also added in the second category.

Third, a firm may need to buy equipment or materials solely for apprenticeship training. Similar to the concept of calculating training hours, only those costs are relevant that arise due to the training of an apprentice. Thus, if an apprentice uses a machine while working productively, then no additional costs arise from the perspective of the firm. The fact that apprentices might not be as productive compared to skilled workers will be considered when calculating the training benefits. Moreover, some (often large large) firms have separate training facilities for apprentices or provide formal training in a classroom-like setting within the firm.

Finally, a several other costs arise, such as tuition fees for external courses, books or learning software, protective gear, and fees for training funds or professional associations. A firm also needs to spend resources to attract and recruit suitable apprentices. Particularly in Germany, demographic change in combination with an increased share of university enrolment currently makes it extremely difficult for firms to find a sufficient number of suitable apprenticeship candidates. Thus, while some firms offer special days for young people to visit the firm and learn about the profession, and subsequently interview interested candidates, other firms run assessment centres to recruit suitable school-leavers.

The benefits from offering apprenticeship training are distinguished chronologically: during training (short-term benefits) and after training (long-term benefits), as outlined in Table 2. Short-term benefits to the training firm arise until the end of training and consist broadly of the value of unskilled and skilled work activities. In the German and Swiss cost–benefit survey, instructors who work daily with apprentices at the workplace were asked to estimate the fraction of time in each training year that apprentices perform unskilled work (performed by an individual without a vocational qualification) and skilled work (performed by an individual with a vocational qualification). The benefit to the training firm from an hour of unskilled work is the total number of hours an apprentice spends performing unskilled tasks, multiplied by the wage of an unskilled worker within the training firm. The same principle applies for skilled work; however, the value to the firm is adjusted by the apprentice's relative productivity in skilled tasks compared to an experienced skilled worker in the firm. For example, if an apprentice takes two hours to carry out skilled tasks that an average skilled worker takes only one hour, then the relative productivity of the apprentice will be 50%. Thus, in this example, the value to the training firm from having an apprentice perform an hour of skilled work equals 50% of the corresponding hourly wage of a skilled worker in the firm.

Table 2: Training benefits from the firm's perspective

Short-run training benefits (*during training*)	Long-run training benefits (*after training period*)
Benefits from unskilled tasks	Savings on future hiring costs for skilled workers
Benefits from skilled tasks (adjusted by the relative productivity)	Shorter vacancy duration
	Better match quality, lower turnover rate
	Compressed wage structures

Regarding the long-run benefits from training, the first requirement is that the firm can successfully retain the graduated apprentice. While some apprentices may want to leave the firm for personal reasons (e.g. to enrol in military services), the firm itself can also influence the retention probability. Even though the starting wage might be an important determinant of apprentice turnover, a firm can also offer career prospects and job security (e.g. by having a works council). However, another important determinant is local labour market conditions (Fitzenberger et al., 2015), as firms may not want to retain all apprentices if the business outlook is bad. Moreover, they will not be able to retain all suitable apprentices if the local labour market is tight, especially when the competition for graduated apprentices is high.

As summarised in Table 2, the main post-training benefits relate to savings on future hiring costs of skilled workers, shorter vacancy durations (meaning less productivity loss due to unfilled vacancies), better match quality and thus lower future labour turnover rates, and potential profits from being able to pay a wage below productivity (due to information asymmetries).

The next section describes the calculations of the costs and benefits of apprenticeship training in more detail, as to how certain components are affected by exogenous and endogenous factors, and how the costs and benefits of apprenticeship training relate to the demand for and supply of apprentices.

Simple analysis of apprentice demand and supply

The main prerequisite for apprenticeship training to be profitable in the short-run is that a firm will need to successfully integrate its apprentices into the production process. To illustrate, a simple production function takes the form $q = f(E, L_u, L_s, K)$, where q denotes the output, E is the number of apprentices a firm employs, L_u is the number of unskilled workers, L_s is the number of skilled workers, and K is the amount of capital.

The law of diminishing returns implies that increasing employment will result in a lower marginal return from employing an additional apprentice, when holding other input factors constant, resulting in a downward-sloping demand for apprentices. However, in contrast to the textbook case of a competitive labour market for regular workers, the costs $c(w_E, h^T(\theta), c^o)$ to employ an apprentice for an entire training

period not only consist of apprentice wage costs w_E, but also include the amount of training h^T provided to apprentices at the workplace (which also depends on training regulations in a particular occupation, skills certification, or quality control θ) and other costs c^o, as discussed in Table 1.

In perfectly competitive labour markets, the prices for apprentices, unskilled workers, skilled workers, and capital cannot be affected by the individual firm (i.e. firms are price takers). A firm's short-run profit function can then be written as $\Pi = pq - cE - w_u L_u - w_s L_s - rK$, where p is the market price for output q, w_u denotes the wage costs for unskilled labour, w_s is the wage costs for skilled labour, and r is the rental costs for capital. A firm will find it profitable to hire apprentices up to the point where the value of the marginal product ($VMP_E = p \times MP_E = p \times \frac{\partial f(E,L_u,L_s,K)}{\partial E}$) is equal to the marginal costs (c) of employing an additional apprentice ($VMP_E = c$).

In the following paragraph, a firm's benefits from employing an apprentice are discussed in more detail. Most production functions, for example, the Cobb–Douglas production function, assume that a firm's output depends on the number of employees and capital, and some technology parameter. Such an assumption makes sense for regular employees, as output grows with employment. However, such a production function does not fully reflect the complexity of apprenticeship training, because a firm can choose many parameters, and is subject to several constraints that affect the productivity (and the costs) of apprenticeship training.

Thus, estimating how a firm's output changes when hiring an additional apprentice does not account for strategic choices regarding the amount of training and the allocation of productive tasks while apprentices are at the workplace.[4] Unlike the case of unskilled or skilled workers, apprentices are not always working productively while they are at the workplace. More precisely, during the time h^W that apprentices spend at the workplace, the firm can decide on the fraction of time that apprentices perform skilled work α_E and unskilled work β_E. Apprentices also spend a fraction of their time ($\mu_E = 1 - \alpha_E - \beta_E$) with activities that have no immediate value to the firm, either when receiving instruction at the workplace, or when carrying out simulations or exercises without the direct supervision of an apprentice instructor.[5] Moreover, the firm invests h^T hours in apprenticeship training, and during that time apprentices also do not work productively, or only at a reduced pace, so that it will always be the case that apprentices spend a minimum fraction of their time at the workplace with unproductive tasks (i.e. $\bar{\mu}_E > 0$). The share of productive work also depends on the volume of suitable work that an apprentice can perform, which in turn depends on a firm's production technology τ and on business conditions b in a given training year. For example, some firms may be highly specialised and use automated production processes so that there are only few routine tasks available that a firm can allocate to inexperienced apprentices. Moreover, during a boom period, an apprentice's share of productive tasks at the workplace is likely to be higher than during a recession.

Some firms might provide better quality training than others, which is reflected by the parameter φ, a measure of training quality/technology (which depends, e.g. on the teaching skills and experience of individual training instructors, or the quality of training facilities).[6] In addition, the ability η of an

[4] For example, Mohrenweiser and Zwick (2009) estimate the value added of a marginal apprentice compared to that of an unskilled worker, and find heterogeneous effects across different occupations. Note that in equilibrium, the marginal productivity of an apprentice would be equal to marginal costs, so that marginal profits from hiring the last apprentice are zero (although *average* profits from training apprentices can be positive, as discussed below).

[5] Note that $\mu_E \neq h^T$, as time spent practising (without the instructor) is not considered instruction time. Such a distinction is important, since newly learned skills can be applied while working productively or while performing exercises or simulations that are of no productive value to the firm.

[6] The costs for training quality are included in $c_i^o(\varphi)$.

individual apprentice positively affects productivity, since more able apprentices learn quicker and become more productive early on. Finally, experience in performing skilled tasks also influences productivity growth. Thus, apprentices who spend a larger fraction of their time carrying out unskilled tasks β_E that do not require a vocational qualification in period i will be less productive in skilled tasks later compared to apprentices who spend more time with skilled tasks (or time with appropriate exercises or simulations). Hence, the productivity of an apprentice in skilled tasks in period i can be denoted as $\gamma_{\alpha_i}\left(h_{i-1}^T(\theta), \varphi, \eta, \beta_{Ei-1}\right)$.

As it is often very difficult to measure worker's productivity, the concept to measure the costs and benefits of apprenticeship training using representative surveys is based on the opportunity costs principle. The advantage of such a measurement strategy is that there is no need to quantify the absolute value of the output. Instead, the benefit of having apprentices perform skilled work is reflected by how much a firm can save on wage payments because certain tasks do not need to be carried out by other (skilled or unskilled) workers. The value of an apprentice's productive contribution B_{Ei} to the firm in a particular training year i can be described as follows:

$$B_{Ei} = h_i^W[\alpha_{Ei}(b_i, \tau, \gamma_{\alpha i})\gamma_{\alpha i}\left(\varphi, h_{i-1}^T(\theta), \beta_{Ei-1}, \eta(w_E, w_s, w^F)\right)w_s + \beta_{E_i}(b_i, \tau)w_u].$$

Summing up, the firm's benefit B_{Ei} of having an apprentice in a particular year i depends on the hours that an apprentice performs skilled work ($h_i^W \alpha_{Ei}$), multiplied with the relative productivity compared to a skilled worker ($0 \leq \gamma_\alpha \leq 1$) and the skilled worker wage w_s, as well as on the hours of unskilled work ($h_i^W \beta_{Ei}$) multiplied with the unskilled worker wage w_u. To illustrate, if it takes an apprentice twice as long to perform a certain skilled task compared to a skilled worker, then $\gamma_\alpha = 0.5$, so that the value to the firm from having an apprentice perform one hour of skilled tasks is equal to $0.5w_s$, that is, the wage costs a firm can save from not having to employ (and pay) a skilled worker to perform that particular task.[7]

Thus, the total value of employing an apprentice for an entire training period S is given by[8]

$$B_E = \sum_{i=1}^{S} h_i^W\ [\alpha_{Ei}(b_i, \tau, \gamma_{\alpha i})\gamma_{\alpha i}\left(\varphi, h_{i-1}^T(\theta), \beta_{Ei-1}, \eta(w_E, w_s, w^F)\right)w_s + \beta_{E_i}(b_i, \tau)w_u].$$

For a firm to hire at least one apprentice, B_E must be sufficiently high to cover the costs $C_E = \sum_{i=1}^{S}(w_{Ei} + h_i^T w_s + c_i^o)$ for apprentice wages and other training expenditures (although in theory, apprentice pay could be negative so that every firm would be willing to offer training positions).

Finally, the total benefit of training E apprentices can be denoted as

$$TB_E = E^\rho \times \sum_{i=1}^{S} h_i^W \alpha_{Ei}(b_i, \tau, \gamma_{\alpha i})\gamma_{\alpha i}\left(\varphi, h_{i-1}^T(\theta), \beta_{Ei-1}, \eta(w_E, w_s, w^F)\right)w_s + \beta_{E_i}(b_i, \tau)w_u,$$

where $\rho < 1$ implies a concave benefit structure (decreasing marginal training benefits). Total training costs are denoted as

$$TC_E = E^\sigma \times \sum_{i=1}^{S}(w_{Ei} + h_i^T(\theta)w_s + c_i^o(\varphi)),$$

[7] For unskilled tasks, the model assumes that apprentices are equally productive compared to unskilled workers.

