

Dustmann, Christian; Schönberg, Uta

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Christian Dustmann
Uta Schönberg

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Christian Dustmann

*University College London, CEPR,
IFS London and IZA Bonn*

Uta Schönberg

*University of Rochester
and IZA Bonn*

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
Email: iza@iza.org

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ABSTRACT

Training and Union Wages*

This paper tests the hypothesis that unions, through imposing wage floors that lead to wage compression, increase on-the-job training. Our analysis focuses on Germany which provides an interesting context to test this hypothesis, due to its large scale apprenticeship programme and its collective bargaining system that is based on voluntary union recognition. To guide the empirical analysis, we first develop a model of firm-financed training. A novel feature of our model is that a unionised and non-unionised sector coexist, and only unionized firms are bound by union wages. The model creates a rich set of empirical implications regarding apprenticeship training, layoffs, wage cuts, and wage compression in unionized and non-unionised firms. Our empirical analysis is based on firm panel data matched with administrative employee data, and provides strong support for our model. Our main results are that unionisation increases training, and that wage floors and wage compression play a more important role in unionised than in non-unionised firms.

JEL Classification: J24, J40, J51, I2

Keywords: training, unions, wage compression, matched firm-worker data

Corresponding author:

Christian Dustmann
Department of Economics
University College London
Gower Street
London WC1E 6BT
United Kingdom
Email: c.dustmann@ucl.ac.uk

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1 Introduction

Post-secondary education is a major contributor to economic growth and performance. A significant part of this education takes place on-the-job and in the firm. This paper addresses the question of how labour market institutions, in particular minimum wages imposed by unions, affect on-the-job training.

According to standard human capital theory, unions or minimum wages should reduce on-the-job training. The key insight is that if labour markets are perfectly competitive, *workers*, and not firms, finance general training, as workers capture the full return to that investment (Becker 1964). A minimum wage thus reduces training investments as it prevents workers from taking a wage cut during the training period to finance training (Rosen 1972, Hashimoto 1982). If unions compress the wage structure so that training increases workers' productivity more than workers' wages, then workers will not capture the full return to the training investment. Hence, unions may decrease training in the economy too (e.g. Mincer 1983).

The more recent literature on training, in contrast, stresses the importance of labor market imperfections, and notes that *firms* have an incentive to sponsor general training if wages are compressed (Acemoglu and Pischke 1999a, 1999b). Consequently, if unions compress the wage structure, firms have a stronger incentive to finance general training in a unionised than in a non-unionised economy, and whether unions increase or decrease training is no longer clear.

The empirical evidence on the impact of minimum wages and unions on training is mixed. For the US, Neumark and Wascher (2001) report that workers subject to a minimum wage receive less training, whereas Grossberg and Sicilian (1999) and Acemoglu and Pischke (2001) find no such effect. For the UK, several studies indicate that workers covered by union agreements or minimum wages receive more training (e.g. Booth et al. 2003, Green et al. 1996, and Arulampalam et al. 2003).

In this paper we test the hypothesis that unions, through wage compression, increase on-the-job training. Our empirical investigation focuses on Germany which provides an ideal context for this analysis. First, Germany has a large institutionalised youth training programme, the German apprenticeship system,¹ training about 65% of each cohort of labour market entrants.

¹See for instance Soskice (1994), Franz and Soskice (1995) and Winkelmann (1997) for a detailed description of the German apprenticeship system.

Training is mostly in general skills, and financed partly by firms². Apprentices spend 4 days a week in a firm, receiving training in their chosen occupation, and one day a week at state run schools. The training period lasts between two and three years, and firms may lay off apprentices after training without costs.

Second, Germany's collective bargaining system provides a unique opportunity for testing the hypothesis that unions increase training. This system - which we describe in detail below - differs in many respects from those in the US and UK. Most importantly, in Germany union agreements are binding only in firms that belong to an employer federation (*Arbeitgeberverband*). Membership in an employer federation is voluntary. In firms that choose to belong to an employer federation, union agreements apply to all employees, independently of their union status. In contrast, in firms that do not belong to an employer federation, union agreements are not binding. This divides firms and their workers into a unionised and a non-unionised sector. A further crucial feature of the German collective bargaining system is that wage negotiations take place on a yearly basis at the regional and industry level between unions and employer associations, and determine wages for different education groups. Union wages act as minimum wages. It is important to stress that unions and employer federations do not directly bargain over apprenticeship training (Bispinck 2001, Bispinck et al. 2002).