[8] For simplicity, that model assumes that the discount factor is zero.

where $\sigma > 1$ ($\sigma = 1$) implies convex (constant) training costs. As previously discussed, a firm hires apprentices up to the point where the marginal training benefits are equal to the marginal training costs, which is given by

$$\frac{\partial TB_E}{\partial E} = \frac{\partial TC_E}{\partial E},$$

or

$$\rho E^{\rho-1} B_E = \sigma E^{\sigma-1} C_E.$$

The law of diminishing returns to scale implies ρ < 1, yielding a downward sloping apprentice demand curve. Regarding the parameter σ, its magnitude is ambiguous based on theoretical considerations. However, we could expect that firms can exploit economies of scale when instructing several apprentices at the same time. Conversely, we could also expect increasing marginal hiring (and possibly wage) costs for a firm to recruit suitable apprentices, because of a decreasing marginal ability (or match quality) of apprentices regarding a firm's job requirements. Moreover, a firm faces capacity constraints, as it might have to invest in new training facilities or hire additional (full-time) training instructors when the number of apprentices exceeds a certain threshold. Currently, the available empirical evidence does not allow to draw a clear picture about the parameter σ, mainly because of a lack of appropriate (panel) data. However, theoretical reasoning implies that the cost structure is unlikely to be concave across a wide range of E, suggesting that eventually $\sigma \geq 1$.[9]

The above model implies that a firm's demand for apprentices depends on the structure of both the costs and benefits of training, as

$$E = \left(\frac{\sigma B_E}{\rho C_E}\right)^{\frac{1}{\sigma-\rho}}.$$

Thus, as long as $\sigma > \rho$, which is the case if the benefit function is concave and the cost function is linear or exhibits a convex cost structure (or is less concave than the benefit function), the demand for apprentices depends positively on the cost–benefit ratio. In addition, the demand is negatively associated with the degree of concavity ρ of the benefit function (i.e. by how much the additional benefit from hiring an additional apprentice decreases with the number of already hired apprentices), and negatively related to the degree of convexity of the cost function.[10]

Examining the following costs and benefit function further reveals important insights into a firm's demand for apprentices:

$$E = \left(\frac{\sigma \sum_{i=1}^{S} h_i^W \left[\alpha_{Ei}(b_i, \tau, \gamma_{\alpha i})\gamma_{\alpha i}\left(\varphi, h_{i-1}^T(\theta), \beta_{E,i-1}, \eta(w_E, w_s, w^F)\right)w_s + \beta_{E_i}(b_i, \tau)w_u\right]}{\rho \sum_{i=1}^{S}(w_{Ei} + h_i^T(b_i, \theta)\ \times w_s + c_i^o(\varphi))}\right)^{\frac{1}{\sigma-\rho}}.$$

[9] For example, Stevens (1994) or Acemoglu and Pischke (1999) assume convex training costs. The importance about assumptions regarding the cost and benefit structure relate to firm size; for example, in Germany and Switzerland, many (small) firms train only one apprentice at a time. Nonetheless, even though the share of large firms is rather small in both countries, the absolute number of apprentices trained in small firms with less than 10 employees is about equivalent to those trained in firms with more than 100 employees (Muehlemann & Wolter 2014).

[10] In the case where $\sigma \cong \rho$, the demand for apprentices would converge towards infinity if $B_E > C_E$, and towards zero if $B_E < C_E$.

Endogenous factors: Allocation of tasks and investment in apprenticeship instruction

First, it is apparent that having apprentices perform a higher share of productive tasks at the workplace ($\alpha_E + \beta_E$) increases the training benefit, and thus increases the number of apprenticeships E (ceteris paribus). A high share of skilled tasks α_E increases training benefits even more when the relative productivity $\gamma_{\alpha i}$ is high, while $\gamma_{\alpha i}$ in turn depends positively on previous training investments h_{i-1}^T and on apprentice ability η. However, $\gamma_{\alpha i}$ depends negatively on the extent to which apprentices were used for unskilled tasks β_{Ei-1} (rather than given the opportunity to apply newly learned skills in the production process, or by conducting appropriate simulations or exercises). In addition, the benefit from using apprentices in skilled work clearly increases with both skilled and unskilled worker wages w_s and w_u, respectively.

The marginal benefit from increasing the share of skilled work α_{Ei} in a particular training year can be written as $\frac{\partial B_{Ei}}{\partial \alpha_{Ei}} = h_i^W\left[\gamma_{\alpha i}\left(\varphi, h_{i-1}^T(\theta), \beta_{E,i-1}, \eta(w_E, w_s, w^F)\right)w_s\right]$ if $\mu_E > \bar{\mu}_E$, as long as the firm can substitute unproductive time at the workplace with productive tasks. To illustrate, let us assume that the minimum training requirements are h^T= 5 hours of weekly instruction time per apprentice, and that an apprentice spends a total of 25 hours at the workplace each week. Moreover, firm A has a separate training workshop with, let us say, a computer numerical control (CNC) machine that is exclusively used by apprentices to practice their newly acquired skills for another 20 hours, but the parts produced by apprentices on that machine are not sold to customers, as the production of those parts is of no direct value to the firm. Conversely, firm B uses apprentices directly in the production process for an additional 20 hours where apprentices also get to apply their new skills by using CNC machines. Assuming that apprentices do not work productively while being instructed, the share of tasks with no direct value to firm A is $\mu_E = 100\%$ (i.e. 25 hours per week), but $\mu_E = \bar{\mu}_E = 20\%$ in firm B (i.e. 5 hours per week). Note that in this example the relative apprentice productivity $\gamma_{\alpha i}$ is the same in firm A and firm B, as apprentices perform the same tasks on a CNC machine in both firms when they do not receive instruction. The training benefit in firm A, however, is clearly lower than in firm B, as long as $\gamma_{\alpha i} > 0$. The empirical evidence on how substituting non-productive activities with skilled tasks affects relative apprentice productivity is provided in section 3.6.

Further, if a firm uses apprentices exclusively for productive work beyond the minimum time required for workplace instruction $\bar{\mu}_E$, then increasing the share of skilled work comes at a cost $h_i^W w_u$, which is the value of a marginal reduction in the share of unskilled work.[11] There is, however, also a future benefit from decreasing β_E in period i, because using apprentices mainly for unskilled tasks will negatively affect the relative productivity γ_α in period $i+1$, so that $\frac{\partial B_{Ei+1}}{\partial \beta_{Ei}} < 0$.

Besides deciding on the allocation of skilled and unskilled tasks, a second important parameter that a firm can chose is the amount of training provided to apprentices. While there is a minimum level of training required in most countries with a dual apprenticeship system, a firm may find it beneficial to increase h_i^T above the minimum threshold required by training regulations, particularly early on in the training period, because it increases future productivity in skilled tasks $\gamma_{a,i+1}$, thereby also increasing the training benefit by making it more beneficial for the firm to use apprentices in skilled, rather than unskilled tasks. However, as long as the firm has no intention to (or expects a low probability to successfully) retain apprentices as skilled workers after training, the optimal allocation of skilled and unskilled tasks solely depends on the corresponding benefits by the end of the apprenticeship period. As the relative productivity

[11] Conversely, the marginal benefit from increasing the share of unskilled tasks will be reduced by $h_i^W(\gamma_{\alpha i} w_s)$ for firms that are no longer able to reduce the share of unproductive time at the workplace.

reaches full productivity only by the very end of the training programme, a firm may have incentives to allocate a high share of unskilled tasks, particularly if the difference between skilled and unskilled pay is small.[12] In case a firm intends to employ former apprentices as skilled workers, it will however have strong incentives to allocate a high share of productive tasks to avoid future training costs (see below).

Third, a firm can not only invest in the quantity, but also in the quality of training φ, which in turn increases the productivity of apprentices in skilled tasks. Within a particular training occupation, examples of investments in training quality may include training courses for instructors, or state-of-the art training facilities and equipment (such as a 3D-printer for apprentices). Across occupations, both the quality and quantity of training also depend on training regulations (i.e. the amount of training that must be provided at the workplace), and whether skills are subject to external certification and quality control by external authorities.

Consequently, if a firm decides to allocate skilled or unskilled work to apprentices with the aim to maximise training benefits, it will increase the share of productive work up to the point where $\alpha_{Ei} + \beta_{Ei} = 1 - \bar{\mu}_{Ei}$, so that $\beta_{Ei} = 1 - \alpha_{Ei} - \bar{\mu}_{Ei}$ in each training year. Moreover, as the relative productivity depends on past instruction time and experience in applying new skills, the firm needs to solve the following intertemporal maximisation problem regarding the optimal allocation of the share of skilled tasks, and the number of training hours h_{i-1}^{T} and training quality φ in order to maximise profits:

$$\max_{E,\alpha_{Ei},h_i^T,\varphi} \; TB_E - TC_E =$$
$$E^{\rho}\sum_{i=1}^{S} h_i^W \alpha_{Ei}(b_i,\tau,\gamma_{\alpha i})\gamma_{\alpha i}\big(\varphi, h_{i-1}^T(\theta), \beta_{E,i-1}, \eta(w_E, w_s, w^F)\big)w_s + (1-\alpha_{Ei}-\bar{\mu}_{Ei})w_u -$$
$$E^{\sigma}\sum_{i=1}^{S}(w_{Ei} + h_i^T w_s + c_i^o(\varphi)).$$

Assuming that wages are determined by market forces and that other expenditures (beyond investments in the training quality) depend on the training occupation, there are no further variables at the discretion of the firm.[13] A discussion about the effects of monopsony power and the effects of the wage structure within the firm will be provided at the end of the next subsection. Yet, the next subsection first discusses the impact of certain variables on the cost and benefits of training that are not at the discretion of the firm, but are instead determined exogenously by training regulations, market environment, or a firm's overall business strategy.

Exogenous factors that impact the costs and benefits of training

The main exogenous factors that impact the costs and benefits of training are not only the amount of time that apprentices actually spend at the workplace, business cycle fluctuations, and a firm's production technology, but also the supply of potential apprentices and training regulations such as the duration of apprenticeship, and whether apprentices receive certificates that are recognised within the country.

i. Time at the workplace h^W

The time at the workplace denotes the time at the discretion of the firm when apprentices are not away in vocational school, external courses, on vacation, or absent because of sickness. Clearly, having an

[12] Simulations based on the cost–benefit surveys show a Swiss training firm could increase net benefits on average by EUR 22,000 per apprentice when allocating solely unskilled tasks to apprentices (Wolter and Ryan, 2011).

[13] Apprentice ability may also depend on a firm's recruitment effort. For simplicity and to some extent due to information asymmetries in the hiring process, apprentice ability is assumed exogenous to the firm (holding training and future wages constant). However, given that a demographic change and an increasing share of school-leavers make it more difficult for a firm to find suitable applicants for an apprenticeship position, investing more resources in the recruitment process to find an appropriate match might become an important issue.

apprentice at the workplace for a longer period increases the benefit to the firm from an apprentice's productive work, but it may also come at a cost from having to provide additional workplace instruction. While the time in vocational school is typically determined by the national training curriculum, the organization of external courses (e.g. to acquire industry- or occupation-specific human capital) may be determined at the industry-level (e.g. by employer's associations). Thus, the individual firm has very little influence, if any, on how much time an apprentice spends at the workplace in any given training year.

ii. Business cycle fluctuations b

The possibility to use apprentices for skilled work is negatively related to the business cycle b_i, because of a lower work volume in the firm. However, training costs also decrease if a firm can use instructors' slack time for training (see, e.g. Brunello, 2009), so that instructing apprentices results in little extra costs, as instructors would not have worked productively during that time due to a low work volume in the firm. Thus, the net effect of business cycle fluctuations on a firm's demand for apprentices is ambiguous. In particular, firms with an investment-oriented training motivation may not revise their training decision due to short-turn business cycle fluctuations. Section 3.6 provides some empirical evidence of business cycle effects on a firm's training behaviour.

iii. Production technology τ

The productive use of an apprentice also depends on a firm's production technology τ, which determines to what degree a firm can substitute apprentices for skilled and unskilled workers.[14] For example, small and specialised firms may have limited opportunities to use apprentices in the production process. Moreover, as apprentices are required to be instructed on a wide set of occupational skills, some firms might not be able to provide a learning environment in the production process, thereby increasing the share of non-productive tasks μ_E (as apprentices need to rely on simulations or exercises to practice certain skills). Some firms also outsource part of the training activities away from the production process to internal or external training centres. While outsourcing may facilitate the exploitation of economies of scale by training several apprentices simultaneously, and sharing the fixed costs associated with the establishment of such centres by numerous apprentices, the drawback from the perspective of the firm is the missing (or at least lower) productive value when apprentices are away from the workplace (cf. Strupler and Wolter 2012; Muehlemann et al., 2007).

iv. Supply (and ability) of apprentices η

Another important factor to consider is the supply-side of the apprentice market, as the firm needs to attract a sufficient number of qualified candidates. Within a given training occupation or training field, apprentice supply (and also the average ability η of potential apprentices) is an upward-sloping function that depends among other factors including apprentice pay, training quality, and expected future wages and career opportunities. First, a higher pay during the apprenticeship period (w_E) directly and positively affects an individual's rate of return to enrolling in an apprenticeship programme. Second, a higher training quality will increase future productivity and wages, and therefore further increase an individual's rate of return due to apprenticeship training. To the extent that apprentice wages and skilled worker wages are determined by market forces, and training regulations determine the amount of skills provided at the workplace, the ability of potential apprentices to an individual firm can be regarded as exogenous. However, if a training firm can signal good training quality and future career opportunities (w^F), it will be able to attract apprentices with an above-average ability.

[14] While the firm can choose the production technology, it is assumed here than τ is exogenous with respect to the costs and benefits of apprenticeship training, as the provision of apprenticeship training is typically not a firm's core business strategy.

v. Training duration S

The training duration is an important factor regarding the costs and benefits of training. The training duration is specified ex-ante in a training contract, and depends on the amount of skills that are required to master the required tasks in a particular occupation.

The optimal training duration should balance the interests of both the firm and apprentices. A training firm has an interest in a sufficiently long training duration to recoup its initial training investments as apprentices become more productive later in the training period. Put differently, the amount of training a firm is willing to invest increases with the training duration (Malcomson et al., 2003). Conversely, given that apprentice pay is usually set substantially below skilled worker's pay, apprentices would like to get a skilled worker position as soon as they reach the productivity level of a skilled worker in the training occupation.

Thus, while apprentices may potentially acquire all relevant formal skills within one year of extensive workplace instruction, there would be no time left for productive work, so that a firm would not be able to recoup its training investment. In the absence of post-training benefits, the instruction time should instead be spread out across the entire apprenticeship period, so that an apprentice reaches full productivity in skilled tasks around the same time when a firm can recoup its training investment. Moreover, the development of apprentice productivity not only requires workplace instruction, but also work experience in skilled tasks, so that apprentices can apply their newly acquired human capital.[15] Thus, less skill-intensive occupations require shorter apprenticeship duration.

vi. External certification of skills and external quality control θ

While a firm has, to some extent, an incentive to invest in the skills of apprentices because a higher productivity in skilled task yields higher benefits from having an apprentice carry out skilled work, such incentives might not always be sufficient to provide high-quality training for the following reasons. First, if firm-specific and/or product-specific human capital is very important in a particular training firm, then a high relative productivity in skilled tasks is mainly beneficial for the training firm. Given that the training content is limited only to skilled tasks that are of interest to the training firm, future wages and employment prospects (w^F) for graduated apprentices are lower in the absence of external certification of skills and external quality control. Thus, a training curriculum that requires the provision of sufficient general and occupation-specific skills is important so that a dual apprenticeship is attractive for high-ability school-leavers.

Second, a missing external agency responsible for quality control might provide incentives for some training firms to maximise their (short-term) profits by providing only the skills that are relevant to the firm. Although reputation effects might limit the extent of low-quality training provision in a dynamic setting (cf. Wolter & Ryan 2011 for a discussion), potential apprentices are unlikely to have all the required information before the start of training to adequately assess the training quality in a particular firm. A possible consequence of low-quality training is a high dropout rate, possibly being a result of a lack of firm commitment, and thus low-quality training (Dustmann & Schönberg, 2012). Thus, external skill certification and quality control are important to ensure a high-quality training provision in apprenticeship programmes.[16]

[15] Jansen and Pfeifer (2016) show that the relative productivity of German apprentices depends significantly on the share of skilled tasks allocated to apprentices at the workplace.

[16] In Germany, in addition to external monitoring agencies, works councils provide another type of quality control within the training firm, as works councils have the right to call for a replacement of training personnel if the training quality is unsatisfactory (see, e.g. Kriechel et al., 2014).

vii. Wage structure within the firm (w_E, w_u, w_s)

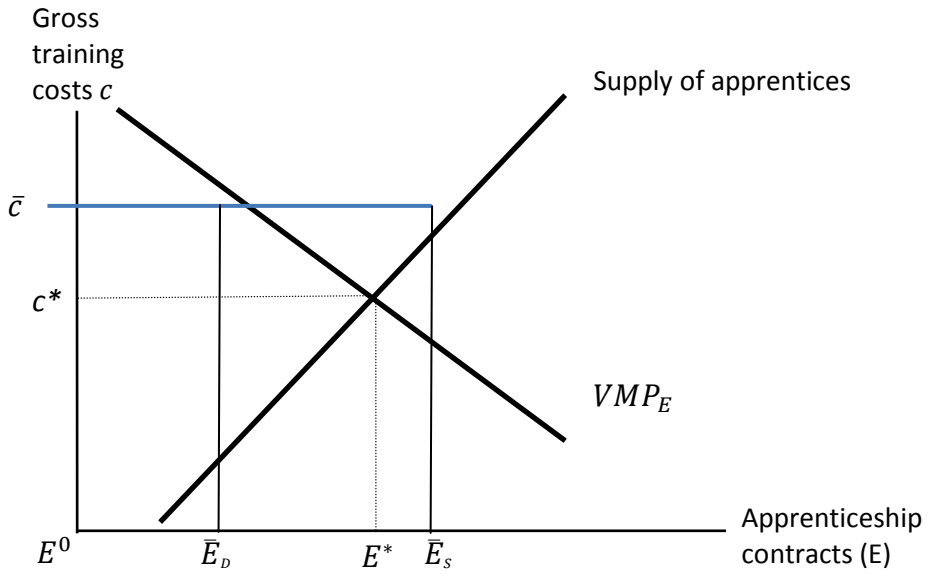
First, as apprentice pay w_E is an important determinant of total training costs, a decrease in apprentice pay will increase a firm's demand for apprentices. However, apprentice pay also affects a firm's supply of potential apprentices, as well as their average ability (as discussed in point iv above), which in turn affects the relative productivity of an apprentice in skilled tasks. Second, the effect of an increase in the wage for unskilled workers w_u is straightforward: the use of apprentices in unskilled tasks β_E becomes more beneficial for the firm, thereby increasing training benefits (and thus the demand for apprentices).[17] Finally, a raise in skilled worker pay w_s has ambiguous effects: while higher skilled worker pay increases the benefit from allocating skilled tasks to apprentices, it also increases the costs for instruction time h^W, as apprentice instructors are either skilled workers in the training occupation or full-time training instructors whose wage likely correlates strongly with the level of skilled worker pay in the firm. Thus, depending on the amount of training provided by the firm, as well as on the fraction of skilled work α_E allocated to apprentices, higher skilled worker pay can increase or decrease a firm's demand for apprentices. However, an increase in skilled workers wages is likely to increase (decrease) the demand for apprentices E if training hours are low (high), and the share of skilled work allocated to apprentices is high (low), ceteris paribus.

In some training occupations, or even entire countries, the equilibrium outcome may require a very low apprentice pay for firms to be interested in offering apprenticeships in addition to bearing the required training expenditures. Figure 1 shows that the introduction of a minimum apprentice pay above the equilibrium level, or minimum training standards regarding the amount of human capital that a firm must provide at the workplace, may lead to a situation with an excess demand for apprenticeship positions ($\bar{E}_S - \bar{E}_D$). Therefore, a firm will hire fewer (if any) apprentices in the case when training costs substantially exceed the market-clearing level if it considers *only* the training period to generate sufficient benefits to cover the training costs.

While a very low apprentice pay may not be problematic for young individuals as long as the expected future wage and employment opportunities after completing apprenticeship training are sufficiently high to cover the short-term costs (i.e. earning losses from unskilled work during the training period), the situation might be different for older workers. First, the payoff period when apprenticeship graduates earn a skilled worker wage rather than an unskilled worker wage is shorter for older workers (as fewer years are left until retirement), thereby lowering the individual rate of return to the investment in apprenticeship training. Second, older individuals often have more financial responsibilities (housing, family obligations, etc.), and credit constraints may prohibit the participation in apprenticeship training even if the return on investment were positive.

[17] The ratio of apprentice pay to unskilled pay (w_E/w_u) varies greatly across countries. While Dustmann and Schönberg (2012) report a ratio of 0.9 for the UK, the corresponding ratio for Germany is 0.44. It is obvious that a very high relative apprentice pay, such as in the UK, leaves little room for firms to recoup training investments by having apprentices perform unskilled work.

Figure 1: Market for apprentices – the effect of minimum training costs for apprentices[18]

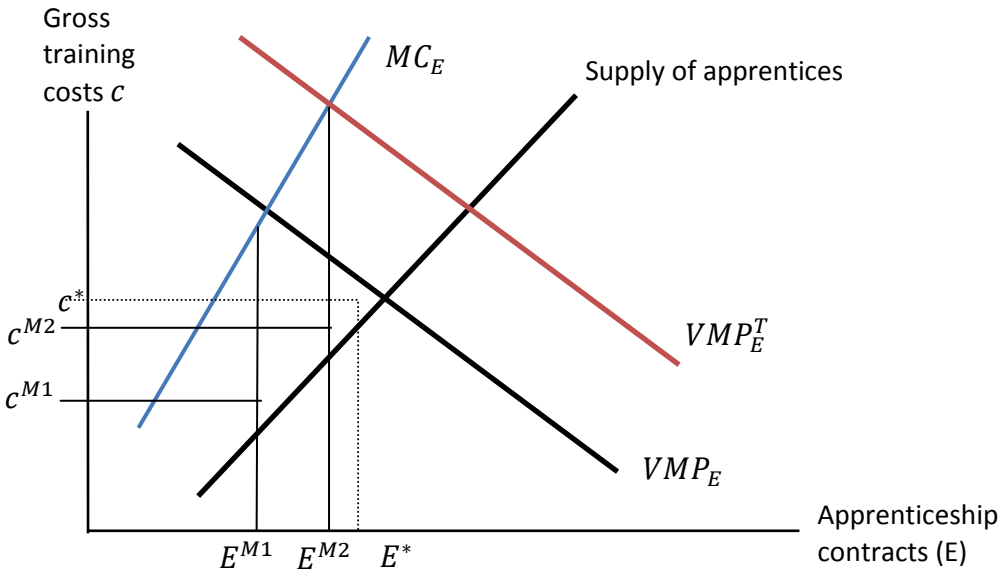


Recent research in labour economics (e.g. Manning, 2011) suggests that there are important imperfections in modern labour markets, which can be well described by the theory of monopsonistic labour markets. The main difference between monopsonistic and perfect labour markets is that firms no longer need to pay market wages, but rather face an upward-sloping labour supply curve. Thus, firms can essentially set wages. The reasons for monopsony power are, among others, mobility and search costs of individuals, as well as information asymmetries between firms and employees regarding the ability or individual characteristics that are relevant to a job, and information asymmetries between firms about the amount and type of human capital that apprentices accumulate (see Manning, 2011 or Muehlemann et al., 2013 for recent surveys of the relevant literature).

Given that apprentices in the same occupation usually earn the same salary (within the training firm), monopsonistic labour markets imply that the marginal wage costs to hire an additional apprentice are not just reflected in the wage costs for the marginal hire, but also in the increase in apprentice pay for all previously hired apprentices. For example, let us assume that a firm can hire two apprentices at EUR 500 per month, and three apprentices at EUR 600 per month (plus training expenditures), then the marginal costs to hire the third apprentice are not just EUR 600 per month, but also the extra EUR 100 per month that need to be paid to the other two apprentices. Hence, the marginal costs for the third apprentice are EUR 800 per month (plus training expenditures), and the marginal training costs (MC_E) are an increasing function of the number of apprentices when a training firm has monopsony power, with a slope that is steeper than the supply curve. Figure 2 shows that the equilibrium outcome of monopsony power in the apprenticeship market regarding the number of apprenticeship contracts: while equilibrium employment and costs in the competitive case are (E^*, c^*), monopsonistic training firms will hire fewer apprentices (E^{M1}) at lower costs (c^{M1}).