To guide the empirical analysis, we first develop a model of firm-financed training. Since our focus is on the impact of unions on training, we abstract from other reasons for wage compression and firm-financed training, such as asymmetric information (Acemoglu and Pischke 1998) and firm-specific human capital accumulation (Acemoglu and Pischke 1999b, Franz and Soskice 1995 and Stevens 1994). Neither of these models yield the same empirical implications as our model. Moreover, (most of) the empirical implications of our model continue to hold if we allow for additional reasons for firm-financed training. Our point of departure is the work by Acemoglu and Pischke (1999a, 1999b), Acemoglu et al. (2001), Booth and Chatterji (1998), and Booth et al. (2002). We extend these models in various directions. First, in our model unionised and non-unionised firms coexist in equilibrium, and only unionised firms are bound to pay union wages. In other words, a unionised sector arises endogenously in equilibrium, and we analyse which employees work in the unionised sector. Second, in our model union agreements act as

²See studies by von Bardeleben et al. (1995) and Acemoglu and Pischke (1999b) on the cost of training apprentices.

minimum wages, and unionised firms are allowed to pay wages above the union wage. Below we provide evidence that in Germany payments above the union wage are frequent. Third, we allow workers to be heterogenous and mobility to be endogenous. Within this framework we analyse the wage and training decision of both unionised and non-unionised firms as well as the sorting of workers and firms into both sectors. Workers choose the sector in which their utility is highest. Firms, in contrast, are indifferent between joining the unionised and non-unionised sector. Although we model the union wage as a minimum wage, our model is different from a simple minimum wage model in several respects. Most importantly, in our model the union (minimum) wage is binding only in unionised firms, and firms and workers always have the option of not unionising. Moreover, the minimum wage does not apply to workers in training.

We analyse firms' incentives to invest in training under three types of labour market imperfections: limited commitment to training provision, the infeasibility of long-term contracts, and rents, allowing firms to pay wages below productivity. We believe that the assumption of limited commitment to training provision is the appropriate one in the context of on-the-job training, as this type of training is not easily verifiable by a third party³. Since firms cannot commit to training, workers are not willing to accept a wage cut to finance training. Consequently, as wages are not compressed in non-unionised firms, these firms offer no training. In unionised firms, in contrast, the union wage compresses wages for workers with a productivity around the union wage, inducing them to train these workers. This argument crucially depends on firms paying wages below (marginal) productivity. If, in contrast, wages were equal to productivity, then unions would neither have an impact on the wage structure nor on training.

In our model, the key difference between unionised and non-unionised firms is that the former guarantee to pay at least the union wage in the future. This is a special form of a long-term wage contract. In principle, firms do not have to join an employer federation in order to commit to a wage guarantee. However, such a commitment is not self-enforceable as firms have an incentive to offer a lower wage in case a negative productivity shock arrives. Hence, in our model unions serve as a commitment device: Unionised firms credibly signal to workers that they will pay at least the agreed union wage in the future. Our paper thus falls into the category of papers

³In Germany, apprentices take centralised exams at the end of the apprenticeship training period and receive a certificate that is widely recognised. Hence, it is verifiable whether a worker has received some training. However, an important part of apprenticeship training takes place inside the firm, and is not easily verifiable by a third party.

that stress the efficiency-improving role of unions (e.g. Freeman and Medoff 1984, Freeman and Lazear 1995). That unions may serve as a commitment device has also been discussed by, among others, Malcomson (1983), Hogan (2001), and, in the case of training, Booth and Chatterji (1998).

Our empirical analysis begins with a comparison of the training intensity in unionised and non-unionised firms. Our analysis is based on a panel of firms between 1996 and 1999, combined with information on the firm's workforce, obtained by matching all employees from administrative records to each firm in the panel. Our estimation strategy takes into account selection of workers and possibly firms into the unionised sector. Our data allows us to control for an unusually rich set of both firm and worker characteristics. Our identification strategy exploits the changes in union status over time. This allows us to control for unobserved time-invariant firm (and worker) heterogeneity. We consistently find that unions increase training.

One possible explanation for why unions increase training is that unions directly bargain with employer federations over training. This explanation is an unlikely candidate in the German case, since such direct negotiations are rare (Bispinck 2002), and did not take place at all over the period we consider. According to our model, unionised firms offer more training than non-unionised firms because, due to wage floors, wages are more compressed in unionised than in non-unionised firms. In the second step of the empirical analysis, we then compare the structure of wages in unionised and non-unionised firms. We test for three implications that directly follow from wage floors which are binding only in unionised firms. First, layoffs should occur more frequently in unionised firms. Second, wage cuts should be observed more often in non-unionised firms. This occurs because unionised firms respond to negative productivity shocks by firing workers, whereas non-unionised firms cut wages. Third, the variance of log-wages should be higher in non-unionised than in unionised firms, conditional on previous wages and staying. The reason is that the wage distribution in unionised firms is truncated, as low productivity workers are laid off and others earn exactly the union wage. We find considerable empirical support for all these implications, particularly for the low educated workers for whom wage floors should be most binding.