[18] In Figure 1, it is assumed that the marginal training costs are constant and that a firm can hire as many apprentices as desired at the going market wage ($\sigma = 1$). Moreover, the negative slope of the VMP_E function is based on the assumption of a diminishing marginal product of apprentices (i.e. a concave production function with $\rho < 1$).

Figure 2: Market for apprentices when firms have monopsony power[19]



However, a firm may not only have monopsony power over apprentices, but also over skilled workers. Thus, post-training benefits arise due to savings on future hiring costs, or because a firm can select and retain more productive individuals while not having to pay above-market wages. The additional post-training benefit will then be reflected in a shift of the firm's demand curve for apprentices to the right (VMP_E^T). The equilibrium outcome (E^{M2}, c^{M2}) therefore describes a situation where a firm has monopsony power in both the apprenticeship and skilled labour markets. Obviously, the extent of how much monopsony power affects the equilibrium levels of apprenticeship contracts and training costs is an empirical question. However, in theory, monopsony power has two opposing effects on a firm's demand for apprentices: while monopsony power in the apprenticeship market tends to reduce apprentice wages and the number of apprenticeship positions, monopsony power in the market for skilled workers has an opposing effect – increasing both the equilibrium number of apprenticeship contracts and training costs (Figure 2). Depending on the relative importance of monopsony power over apprentices and skilled workers (Muehlemann et al., 2013), the equilibrium number of apprenticeship positions may be close to a situation where firms have no monopsony power at all and consider only short-run training benefits (i.e. as long as the labour demand curve exhibits a sufficiently large shift to the right due to large expected post-training benefits).

The next subsection provides a detailed discussion of the determinants of (expected) post-training benefits for training firms.

Post-training benefits

A firm may be able to generate post-training benefits by retaining graduated apprentices as skilled workers. Post-training benefits mainly arise due to an increased match quality, saved future hiring and firing costs, and a possible rent that a firm can generate by paying former apprentices a wage that is lower than the marginal value product. Thus, the total benefits from training an apprentice can be described as follows:

[19] In Figure 2, it is assumed that the marginal training costs are convex ($\sigma > 1$) due to monopsony power, in contrast to Figure 1, where the marginal training costs are constant.

$$NB_E^{Total} = TB_E - TC_E + p_r[B_E^{PT}],$$

where $p_r = f(w_{sE} - w_s, w^F, v(I,b), L_{s(S+1)}, \eta, \gamma_{aS})$ denotes the (expected) retention probability of apprenticeship graduates.

From the perspective of an apprentice, the willingness to remain with the training firm and to accept a job as a skilled worker depends on the difference between the post-training skilled worker wage in the training firm w_{sE} and the going wage rate for skilled workers in the external labour market w_s (i.e. $\Delta_w = w_{sE} - w_s$), expected career opportunities in the training firm w^F, as well as the number of external vacancies v (outside options) in the labour market. In times of a tight labour market (due to business cycle fluctuations b), search costs may reduce the probability of finding the appropriate job offer. In turn, the number of vacancies depends on labour market institutions I; for example, strict employment protection legislation may reduce the overall number of vacancies in a (national) labour market, and business cycle conditions at the time of graduation.

From the perspective of a firm, the willingness to retain a graduated apprentice as a skilled worker depends on the firm's future demand for skilled workers $L_{s(S+1)}$, the overall ability of the apprentices η (which may only be observable to the firm by the end of training), and the relative productivity of the apprentice in skilled tasks by the end of training γ_{aS}. Thus, the relative productivity of an apprentice in firms that offer poor training conditions might be substantially below the productivity of a skilled worker available in the external labour market (i.e. $\gamma_{aS} \ll 1$). Conversely, a firm that anticipates retaining a high share of apprentices after training may have an incentive to invest beyond the minimum training requirements ($h_i^T >> h_i^{T^{min}}$), so that apprentices are equally productive compared to other skilled workers in the firm by the end of the apprenticeship. The incentives for doing so are clear, because the firm's opportunity costs to providing training are considerably lower for apprentices compared to newly hired skilled workers, as $w_E < w_s$.

More specifically, post-training benefits can be written as

$$B_E^{PT} = H\left(\gamma_{aS}\left(\sum_{i=1}^{S} h_i^T, \eta, \beta_{Ei}\right), \tau, \frac{w_{sE}}{w_s}\right) + F(I) + [(VMP_{sE} - w_{sE}) - (VMP_s - w_s)],$$

where H denotes the hiring costs for externally recruited skilled workers, F denotes the firing costs, VMP_{sE} is the marginal value product of a skilled worker that was previously an apprentice with the training firm, whereas VMP_s corresponds to an externally hired skilled worker.

i. Hiring costs *H*

A potentially important component of post-training benefits are savings on future hiring costs if an apprentice reaches a high relative productivity in skilled task ($\gamma_{aS} \cong 1$) by the end of training, which in turn positively depends on the total amount of training hours and an apprentice's innate ability (which is revealed to the firm by the end of the apprenticeship), but negatively depends on the apprentice's time used for unskilled tasks (i.e. time not spend with learning or applying skilled tasks). Moreover, the savings on hiring costs depend on the firm's production process τ; thus, retaining apprentices might be particularly beneficial if firm- or product-specific human capital is important (as this would result in higher training costs for externally recruited workers, whereas apprentices acquire such skills during the apprenticeship

period). While high-wage firms may find it easier to attract qualified skilled workers, the personnel costs of the search and selection process are also higher in high-wage firms (Blatter et al., 2012), leading to an ambiguous effect of relative wages ($\frac{w_{sE}}{w_s}$) on hiring costs. Finally, hiring costs are positively associated with the skill requirements in a particular occupation beyond a firm's production technology, because it becomes more difficult – and thus more expensive – to find suitable job applicants when skill requirements are high (see also Muehlemann and Strupler Leiser, 2015).

ii. Firing costs F

Firing costs F largely depend on labour market institutions I. While firms face relatively low firing costs in countries with little employment protection legislation, there will always be some administrative costs to lay off a worker. Moreover, once workers receive the layoff notice, the motivation to put in effort during the remainder of the time with the firm may decrease, so that the productivity of the employee is likely to be lower during the notice period (yet the duration of the notice period again depends on labour market institutions). When information asymmetries are important, then apprenticeship training becomes an important screening tool for employers to uncover the true ability and motivation of an individual, a process that can take several years (Lange, 2007). Thus, the advantage of apprenticeship training is to reduce information asymmetries between the training firm and apprentices, so that the firm can determine more accurately whether a particular individual is a good match (Muehlemann et al., 2010). Accordingly, the firm is willing to make net investments in training, as it can reduce the number of future layoffs, and save the corresponding firing and hiring costs to refill the vacancy.

iii. Compressed wage structures

A third main component of post-training benefits are compressed wage structures (e.g. Acemoglu and Pischke, 1998, 1999). Owing to information asymmetries, the training firm has an information advantage about the true ability of (former) apprentices. Moreover, even in the case when training is certified, the training firm may have superior knowledge about the exact content of training compared to outside firms. Additionally, frictions in the labour market, such as mobility costs, reduce the number of job offers (vacancies) for graduated apprentices. Therefore, the training firm is able to retain the abler apprentices, while the less able ones need to find a new employer. However, while other firms cannot observe the ability of individual apprenticeship graduates, they are aware that training firms retain the ablest apprentices, so that the expected ability of graduated apprentices in the labour market will be of below-average productivity. Thus, the going wage rate in the external labour market will adjust accordingly, and even the most able apprentices will stay with the training firm and accept a wage that is lower than their productivity, as long as the wage offered by the training firms exceeds the wage in the external labour market (i.e. $VMP_{sE} > w_{sE} > w_s$). Summing up, a firm can generate post-training benefits from apprenticeship training, as long as the difference between the wage and the productivity is larger for former apprentices compared to workers that are hired from the external labour market.

Cost-elasticity of firm's demand for apprentices and expected effects of subsidy schemes

The basic concept of the apprenticeship market is useful to make predictions regarding several potential policy questions. An important factor is the cost-elasticity of a firm's demand for apprentices (i.e. a measure that shows how a firm's demand reacts to a change in training costs). Similar to the textbook case of a firm's demand for labour (i.e. the own-wage elasticity of labour demand), the Hicks–Marshall laws of derived demand also directly apply to the firm's demand for apprentices (see, e.g. Ehrenberg & Smith 2015):

i. The demand for apprentices is more elastic when the elasticity of substitution between production factors is higher.

When apprentices are close substitutes for both skilled and unskilled workers, then the changes in relative wages are likely to affect a firm's demand for apprentices more strongly compared to a situation where the elasticity of substitution is low.[20] For example, let us assume that apprentices perform both skilled and unskilled work during the training period. An increase in the apprentice wage (ceteris paribus) would make the use of apprentices more expensive relative to skilled and unskilled labour, and thus the firm may want to substitute skilled and unskilled workers for apprentices.

Conversely, an increase in the minimum wage of unskilled workers would make the use of apprentices (ceteris paribus) in the production process more beneficial for firms, so that they would want to substitute apprentices for unskilled workers. Thus, as long as apprentices are close substitutes for unskilled workers, a relative increase in apprentice pay compared to unskilled pay would have a strong effect on apprentice demand in firms, occupations, or apprenticeship systems (such as in Switzerland) where the share of unskilled work β_E allocated to apprentices is high.

ii. The demand for apprentices is more elastic when the elasticity of demand on the product market is higher.

An increase in training costs (ceteris paribus) increases production costs. If the elasticity of demand on the product market is very high (i.e. the product market is competitive), then a small increase in production costs would result in a significant drop in sales. Consequently, a firm would need to reduce production when producing at higher costs, and therefore decrease the demand for apprentices. Conversely, if customers do not react strongly to small price changes, then an increase in training costs (that goes along with an increase in the product price) would have a small effect on a firm's demand for apprentices, because sales would be hardly affected by the change in training costs. However, firms operating in competitive industries may also require a more skilled workforce, thus competition per se does not prevent firms from training their workers. Bassanini and Brunello (2011) find that the deregulation in some industries in the European Union increased the training participation of firms. Nonetheless, holding skill requirements constant, we would still expect that firms in competitive industries react stronger to changes in training costs.

iii. The demand for apprentices is more elastic when the supply of other factors of production is highly elastic.

A firm's ability to substitute (e.g. skilled workers for apprentices) may become increasingly difficult depending on whether skilled workers are readily available in the labour market. Thus, while it may be relatively easy for a firm to find one full-time skilled worker to replace the amount of skilled work performed by apprentices, hiring many skilled workers simultaneously may become more difficult and thus more expensive if skilled workers are hard to find in the external labour market.

iv. The demand for apprentices is more elastic when the total net costs of apprenticeship training are a larger share of total production costs.

The extent of how strongly an increase in apprentice pay affects a firm's demand for apprentices also depends on the total number of apprentices, and on the capital-intensity of a firm's production process. Thus, if a firm employs a high share of apprentices (relative to total employment) and has a labour-intensive production technology, then an increase in apprentice pay affects total production costs relatively

[20] Fougère and Schwerdt (2001) calculate substitution elasticities of apprentices for skilled and unskilled workers for France and Germany based on the Cobb–Douglas production functions. They find an elasticity of substitution close to unity for small and medium-sized German firms, and mixed results for large firms with more than 200 employees. However, not all estimates are statistically significant.

more compared to a firm that hires fewer apprentices and generally uses a more capital-intensive production process.

The cost-elasticity of demand for apprentices is also an important factor to consider by governments when deciding on potential subsidy schemes. If the firm's demand for apprentices is relatively inelastic, subsidies (i.e. a reduction in training costs) would not have a strong effect on the provision of apprenticeships. Conversely, an elastic demand for apprentices would react strongly to financial incentives (or the introduction of minimum apprentice pay). The main issue regarding the provision of subsidies in dual apprenticeship programmes is that there is not much empirical evidence regarding their effectiveness, and equally important – regarding their cost-effectiveness (see Muehlemann and Wolter (2013) for a discussion of this issue). While subsidies could encourage firms to take on apprentices, governments should also consider the costs of alternative options in the education system (e.g. per student costs of other full-time schooling programmes). However, based on the above analysis, it can be concluded that a firm's demand for apprentices would react more strongly to financial incentives if apprentices are close substitutes for skilled and unskilled workers, and the competition in the product market is high.

Subsidies could also distort incentives when apprentices are close substitutes for unskilled workers. In that case, a firm would have an incentive to hire as many apprentices as possible as substitutes for unskilled workers, and then exploit the apprentices by having them perform mainly unskilled work (while providing low-quality training). Thus, providing training subsidies should go along with regulations concerning the quantity and quality of training, but also with monitoring and enforcement of the firm´s actual training behaviour (Muehlemann and Wolter, 2013).

However, providing subsidies to training firms only affects the demand for apprentices. Thus, an alternative approach is to increase the supply of suitable apprentices in training markets where there is currently a lack of apprenticeship training. While apprenticeship training is seen as a viable career path in countries such as Germany or Switzerland, entering an apprenticeship is not the preferred career choice in many countries with an established academic education system. Therefore, while it is important to convince firms of the benefits of apprenticeship training, it is equally important to convince potential apprentices (and their parents) that apprenticeships may offer successful careers, as this affects the supply of potential apprenticeship candidates.

A major disadvantage of training subsidies targeted at individual firms is the administrative costs associated with the redistribution of funds from non-training firms to training firms. Such adverse effects are particularly pronounced if training funds are managed regionally and across all sectors. More cost-efficient options can be found at the sectoral level, if transfers from non-training to training firms are handled by employer's associations. For example, all firms pay their membership fees, and part of those fees could be used for industry-specific training courses for apprentices. In such a scheme, apprentices from all training firms spend some time (ranging from a few days to several weeks, depending on the skill requirements) at the beginning of an apprenticeship, in such external courses where they are instructed on industry- or occupation-specific skills that are relevant for all apprentices. Moreover, governments might pay part of such costs, as is the case in Switzerland (see also SERI, 2015). An advantage of sectoral agreements is that the heterogeneity in training costs, apprentice supply, and the availability of skilled workers with the corresponding vocational qualification in the external labour market can be considered by focusing on sectors with an excess supply of apprentices.

Related to the discussion of the cost structure of apprenticeship training, the design of potential subsidy schemes matters as well. While in practice, subsidies may take the form of a lump-sum transfer, such subsidies largely encourage those firms to participate in training that decided to do so because of high fixed-training costs. Conversely, profit-maximising firms train apprentices and hire up to a point where marginal training benefits equal marginal training costs. As lump-sum payments do not affect a firm's

decision at the margin, such subsidies merely increase its training benefit, but the number of training places remains unaffected.[21] Thus, such subsidies would only be optimal in countries with a very low share of training firms, and where fixed costs are the main reason for many firms to not engage in training. Otherwise, there are large windfall gains associated with such schemes, as many training firms would have offered the same number of training positions even in the absence of lump-sum subsidies. Thus, to affect the demand for apprentices for all firms, subsidies should be linked to the actual number of apprentices. The empirical evidence on how financial incentives affect a firm's training behaviour is provided in section 3.3.

Some challenges in measuring costs and benefits

The organization of apprenticeship training takes different forms. While many firms train according to the 'classical' dual system, where an apprentice works closely with training instructors and is integrated into the regular work process, other firms – particularly large firms – have separate training facilities. Moreover, large firms may have a separate human resource department that manages the recruitment and selection processes, and makes the decision whether to retain an apprentice after the training. To account for such differences, the Swiss cost–benefit survey use different questionnaires for small and large firms. In large firms, a first questionnaire is addressed to the corresponding individuals who are in charge of human resources, whereas a second questionnaire is addressed to those individuals who are directly instructing the apprentice daily. Firms with separate training centres are asked about the costs of training centres, as well as the value of the productive contribution of apprentices in such centres.

While the training costs are rather straightforward to measure, quantifying the training benefit is more challenging. In particular, it remains a challenge in empirical research to measure the value of the productivity of employees. Therefore, the German and Swiss cost–benefit surveys do not attempt to directly measure the productivity of an apprentice. Instead, the aim of the survey is to obtain a measure of the apprentice's production value compared to that of a skilled worker or an unskilled worker. Thus, rather than estimating the (absolute) productivity of an apprentice during an hour of skilled work, the training instructors are asked to give an estimate of an apprentice's productivity relative to the productivity of a skilled worker in the firm, as discussed above. The main advantage of this approach is that there is no need to measure the actual productivity of apprentices or skilled workers. In case that the firm does not pay skilled workers a wage that is equal to the productivity, the firm still makes the same amount of profit when the apprentice executes skilled tasks, but depending on training costs, the firm might make an additional profit from having an apprentice carry out the tasks rather than the skilled worker. Thus, the survey essentially compares the situation for with or without having offering apprenticeship training.

2.2. Empirical evidence

This section provides the empirical evidence on the costs and benefits of apprenticeship training from a firm's perspective based on the most recent surveys from different countries, as well as data on apprentice retention rates and a firm's potential savings from not having to hire skilled workers from the external labour market. A more detailed analysis of the costs and benefits of apprenticeship training by different factors, such as firm size, occupation, financial incentives, or training duration will be provided in section 3.

[21] Suppose that the total net training costs take the form $TC = aE$, where E denotes the number of apprentices. A lump-sum subsidy S for firms reduces total the training costs, so that $TC = aE - S$. However, the marginal training costs remain unaffected for firms with E>0, as $c = \frac{\partial TC}{\partial E} = a$, so that the lump-sum subsidies only create financial incentives for firms that previously did not train any apprentices. Conversely, if subsidies depend on the number of apprentices, then $TC' = aE - ES$, and $c' = a - S$, so that training firms would also offer additional apprenticeship positions.

Costs and benefits of apprenticeship training

The empirical evidence on the costs and benefits of apprenticeship training is rather limited. So far, large-scale and representative surveys on the costs and benefits of apprenticeship training were only conducted in Germany and Switzerland. While Germany started their first surveys in the 1970s (Sachverständigenkommission Kosten und Finanzierung der beruflichen Bildung, 1974), the first Swiss survey was conducted in the year 2000 (Schweri et al., 2003). The latest German survey was conducted in 2012/13 (Jansen et al., 2015a), whereas the latest Swiss survey was conducted in 2009 (Strupler and Wolter, 2012).

Table 3: Costs and benefits of apprenticeship training in Germany and Switzerland, per apprentice and training year

Costs and benefits of apprenticeship training	Germany (mean)	Switzerland (mean)
Costs	17,933	26,179
Benefits	12,535	28,496
Net costs	5398	-2316
Year of survey	2012/13	2009
Observations	3032	2518

Note: Costs and benefits in EUR, conversion based on CHF/EUR exchange rate of 1.10 (on 11 Sept. 2015).
Source: Adapted from Jansen et al. (2015a), Apprenticeship training in Germany remains investment-focused – results of BIBB Cost-Benefit Survey 2012/13, BIBB Report 1/2015, and Strupler and Wolter (2012), Die duale Lehre eine Erfolgsgeschichte - auch für Betriebe. Ergebnisse der dritten Kosten-Nutzen-Erhebung der Lehrlingsausbildung aus der Sicht der Betriebe, Glarus/Chur: Rüegger Verlag.

Table 3 shows the average training costs, benefits, and net costs for Germany and Switzerland. The difference in net costs between the two countries is striking: while a German firm on average makes a net investment of EUR 5 400 per year per apprentice, the average Swiss firm generates a net benefit of EUR 2 300 per year per apprentice. Thus, in Germany, the productive contribution of apprentices covers on average about 70% of the firm's training investment, while the work of an average Swiss apprentice covers all of the firm's training costs. However, the variance in net costs (benefits) is rather large. In Germany, about 30% of apprenticeships result in net benefits from the firm's perspective, while the corresponding figure for Switzerland is 71%.

The evidence for other countries is rather limited. An older study from Austria based on a survey in 1995 (Lassnigg and Steiner, 1997) showed that about 35% of Austrian firms could generate a net benefit from training apprentices (based on the 'equivalence method'). Moreover, based on interviews in 42 firms in five sectors in the UK, Gambin et al. (2010) find that firms make a considerable net investment when taking on apprentices. Gambin et al. (2010) also report that most training firms can break even when subsequently retaining their apprentices as skilled workers for one to three years. Finally, for Australia, Dockery et al. (1997) report considerable net training costs of AUD 22 000, although the data refer only to 59 firms in traditional trades.

More recently, Wolter and Muehlemann (2015) simulated the hypothetical costs and benefits of apprenticeship training for the case that Spanish firms were to start dual apprenticeships similar to Switzerland or Germany. The simulations show that there would be at least one scenario for each of the analysed occupations so that training firms could reach the break-even point by the end of the training

period (i.e. without having to rely on post-training benefits). The main factors affecting the cost–benefit ratio for the firm are apprentice pay, time spent in vocational school, and the training duration, ensuring that a firm has enough time to recoup the training investment.

Long-run training benefits: saved future hiring costs

One of the most important potential post-training benefits is that a training firm can save on future hiring costs when retaining former apprentices as skilled workers. In the cost–benefit surveys, both German and Swiss firms were asked to report their recruitment and training expenditures to fill a vacancy for a skilled worker position. Muehlemann and Strupler Leiser (2015) classify hiring costs by three main components: (1) search costs; (2) adaptation costs; and (3) disruption costs. Search costs include expenditures on job advertisements and interview costs, while adaptation costs include formal training expenditures and the costs associated with initially low productivity during the adaptation period (until a worker reaches full productivity). Finally, disruption costs measure informal training expenditures, as new hires require instruction from other workers in the firm, thereby distracting them from their regular work duties.

Table 4: Average hiring costs for skilled workers in Germany (in EUR), 2012/13

Employees	< 10	in %	10-49	in %	50-499	in %	500+	in %	All firms	in %
Search costs	527	7%	1622	15%	1832	15%	3233	20%	928	11%
Adaptation costs	3538	47%	3905	37%	4191	35%	5127	31%	3689	42%
Disruption costs	3540	47%	4945	47%	5798	49%	8098	49%	4097	47%
Total	7605	100%	10472	100%	11821	100%	16458	100%	8714	100%

Source: Adapted from Jansen et al. (2015a), Apprenticeship training in Germany remains investment-focused – results of BIBB Cost-Benefit Survey 2012/13, BIBB Report 1/2015.

In Germany, hiring costs amount on average to EUR 8 700 to successfully fill a vacancy, and consist mainly of disruption and adaptation costs, as search costs only account for 11% of the total hiring costs (Table 4). Hiring costs increase strongly with firm size, and large firms spend more than twice as much to fill a vacancy compared to the smallest firms. Moreover, search costs become more important for larger firms relative to adaptation costs. Nonetheless, the share of disruption costs remains constant at almost 50% across all firm-size categories.

Table 5: Average hiring costs for skilled workers in Switzerland (in EUR), 2009

Employees	< 50	in %	50+	in %	All firms	in %
Search costs	3395	20%	6483	25%	3992	21%
Adaptation costs	9110	53%	14,039	54%	10,063	53%
Disruption costs	4585	27%	5719	22%	4805	25%
Total	17,090	100%	26,241	100%	18,859	100%

Note: CHF/EUR exchange rate of 1.10 on 11 September 2015.
Source: Adapted from Muehlemann and Strupler Leiser (2015), The facts you need to know about hiring. IZA , Discussion Paper No. 9363, http://ftp.iza.org/dp9363.pdf (accessed 7 March 2016).

For Switzerland, the average hiring costs are just below EUR 19 000 (Table 5). Similar to German firms, search costs constitute the smallest fraction of total hiring costs, and even their share is twice as high compared to Germany. Moreover, hiring costs also increase with firm size, although the difference is not as pronounced compared to Germany.