To conclude, the empirical evidence strongly supports our hypothesis that membership of firms in employer federations (we refer to these firms as "unionised firms"), via imposing minimum wages and wage compression, increases training in apprenticeship programmes.

The structure of the paper is as follows. Section 2 describes the German collective bargaining system. Section 3 develops a model of employer-financed training. We begin with a base model and then incorporate union agreements into the model. Section 4 outlines the empirical implications and the empirical strategy. We describe the data and results in section 5. Section 6 concludes with a discussion of our findings.

2 Collective bargaining in Germany

In Germany⁴, negotiations between unions and employer federations take place at a regional and industry level, typically on an annual basis. The central feature of the German collective bargaining system is that not all firms are bound by union agreements. Only firms that belong to an employer federation (*Arbeitgeberverband*) are legally obliged to pay (at least) union wages. Membership in an employer federation is voluntary. In firms that belong to an employer federation, union agreements apply de facto to all employees, not only to union members. On the other hand, workers who are union members but work in firms that do not belong to an employer federation are not entitled to union wages. Between 1996 and 1999, the proportion of West-German firms that voluntarily recognise industry-wide union agreements was 49.9 %. These firms employed 67.0 % of the West-German work force⁵. This differs from the US system where employers often attempt to resist organising drives, and firms are forced to recognise unions if at least 50 % of its work force votes in favour of union organisation (DiNardo and Lee 2003).

Firms that do not belong to an employer federation have two options. They can either engage in bilateral negotiations with the union or negotiate individual contracts with their employees. The proportion of firms which bilaterally negotiate with unions is relatively small (6.4 %). Between 1996 and 1999, 43.7 % of firms were neither bound by industry-wide or firm level agreements. Firms can change their union status. Between 1996 and 1999, 6.6% of firms previously covered by union agreements left the employer federation, while 4.4% of firms not

⁴Our empirical analysis is restricted to former West-Germany. Numbers given below refer to West-Germany only.

⁵Our own calculations based on the IAB firm panel. Not surprisingly, in Germany union membership is much smaller than union coverage. Between 1996 and 1996, only one in four employees in West Germany was a union member (Schnabel and Wagner 2003).

previously covered by union agreements joined an employer federation⁶.

The most important outcome of the negotiation between unions and employer associations is the union wage. Union wages depend on easily observable worker characteristics, such as workers' skill, occupation, and experience. A different union wage applies for workers in apprenticeship training. Legally, union wages act as minimum wages, and firms may pay wages above the union wage. Payment above the union wage appears to be common. Bellmann et al. (1998) report that in 1997 49% of West German firms paid wages above the union wage, although little is known about how many workers in these firms received higher wages.

Besides wages, union agreements typically specify overtime payments and the weekly working time. For our purpose, it is important to stress that unions and employer federations generally do not directly bargain over training. Bispinck (2001) and Bispinck et al. (2002) analyse all union contracts in Germany since 1997 with respect to training agreements. Only very recently do some union contracts include references to apprenticeship training, but these agreements are almost entirely based on firms' good will, and do not involve sanctions if firms do not comply.

3 A model of firm-financed training

We now develop a model of union agreements and firm-financed training. We first analyse firms' incentives to train when there are no union agreements (section 3.1). We then incorporate wage rigidities due to unions into the model (section 3.2). In order to focus on the impact of union agreements on training, we abstract from other reasons for wage compression and firm-financed training, such as complementarity between general and firm-specific skills (Acemoglu and Pischke 1999b, Franz and Soskice 1995 and Stevens 1994), asymmetric information with respect to incumbent and outside firms (Acemoglu and Pischke 1998), and asymmetric information with respect to workers and firms (see Autor 2001 and Bhaskar and Holden 2002 for models of this type). None of these explanations yield the same empirical implications as our model. Moreover, most of the empirical implications of our model continue to hold if we allow for additional reasons for firm-financed training.

⁶Our own calculations based on the IAB firm panel.