Table 6: Average retention rate of apprentices in Germany (in %), 2012/13

Retention rate by firm size, 2012/13	(in %)
Total	59.0
<10 employees	49.0
10-49 employees	65.0
50-499 employees	75.0
500+ employees	82.0

Source: Adapted from Jansen et al. (2015a), Apprenticeship training in Germany remains investment-focused – results of BIBB Cost-Benefit Survey 2012/13, BIBB Report 1/2015.

Even though the average hiring costs in Germany are smaller than the average net investment, large firms can – on average – save EUR 16 500 on hiring costs by retaining a former apprentice, which could cover the average net investment of a 3-year apprenticeship. Moreover, retention rates are highest in large firms (Table 6), implying that large firms are frequently able to reap the benefits from saving future hiring costs.

Table 7: Average retention rate of apprentices in Switzerland (in %), 2009

Retention rate by firm size, 2012/13	(in %)
Total	35.5
<5 employees	22.6
5-9 employees	26.7
10-49 employees	32.1
50-249 employees	43.0
250+ employees	47.8

Source: Adapted from Strupler and Wolter (2012), Die duale Lehre eine Erfolgsgeschichte - auch für Betriebe. Ergebnisse der dritten Kosten-Nutzen-Erhebung der Lehrlingsausbildung aus der Sicht der Betriebe, Glarus/Chur: Rüegger Verlag.

In Switzerland, hiring costs are considerably higher in monetary terms. However, as most hiring costs depend on wages, this difference is largely due to the higher overall wage level in Switzerland. In both countries, the average hiring costs are equivalent to about 3-4 months of skilled worker pay. However, as 70% of Swiss firms already generate a net benefit from training apprentices, these firms do not require to retain apprentices as skilled workers to recoup the initial training investment. The relatively low retention rates at the firm level in Switzerland (35.5% compared to 59.0% on average in Germany) are associated with the overall higher mobility in the labour market (Table 7). Thus, an average Swiss training firm must recoup its training investment by the end of the apprenticeship, because the post-training turnover rates are high. Breaking even is particularly relevant for small firms that often only train one apprentice at a time. Suppose that a small firm trains a single apprentice for four years, but then the apprentice unexpectedly leaves the training firm, then it would take at least another four years (and eight years in total) to fill a vacancy by means of apprenticeship training. Thus, particularly for small firms, it is important to be able to provide training without having to make a substantial net investment when labour market mobility is high. Moreover, when most human capital is general, or at least occupation- or industry-specific, then small

firms in a particular industry will find it easier – and thus also cheaper – to recruit qualified and suitable skilled workers from the external labour market, as long as there is a sufficient number of firms offering apprenticeships that meet the required qualification level.

3. FACTORS THAT AFFECT THE COST–BENEFIT BALANCE

As previously discussed in section 2.1, many factors potentially affect a firm's cost–benefit balance. This section presents the currently available empirical evidence of how training costs and benefits differ by factors, such as firm size, training occupation or sector, financial and non-financial incentives, institutions, training duration, and business cycle fluctuations.

3.1. Firm size

Large firms differ in many dimensions from smaller firms regarding their training behaviour. First, large firms need to replace a higher (absolute) number of vacancies, even if the turnover rates were comparable across firm sizes. In competitive labour markets, large firms can hire as many workers as they like at the going market wage. However, if the labour markets are monopsonistic, large firms will need to offer higher pay in order to attract a sufficient number of skilled workers. However, Manning (2006) argues based on a generalised model of monopsony, that firms can also increase their recruitment effort to hire more workers, rather than to simply increase wages. While a firm can increase its recruitment effort by searching more intensively for skilled workers in the external labour market (e.g. by posting more job advertisements), another strategy is to train more apprentices internally. Blatter et al. (2016) show that firms train more apprentices when it becomes increasingly costly to hire skilled workers from the external labour market. While the basic result applies to all firms, particularly large firms that hire many employees in a given period will find it increasingly difficult to exclusively hire from the external labour market. In line with this argument, training statistics show that the training participation increases strongly with firm size (Muehlemann and Wolter, 2013).

Firm size may also be related to different cost–benefit components. While large firms often pay higher wages to all employees, including apprentices, large firms can potentially exploit economies of scale in the provision of training. Moreover, large firms may have better opportunities to instruct apprentices while being involved in the work process compared to small and highly specialised firms. However, large firms are not equally distributed across different training occupations. Large firms frequently train apprentices in technical fields that require a higher (net) training investment (see section 3.2), such as metalworking or IT, compared to smaller firms that frequently train apprentices in the crafts sector. Moreover, large firms specialising in technical occupations frequently use separate in-house training facilities to train their apprentices, which is costlier compared to the traditional form of apprenticeship training (Strupler and Wolter, 2012). Thus, simply looking at cost–benefit statistics that compare large and small firms may not necessarily tell us much about firm-size effects, but rather shows the result of various factors that affect the cost–benefit balance differently across firm-size categories.

Table 8: Average costs and benefits by firm size, per apprentice, and training year, Germany (in EUR), 2012/13

Employees	<10	10-49	50-499	500+
Costs	15,911	16,452	18,111	21,757
Benefits	10,807	12,199	12,720	14,403
Net costs	5104	4254	5391	7354

Source: Adapted from Jansen et al. (2015a), Apprenticeship training in Germany remains investment-focused – results of BIBB Cost-Benefit Survey 2012/13, BIBB Report 1/2015.

Table 8 shows that, in Germany, the training costs as well as training benefits increase by firm size. Thus, the net training costs do not differ much by firm size, except for the largest firm size category. As regards Swiss firms, the results reveal a similar picture (Table 9). However, the differences between firm-size categories are much more pronounced than in Germany. While the highest net benefits are generated in medium-sized firms with 5-49 employees, large firms in 4-year programmes incur significant net costs of almost EUR 3 000 per apprentice per training year.

Table 9: Average costs and benefits by firm size, per apprentice, and training year, Switzerland (in EUR), 2009

Employees	<5	5-9	10-49	50-249	250+
3-year programmes					
Costs	24,265	22,440	26,299	27,219	29,627
Benefits	26,132	27,587	29,159	29,925	29,767
Net costs	-1867	-5147	-2860	-2705	-140
4-year programmes					
Costs	24,499	23,246	25,024	29,478	29,403
Benefits	26,036	27,637	29,910	29,056	26,425
Net costs	-1538	-4391	-4887	422	2978

Notes: CHF/EUR exchange rate of 1.10 on 11 September 2015.
Source: Adapted from Strupler and Wolter (2012), Die duale Lehre eine Erfolgsgeschichte - auch für Betriebe. Ergebnisse der dritten Kosten-Nutzen-Erhebung der Lehrlingsausbildung aus der Sicht der Betriebe, Glarus/Chur: Rüegger Verlag.

3.2. Occupations and training domains

There are large differences in the costs and benefits by sectors or occupational fields. Table 10 shows a substantial variation in net training costs by the domain of apprenticeship training and occupational groups in Germany. For example, the average net costs in technical occupations is almost EUR 9 000 per apprentice per training year, resulting in net training costs beyond EUR 30 000 in 3.5-year apprenticeship programmes. Conversely, apprenticeships in agriculture or commercial occupations require a considerably smaller net investment.

Regarding the relative productivity of German apprentices in skilled tasks compared to an average skilled worker in the training firm, the corresponding values also differ rather strongly by training occupation (Table 11). While there are no differences by firm size regarding the relative productivity in the first training year, apprentices tend to have a higher relative productivity in the last training year, particularly in firms with more than 100 employees.

Table 10: Average costs and benefits by domain/occupational group per apprentice p.a., Germany (in EUR), 2012/13

	Costs	Benefit	Net costs
Domain of apprenticeship training			
Industry and trade	19,535	13,389	6146
Skilled crafts	15,187	10,798	4390
Agriculture	14,043	12,750	1293
Free professions	14,474	12,769	3705
Public service	19,801	11,768	8032
Home economics	15,329	8945	6385
Occupational group			
Commercial occupations	18,206	14,684	3522
Industrial occupations	16,116	11,859	4257
Technical occupations	19,092	10,153	8939

Source: Adapted from Jansen et al. (2015a), Apprenticeship training in Germany remains investment-focused – results of BIBB Cost-Benefit Survey 2012/13, BIBB Report 1/2015.

Table 11: Average relative apprentice productivity, Germany, 2012/13

Relative productivity of apprentices in skilled tasks compared to a skilled worker	1st year (in %)	last year (in %)
Commercial clerk (Office)	43.7	74.3
Commercial clerk (Office communications)	48.2	63.5
Commercial clerk (Industrial)	54.1	75.8
Commercial clerk (Retail)	44.1	77.8
Commercial clerk (Wholesale and export)	48.8	73.6
Car mechatronic	15.3	68.6
Cook	30.9	72.9
Dental assistant	34.3	63.3
Electronics technician	22.3	81.2
Gardener	36.8	66.8
IT specialist	40.4	67.4
Joiner	33.8	65.1
Logistician	46.2	79.6
Medical employee	47.1	74.4
Painter	30.9	62.7
Public administration employee	39.5	70.1
Systems mechanic	25.7	75.8
Tax specialist	29.0	75.1
1-9 employees	39.6	69.4
10-49 employees	37.7	72.1
50-499 employees	41.0	73.6
500+ employees	37.1	77.2

Source: Provided by the BIBB, based on Jansen et al. (2015a), Apprenticeship training in Germany remains investment-focused – results of BIBB Cost-Benefit Survey 2012/13, BIBB Report 1/2015.

Moreover, as the measure is 'relative' productivity (compared to an average worker in the same firm), the productive contribution of apprentices in large firms is likely to be higher in absolute terms even if the relative performance compared to a skilled worker does not differ across firm sizes. In large firms, skilled workers typically earn considerably higher wages (e.g. in Switzerland, large firms with 100+ employees pay almost 20% higher skilled-worker wages compared to small firms with 1-9 employees). Thus, to the extent that higher pay reflects higher productivity, apprentices in large firms also generate higher training benefits in absolute terms.

Table 12: Average net costs and relative apprentice productivity by training occupation, Switzerland (in EUR), 2009

	Average net costs (per apprentice)	Relative productivity 1st year (in %)	Relative productivity last year (in %)	Training duration (in years)
Electrician	-47,393	18.6	79.2	4
Dental assistant	-46,239	36.8	84.8	3
Painter	-39,323	32.5	71.7	3
Carpenter	-32,828	30.5	67.3	3
Gardener	-26,545	31.6	71.9	3
Social care specialist	-21,437	38.5	79.2	3
Plumbing and heating engineer	-20,649	27.6	69.8	3
Joiner	-19,986	22.7	68.7	4
Medical assistant	-18,925	33.8	82.5	3
Retail worker	-13,186	41.3	79.7	3
Health care specialist	-10,858	26.6	73.1	3
Logistician	-8986	33.4	76.7	3
Civil engineering draughtsman	-7705	18.8	72.0	4
Bricklayer	-5988	23.3	71.5	3
Commercial employee	2765	41.1	74.3	3
Car mechanic	6171	23.5	74.8	4
IT specialist	6785	29.3	88.1	4
Cook	8485	36.9	79.5	3
Industrial mechanic (Polymechanic)	28,753	20.0	80.6	4
Electronics technician	34,452	21.9	80.0	4
other 3-year apprenticeships	-6648	34.1	75.6	3
other 4-year apprenticeships	-9485	29.0	80.9	4

Note: CHF/EUR exchange rate of 1.10 on 11 September 2015.
Source: Author's calculations based on Strupler and Wolter (2012), Die duale Lehre eine Erfolgsgeschichte - auch für Betriebe. Ergebnisse der dritten Kosten-Nutzen-Erhebung der Lehrlingsausbildung aus der Sicht der Betriebe, Glarus/Chur: Rüegger Verlag..

In Switzerland, there is a substantial variation in net training costs, ranging from a net benefit of almost EUR 50,000 when training electricians, to substantial net costs of almost EUR 34 000 for electronics technicians (Table 12). The example of the electrician illustrates the point regarding the cost-elasticity of the firm's demand for apprentices in section 2.1. The electrician is one of the most popular training occupations in Switzerland, and the most beneficial profession from the firm's perspective. However, the situation on the product market is very competitive, and thus, apprentices are substituted not only for unskilled, but even more so for skilled workers early on during the apprenticeship period, so that

the remaining share of unproductive time at the workplace is only 18%.[22] As a result, training firms have a competitive advantage to non-training firms and thus the ability to offer better prices. Consequently, a substantial fraction of the net benefits that a firm can generate during the training period will be passed on to consumers in the form of lower prices for the services of electrician. Conversely, the examples of the electronics technician and industrial mechanic (Polymechanic) illustrate the importance of post-training benefits. In these occupations, external hiring costs average more than EUR 32,000, thereby justifying a net investment in apprenticeship training in order to save future hiring costs for skilled workers (Blatter et al., 2016).[23]

For Swiss apprentices, there is a tendency for 3-year apprenticeships that the last-year productivity in large firms with more than 100 employees is somewhat higher, but the effect is not very strong in economic terms (Table 13). Moreover, there are no statistically significant differences among firms with less than 100 employees. In the four-year apprenticeships, there are no significant differences by firm size.

Table 13: Average relative apprentice productivity by firm size, Switzerland (in EUR), 2009

	1-9 employees (in %)	10-49 employees (in %)	50-99 employees (in %)	100+ employees (in %)
1st year relative productivity of apprentices in skilled tasks				
Commercial employee	40.4	44.4	37.5	38.5
3-year apprenticeships	35.2	37.1	34.9	35.8
4-year apprenticeships	24.2	25.1	27.9	25.7
Last year relative productivity of apprentices in skilled tasks				
Commercial employee	68.1	75.2	75.4	75.4
3-year apprenticeships	73.3	74.7	74.6	77.9
4-year apprenticeships	74.6	78.9	84.2	83.2

Source: Own calculations based on Strupler and Wolter (2012), Die duale Lehre eine Erfolgsgeschichte - auch für Betriebe. Ergebnisse der dritten Kosten-Nutzen-Erhebung der Lehrlingsausbildung aus der Sicht der Betriebe, Glarus/Chur: Rüegger Verlag.

3.3. Financial and non-financial incentives

There are many financial and non-financial incentives to encourage firms to take on apprentices. In most countries with apprenticeship training, the government bears the costs for vocational schools (e.g. teacher salaries, infrastructure, etc.). Moreover, some countries reimburse the firms for their training expenses (e.g. the Czech Republic, Finland, Norway, or the Slovak Republic) or reimburse the company for the wages paid to apprentices (Denmark).[24] In addition, there are local or industry-wide training funds, to which all firms contribute, but the funds are subsequently allocated to training firms. The rationale for such funds is to increase firms' willingness to provide apprenticeship training, and simultaneously make it more expensive for non-training firms to poach graduated apprentices from other training firms. While

[22] Own calculations, based on Strupler and Wolter (2012).

[23] In contrast to the electrician, the share of non-productive tasks of electronics technicians and industrial mechanics is 43% in the first training year. Moreover, in these occupations, some apprentices (between 22-24%, see Strupler and Wolter, 2012) spend the entire first year in an external training facility (*Basislehrjahr*) or an internal training center to acquire basic occupation-specific skills. Hence, net costs differ strongly: while net costs amount to EUR 50,000-60,000 for firms that place apprentices in external training centers, training by firms according to the 'classical' dual model are able to break even by the end of training (Strupler and Wolter, 2012, pp. 109).

[24] See OECD (2011), pp. 234, for more details.

some funds are run privately by professional associations, others are run locally by regional governments. Muehlemann and Wolter (2013) argue that the effectiveness of such training funds depends on the specific situation of the local or occupational apprenticeship market. As long as those firms that train apprentices do not incur substantial net costs, and if there is no scarcity of skilled workers in the external labour market, then there is little need for such schemes. However, if there is a general lack of skilled workers, and firms are reluctant to train apprentices because of the threat of poaching (Muehlemann and Wolter, 2011), then such training funds may indeed have positive effects on the apprenticeship market.

Another type of incentive that is not costly for the government is to link the award of public contracts to the provision of apprenticeships. Strupler Leiser and Wolter (2016) analyse the existence of public procurement policies in Switzerland on the probability that firms offer apprenticeship training. They find that small firms with less than 50 employees are more likely to train apprentices if public procurement policies are relevant for particular firms. Moreover, analysing different indicators for training quality (such as instruction time) does not reveal any adverse effects on the training behaviour of firms. However, even though such a policy is cost-efficient for the government, and appears to be highly effective, Strupler Leiser and Wolter identify at least three possible drawbacks: (i) there might be discrimination against highly specialised firms that cannot train due to a lack of appropriate training occupation; (ii) there might be discrimination against small firms (compared to large firms) in times when there is a lack of qualified applicants for apprenticeships; and (iii) such a policy may lead to too many apprenticeships in certain industries or occupations where public procurement is widespread. Nonetheless, public procurement policies may be a suitable instrument to increase a firm's training participation when there is an excess supply of apprentices (although such an instrument would have to be limited to small public contracts that are not relevant to WTO guidelines).

In Germany, firms received a training bonus (*Ausbildungsbonus*) to hire disadvantaged youth for new apprenticeships that started between August 2008 and the end of 2010 (Bonin et al., 2013). Disadvantaged youth are defined as individuals who unsuccessfully applied for training positions in the previous year, and had a low educational qualification at the compulsory-level (*Hauptschulabschluss, Sonderabschluss*), no completed compulsory education, learning difficulties, or come from a disadvantaged social background. For each disadvantaged apprentice, a firm received EUR 4,000, EUR 5,000, or EUR 6,000, depending on the corresponding tariff for apprentice pay. For hiring disabled apprentices, a firm could receive an additional 30% on top of the training bonus. A firm received 50% of the bonus at the end of the trial period, and the remaining 50% at the time when the apprentice was registered for the final examinations. Given the difficulty to assess whether the firm in fact offers an additional training position due to the subsidy, it would only receive a subsidy if the number of apprenticeship positions including the disadvantaged apprentices was higher in the three-year average (in the previous three years).

However, the evaluation of the training bonus is not encouraging. According to Bonin et al. (2013), the training bonus did not create any additional apprenticeship positions. Moreover, there were no statistically significant differences regarding the training success (i.e. graduation rates, or transition in the labour market). Bonin et al. (2013) conclude that the design of the bonus was responsible for poor effectiveness, and resulted in very high windfall gains. In particular, a firm frequently applied for the bonus only once the hiring decision was already made, meaning that the firm only applied for subsidies for apprentices that meet the firm's requirements, so that the firm would also have hired the applicant in the absence of the training bonus. Thus, there is no evidence that the training bonus led to substitution effects, so that disadvantaged applicants were hired instead of non-disadvantaged applicants. Moreover, while the criterion regarding the 'additional training position' is superior to a general subsidy to training firms that is independent of the number of apprentices, Bonin et al. (2013) argue that it is a disadvantage of the criterion that is not binding to firms that previously did not train apprentices (for some time).

However, given that the net training costs in Germany are on average about EUR 5,000 per year per apprentice, it is not surprising that a firm only hires those disadvantaged applicants who they expect to

successfully graduate. Even when considering the subsidy, the firm is left with a substantial net training investment (particularly if disadvantaged apprentices also require above-average instruction time). Thus, a firm will only be willing to offer apprenticeship training under the training bonus scheme if it intends to retain an apprentice as a skilled worker afterwards. Conversely, for a firm to train disadvantaged apprentices at zero net costs (i.e. with a production motive), the corresponding training bonus would need to cover the entire net investment, which might be even higher than the average net costs because disadvantaged youth might need additional support from the company.

In Australia, a recent withdrawal of a training bonus of 4 000 AUD led to a strong reduction in training enrolments in the service sector (Pfeifer, 2016). Particularly in this sector, training firms often offer low-quality training that results in low graduation rates (Snell and Hart, 2007) and only marginally better employment outcomes (Dockery et al., 2005). Conversely, in the traditional trade and industries, where more firms follow an investment-oriented training model, the withdrawal of the bonus was not accompanied by a significant reduction in enrolments. Thus, these results imply that even though subsidies increased training participation of Australian firms in the service sector, the benefits for apprentices from completing such a programme were often quite limited as the accumulation of skills was rather low.

Evidence from Switzerland suggests that no subsidies are necessary for firms to hire applicants with bad school grades and invest in additional training time in occupations where training on average generates a net benefit (Muehlemann et al., 2013). Thus, designing an apprenticeship system that allows firms to train cost-efficiently while ensuring training quality might likely be the most efficient policy for a government to promote dual apprenticeship training that also encourages firms to train lower-ability school-leavers.

Moreover, based on the simulations for Spain in 10 different training occupations, Wolter and Muehlemann (2015) show that there would always be a training model with a certain framework that allows a firm to train apprentices without having to make a net investment. While an existing Spanish training curriculum ensures the corresponding training content in vocational school, firms could offer apprenticeship training similar to Swiss firms (around five hours per week per apprentice) and still break even, as long as the training duration and apprentice pay are set accordingly. Thus, firms would be able to cover their training expenses if apprenticeships last three years, and if apprentice pay is set around 15-25% of the skilled worker pay (or 40-70% of the Spanish minimum wage), which is a scenario that is fairly similar to Switzerland where apprentices earn on average less than 20% of the skilled worker pay (Muehlemann et al., 2013).

Summing up, the empirical evidence on the effectiveness and efficiency of subsidies to firms with the aim to increase training participation is not very encouraging, suggesting alternative forms of state interventions. The most promising type of state support might be the provision of (high-quality) public vocational schools, and the support of industry-specific training courses aimed at increasing transferable skills of apprentices. At the individual level, the provision of training subsidies for at-risk-applicants might be effective when such individuals can be readily identified, and if the provided subsidy is sufficiently high to cover a firm's entire net training investment. While firms and individuals react to incentives such as subsidies, it is important to consider possible adverse effects of subsidy payments, and to ensure that a monitoring system is in place to prevent misallocation of funds and to enforce minimum training standards. Nonetheless, even when subsidies are effective, the question regarding the efficiency of subsidies needs to be considered as well.

3.4. Duration of apprenticeship training

The duration of a training programme is a very decisive factor both for the costs-benefit ratio of the firm and for an individual rate of return to an apprenticeship programme. At the beginning of an apprenticeship, apprentices are not very productive in skilled tasks, and firms make the highest investment in training (Malcomson et al., 2003). Tables 14 and 15 show how the costs and benefits of training evolve over time in Germany and Switzerland, respectively. Moreover, firms make a higher net investment in the

beginning of the training period when the apprenticeship duration is longer (i.e. 3.5 years in Germany or 4 years in Switzerland).

The training investment in Switzerland is even more front-loaded than in Germany (Table 15). While a firm makes a net investment of more than EUR 6,000 in the first 2 years of a 4-year apprenticeship programme, it already generates sufficient net benefits in the last two years to recoup its initial investment. However, three years would not have been sufficient to cover the initial training expenses. Thus, from the firm's perspective, a longer training duration clearly increases the probability to cover the initial training investment. Yet, looking at the German case in Table 14 shows that firms do not generate a net benefit even in the last year of the training, although the amount of net investment decreases over time.

Table 14: Costs and benefits of apprenticeship training in Germany by duration and training year (in EUR), 2012/13

Duration		1st year (mean)	2nd year (mean)	3rd year (mean)	4th year (mean)
2 years	Costs	15,823	17,713		
	Benefits	10,561	12,358		
	Net costs	5262	5355		
3 years	Costs	16,827	17,686	18,528	
	Benefits	11,367	13,757	16,564	
	Net costs	5460	3928	1964	
3.5 years	Costs	19,612	19,742	20,528	12,700
	Benefits	6866	9636	13,139	7594
	Net costs	12,746	10,105	7389	5106

Source: Adapted from Jansen et al. (2015a), Apprenticeship training in Germany remains investment-focused – results of BIBB Cost-Benefit Survey 2012/13, BIBB Report 1/2015.