3.1 Base model

There are many workers and firms, both are risk-neutral. Firms maximise expected profits, and workers maximise expected utility. We consider two periods, where the first period is the training period. There is no discounting in our model.

Workers' productivity in period 2 depends on their (true) ability η as well as on the amount of training received in period 1, τ :

$$y = \eta h(\tau).$$

We assume $h(\tau)$ is strictly increasing, differentiable and concave in τ , with $h''(\tau) < 0$ and $h(\tau) > 1$ for $\tau > 0$. Our results do not depend on training and ability entering the production function multiplicatively. It is important, however, that the return to training is higher for more able workers. The multiplicative specification captures this complementarity in a simple manner. The productivity of an untrained worker is η , i.e. $h(0) = 1$. The productivity of a worker in training is smaller than the productivity of an untrained worker by a constant k , which represents a fixed cost of training. There are also variable training costs which we denote by $c(\tau)$. The function $c(\tau)$ is strictly increasing, differentiable, and convex, with $c(0) = c'(0) = 0$, $c''(\tau) > 0$. We further assume that the firm's production function exhibits constant returns to scale, i.e. the total productivity of a firm is equal to the sum of each worker's productivity.

Workers' ability η is drawn from a normal distribution with mean $\bar{\eta}$ and variance σ_{η}^2 . Information about ability is imperfect. In the first period firms and workers receive a noisy signal $\tilde{\eta} = \eta + \varepsilon_{\eta}$, which they use to update their beliefs about workers' ability. If ε_{η} is normally distributed with mean 0 and variance $\sigma_{\tilde{\eta}}^2$, then the updated belief about the worker's productivity is also normally distributed (DeGroot 1970), and a weighted average of the prior mean, $\bar{\eta}$, and the signal, $\tilde{\eta}$. We denote this updated belief by $\hat{\eta}$. Let $F_1(\eta|\hat{\eta})$ denote the ability distribution of a worker with expected ability $\hat{\eta}$ ⁷. In the second period both incumbent and outside firms symmetrically learn about workers' true ability. The assumption that firms perfectly learn about workers' ability is not essential for our results.

In the first period, firms - as opposed to workers - decide how much training to offer to a worker. Training is continuous, and firms can condition their investment decision on workers' expected ability. We analyse the firms' decision to train under the assumption that firms can

⁷>From DeGroot (1970), $E[\eta|\hat{\eta}] = \frac{\bar{\eta}\sigma_{\tilde{\eta}}^2 + \hat{\eta}\sigma_{\eta}^2}{\sigma_{\tilde{\eta}}^2 + \sigma_{\eta}^2}$, and $V[\eta|\hat{\eta}] = \frac{1}{\frac{1}{\sigma_{\tilde{\eta}}^2} + \frac{1}{\sigma_{\eta}^2}}$.

only commit to *providing* training, but not to the *amount* of training. We refer to this case as *limited commitment*. One justification for this assumption is that training is not easily verifiable by a third party. For our particular application - apprenticeship training in Germany - the assumption that firms can commit to providing training, but not to the amount of training is reasonable. Trainees take centralised exams at the end of the apprenticeship training period and receive a certificate that is widely recognised. Hence, it is verifiable whether a worker has received some training. However, an important part of apprenticeship training takes place inside the firm, which is not easily verifiable by outside parties. We do assume, however, that training is observed by outside parties.

At the end of the training period workers decide whether to switch firms. As in Acemoglu and Pischke (1998), we assume that during the training period workers experience a utility shock θ . This shock captures the worker's ex post evaluation of her work environment. Only the worker, but not the firm, observes θ . We specify the worker's utility in period 2 at the incumbent firm, U as a simple linear function of the incumbent firm's wage offer, w , and the utility from non-pecuniary job characteristics, θ :

$$U = w + \theta.$$

The utility shock is drawn from a distribution with the cumulative distribution and probability density function G and g and support $[\underline{\theta}, \bar{\theta}]$, with $\bar{\theta} > 0$. We assume that $G(\cdot)$ belongs to the family of log-concave distribution functions, i.e. $\frac{g(\theta)}{1-G(\theta)}$ is non-decreasing in θ . We also assume that the distribution of the utility shock neither depends on worker's ability nor on training. The worker's utility at outside firms is equal to the wage offer, v . Notice that the assumption that the upper support of G is positive, $\bar{\theta} > 0$, implies that *some* workers may stay with the employer even if offered a lower wage than by outside firms. Consequently, firms make positive profits in the second period.