Table 15: Costs and benefits of apprenticeship training in Switzerland by duration and training year (in EUR), 2012/13

Duration		1st year (mean)	2nd year (mean)	3rd year (mean)	4th year (mean)
3 years	Costs	24,605	24,876	29,077	
	Benefits	24,425	27,848	34,207	
	Net costs	182	-2972	-5130	
4 years	Costs	24,523	24,528	26,881	29,223
	Benefits	19,486	23,369	30,482	39,442
	Net costs	5036	1159	-3601	-10219

Note: CHF/EUR exchange rate of 1.10 on 11 September 2015.
Source: Adapted from Strupler and Wolter (2012), Die duale Lehre eine Erfolgsgeschichte - auch für Betriebe. Ergebnisse der dritten Kosten-Nutzen-Erhebung der Lehrlingsausbildung aus der Sicht der Betriebe, Glarus/Chur: Rüegger Verlag.

From the individual's perspective, a longer training duration must not necessarily translate into higher post-training earnings, particularly if firms use the extra year to recoup their training investment (rather than to invest in more human capital). Oosterbeek and Webbink (2007) find that an extra year of apprenticeship training in the Netherlands (although back in 1975) did not have a statistically significant wage effect. Oosterbeek and Webbink (2007) show that the extra year of training was awarded an equally

high pay rise as a year of work experience, and conclude that the amount of human capital provided under the old system may have been roughly equivalent compared to the system with a longer training duration.

Table 16: Allocation of time to apprentices at the workplace in Germany (3-year apprenticeships)

Germany	Year 1 (mean)	Year 2 (mean)	Year 3 (mean)
Unskilled tasks (β_E)	48.5%	36.9%	29.1%
Skilled tasks (α_E)	26.4%	42.5%	53.7%
Other activities with no direct value to the firm (μ_E)	25.1%	20.7%	17.2%
Productivity in skilled tasks compared to a skilled worker	41.6%	57.8%	72.6%

Source: Adapted from Jansen et al. (2015b), Labour market deregulation and apprenticeship training: A comparison of German and Swiss employers", *European Journal of Industrial Relations*, 21(4) 353–368. Year of survey: 2007.

In Germany, apprentices are allocated about 50% of unskilled tasks at the workplace in the first training year. However, the corresponding share declines to about 30% in the last training year (Table 16). Conversely, the share of skilled tasks increases from about 25% in the first year to more than 50% in the last training year. Finally, the share of activities with no direct value to the firm (such as performing exercises and simulations) declines with the duration of the training from 25% to 17%, as apprentices become more skilled. A similar pattern can be observed for Switzerland (Table 17), although Swiss apprentices spend a somewhat higher (lower) share of unskilled work (non-productive tasks).

Table 17: Allocation of time to apprentices at the workplace in Switzerland (3-year apprenticeships)

Switzerland	Year 1 (mean)	Year 2 (mean)	Year 3 (mean)
Unskilled tasks (β_E)	53.0%	41.6%	31.5%
Skilled tasks (α_E)	25.8%	43.1%	53.7%
Other activities with no direct value to the firm (μ_E)	21.2%	15.3%	14.8%
Productivity in skilled tasks compared to a skilled worker	36.2%	55.8%	74.2%

Source: Adapted from Jansen et al. (2015b), Labour market deregulation and apprenticeship training: A comparison of German and Swiss employers", *European Journal of Industrial Relations*, 21(4) 353–368. Year of survey: 2009

The use of apprentices in Swiss and German firms suggests that it is important to have apprentices perform unskilled tasks. On one hand, apprentices may develop certain desirable personality traits even when performing unskilled tasks (such as successfully completing an assigned task on time). On the other hand, the value of unskilled tasks to the firm is important to recoup part of the firm's training investment. As apprentices receive an education at the workplace and also receive a salary, performing unskilled work at the beginning of an apprenticeship is a way to repay some of the costs of their education. Nonetheless, as apprentices become more skilled, it becomes increasingly beneficial for the firm to use apprentices for skilled tasks (which in turn reinforces the productivity growth of apprentices in skilled tasks).

3.5. Institutions

A country's institutional setting can have a strong effect on the costs and benefits of training. Minimum wage laws and collective bargaining agreements directly influence wage costs of skilled and unskilled workers, as well as apprentices and, therefore, both the costs and benefits of training. Kriechel et al. (2014) show that collective bargaining agreements and the existence of a works council are both positively associated with apprentice pay.

Dustmann and Schönberg (2009) find that union membership matters, as the existence of minimum wage floors lead to compressed wage structures. Union membership consequently encourages firms to invest in firm-sponsored training, a prediction that is supported by the data. From 1996-1999, the average share of unionised firms that offered apprenticeship training was 36.15%, whereas the corresponding figure for non-unionised firms was only 15.46%. Similarly, regarding the proportion of trained apprentices to overall employment, 6.5% of the workforce were apprentices in unionised firms, compared to 2.9% in non-unionised firms. Thus, the theoretical reasoning and empirical evidence show that unions can foster firm-financed training.

However, while unions provide incentives for firms through compressed wage structures to make net investments in apprenticeship training, apprenticeship training per se does not need to be financed by the employer. The case of the Swiss apprenticeship system shows that firms may indeed recover their training expenses by the end of the apprenticeship as long as apprentice pay is set at a reasonable level, and if apprentices can be involved in the firms' production process.

Germany was subject to major labour market reforms since 2003, aimed at improving the flexibility of the German labour market. Jansen et al. (2015b) analyse how that labour market reform affected the training behaviour of German firms (compared to a control group of Swiss firms that were not subject to labour market regulations). The results show that German firms, unable to significantly reduce apprentice pay (due to tariff agreements) or lower training investments (due to training regulations), used apprentices more productively after the reforms. While the share of unproductive tasks at the workplace of an average 1st year apprentice in Germany was 57% in 2000, the corresponding share fell to 25% in 2007, resulting in substantially higher (short-run) training benefits for the firm. While non-productive tasks may potentially have contributed to the accumulation of human capital, the empirical evidence shows that the productivity of German apprentices in skilled tasks even slightly increased from 2000 to 2007. Thus, the increased use of apprentices in the production process did not have an adverse effect on the accumulation of human capital. However, in Switzerland, there were no major labour market reforms between 2000 and 2009, the time between the first and the third cost–benefit survey. On average, the costs and benefits remained remarkably stable, although there were some changes within particular training occupations where apprenticeship reforms took place.

Regarding the potential savings on hiring costs for skilled workers, Muehlemann and Pfeifer (2016) find mixed evidence about the institutional effects on such post-training benefits. While works councils tend to be associated with higher hiring costs, there is no evidence of a significant association between hiring costs and collective bargaining agreements. Moreover, Kriechel et al. (2014) show that firms with a works council are able to retain a significantly higher fraction (+15 percentage points) of their apprentices five years after training, even though the difference in the initial retention rate was similar to other firms.

3.6. Changes over time

Apprenticeship training also reacts to dynamic changes. As the skill requirements in certain industries or occupations change, adjustments to training curricula are necessary so that graduated apprentices possess the skills that are demanded by other firms in the labour market. However, as firms cannot be forced to take on apprentices in a dual system, a major concern is how the firms' demand is affected by business cycle fluctuations. Brunello (2009) argues that during a recession, there are two opposing effects: while the productivity of apprentices declines (due to less work volume), the opportunity costs of training decline as well, because (part-time) instructors are less frequently taken away from their regular work duties while training apprentices. Thus, the effect of the business cycle on net training costs is ambiguous. Moreover, as recessions are only temporary, the long-term benefits from training remain unaffected by short-term business cycle fluctuations. Bellmann et al. (2014) show that apprenticeship training in Germany was much less affected by the financial crisis in 2008/09 than continuing vocational training in firms, concluding that apprenticeship training is rather crisis-resistant even when firms face very strong economic shocks. Consistent with these results, Muehlemann et al. (2009) show for Switzerland that while the number of apprenticeship contracts is significantly associated with business cycle effects, the magnitude of the effects is quite small.

4. CONCLUSIONS

Dual apprenticeship training requires a firm to make a training investment, mainly in the form of personnel costs for apprentice instructors and paying apprentices a salary. However, a training firm also receives a benefit because apprentices work productively during training. Moreover, retaining apprenticeship graduates as skilled workers may result in additional post-training benefits in the form of selecting the most suitable apprentices through employer screening, saved future hiring and firing costs, or by generating employers' rents from being able to pay skilled worker wages below productivity (due to monopsony power).

The empirical evidence from large-scale survey on the costs and benefits of apprenticeship training is limited to Germany and Switzerland. However, the results show that apprenticeship training may yield rather different outcomes regarding the required net investment of a training firm. While German firms make substantial net investments of more than EUR 5 000 per apprentice per training year, Swiss firms on average generate a net benefit from training apprentices. The findings suggest that the willingness of firms to make a net investment depends strongly on institutions and the labour market environment.

In Germany, training firms are able to retain about 60% of apprentices as skilled workers after training, allowing training firms to realise post-training benefits. Conversely, the mobility on the Swiss labour market is much higher, as two-thirds of Swiss apprentices leave the training firm within a year after training, so that the expected post-training benefits for a firm are in general rather low. Small firms frequently have lower probabilities to retain apprentices as skilled workers, and are thus less willing to make a net investment in training. Consequently, it is particularly important that apprenticeship training does not require a substantial net investment in markets with a high share of small firms.

While subsidies may encourage a firm's willingness to participate in training (increase the demand for apprentices), the effectiveness of subsidies depends positively on the cost-elasticity of the demand for apprentices, such as the substitution elasticity regarding other types of labour (skilled and unskilled), as well as the degree of competition on the product market. As the demand for apprentices likely varies strongly across different sectors and training occupations, the potential subsidy schemes require a careful ex-ante evaluation of a firm's demand for apprentices. Implementing subsidy schemes targeted at all training firms in an entire country are likely to result in large windfall gains. Moreover, the successful implementation of subsidy schemes also requires a monitoring system to ensure training quality. As long as the supply of potential (and qualified) apprentices is low and relatively inelastic (with respect to training costs), increasing the firm's demand for apprentices by means of subsidies does not result in substantially more additional apprenticeship positions (but merely reduces the net costs of existing apprenticeships).

From the individual perspective, apprenticeship training is only an attractive schooling choice for young people if they can expect that the accumulation of human capital during training will be useful and recognised in the labour market after graduation. Thus, training regulations should ensure that apprentices receive a substantial amount of general human capital that compares to other (full-time) educational programmes, and not mainly firm-specific on-the-job training. Once apprentices can expect good career options with a vocational qualification, apprenticeship training becomes more attractive for talented young school-leavers. Thus, training regulations should ensure minimum training standards, and standardised examinations at the end of an apprenticeship programmes, so that apprentices' skills are recognised and transferable in a national labour market. In addition, an increase in the provision of human capital in vocational schools further increases future productivity (and therefore also future wages). Hence, an increase in the quality and quantity of human capital accumulation during an apprenticeship will increase the supply of potential apprentices, as apprenticeship training becomes a more attractive educational pathway.

Furthermore, an increase in the supply of suitable apprentices also affects the firm's demand for apprentices. As more talented apprentices are more productive (holding other factors constant), an increase in the supply of more talented apprentices also leads to a shift in the firm's demand for apprentices, leading to more apprenticeship positions.

Finally, besides ensuring a certain level of training quality and quantity, and the external certification of skills, regulatory bodies can influence two additional factors that are important when a country decides to implement a dual apprenticeship system: (i) setting minimum apprentice pay; and (ii) determining the training duration. In the case where mandated apprentice pay is set substantially above the market-clearing level, there will be an excess supply of apprentices, as not all interested individuals will find an apprenticeship position. Additionally, the training duration needs to be long enough so that firms have incentives to make a substantial investment in human capital, yet still have sufficient time to recoup their training investment by having apprentices perform (skilled) work towards the end of the training period. A vocational schooling system that requires more attendance in vocational school at the beginning of the training period so that apprentices can spend more time at the workplace towards the end of the programme might further increase the possibilities of firms to break even by the end of the training period.

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