In each period firms simultaneously make wage offers to workers by maximising expected profits. Wages are thus determined in spot-markets, and long-term wage contracts are not feasible. We further impose the standard free entry condition on firms: No firm earns positive profits in the long-run in equilibrium.

To summarise, the sequence of events is as follows. At the beginning of the first period firms and workers receive a noisy signal about workers' ability. Firms offer a (first period) wage and choose whether and how much to train the worker. Firms cannot commit to the amount of

training. Workers choose the offer that yields the highest utility. Then training and production takes place. At the end of the first period, all firms and workers learn workers' ability as well as training. Both incumbent and outside firms make a wage offer to the worker. Workers then discover their utility shock, and decide whether to stay with or to leave the training firm. At the end of the second period workers retire.

We first analyse wage determination in the second period. We then turn to firms' incentives to train and wage determination in the first period.

Wage determination in the second period

Firms observe workers' ability and training in the second period. Hence, wage offers of incumbent and outside firms depend on ability as well as training.

Let w denote the wage offer of the incumbent firm and v the worker's outside wage offer. Due to perfect competition in the outside market, outside firms bid up workers' wage until it equals the worker's (marginal) productivity, i.e. $v = y = h(\tau)\eta$. Incumbent firms set wages by maximising expected profits, and trade off a higher chance of attracting the worker with a lower rent per worker. A worker stays with the training firm if the utility from staying, $w + \theta$, exceeds the utility from moving, $v = y$. Hence, the probability of staying is

$$Pr(\text{stay}) = Pr(\theta > y - w) = 1 - G(y - w).$$

If $\bar{\theta} > 0$, this probability is positive even if $w < y$: Some workers stay with the firm although they receive a lower wage offer from the incumbent than from outside firms. Incumbent firms maximise

$$\max_w (1 - G(y - w))(y - w).$$

>From the first order condition, w satisfies

$$w = y - \frac{1 - G(y - w)}{g(y - w)}.$$

Log-concavity of G guarantees that the second order condition for a maximum is satisfied. Since workers stay with a positive probability with the incumbent firm even if they receive a higher outside wage offer, firms have monopsonic power and pay wages below productivity. It can be easily verified that $\frac{dw}{dy} = 1$: A productivity increase of one unit leads to a wage increase of the same magnitude. Hence, the wage offer of the incumbent firm is equal to the worker's

productivity minus a constant, Δ :

$$w = y - \Delta. \tag{1}$$

This follows from the assumption that the distribution of non-pecuniary job characteristics does not depend on workers' ability and training.

Training decision and wage determination in the first period

We now turn to the firm's training decision. Since commitment to training provision is limited, the only training level workers consider credible is the one that maximises firms' future profits. Firms thus ignore the impact training has on the utility of the worker. From (1), firms earn a rent of Δ on each retained worker. Since workers stay with the incumbent firm with probability $(1 - G(\Delta))$, firms' profits in the second period equal $\Pi = (1 - G(\Delta))\Delta$. Clearly, they do not depend on training, and firms offer no training in equilibrium. We summarise:

Proposition 1 *Under limited commitment firms offer no training.*

The result that in the absence of wage compression the training market breaks down completely is due to two labour market imperfections, limited commitment to training provision and the infeasibility of long-term contracts. Suppose first that firms can commit not only to training provision, but also to the amount of training. Then workers are willing to accept a wage cut to finance training. Firms take into account the impact training has on workers' utility, and offer training⁸. Next suppose that commitment to training provision is limited, but firms can offer a long-term wage contract and commit to a post-training wage. This essentially compresses the wage structure: Training increases workers' productivity, but not their wages, inducing firms to train workers⁹. Such a contract, however, is typically not self-enforceable. We next show that unions may help to enforce such a long-term contract, and thus increase training¹⁰.

⁸In the absence of wage compression, training will be socially optimal. It is the worker who bears the training cost through a lower first period wage (see Acemoglu and Pischke 1999b).

⁹As we explain in the next section, this holds even if firms can lay off workers at the end of the training period without cost, as in our model. What is required is that some workers stay with the training firm even if offered a wage below their productivity. This holds in our model because of non-pecuniary job characteristics.

¹⁰To be complete, we need to derive wage offers in the first period. Because of the free-entry condition firms bid up workers' wage until they make zero profits in the long-run. As firms make positive profits in the second period $(1 - G(\Delta))\Delta$, first period wages are higher than workers' expected productivity. They satisfy $W = \hat{\eta} + (1 - G(\Delta))\Delta$.

3.2 Union agreements

We now incorporate wage rigidities due to unions into the model, and show that unions lead to wage compression and hence to training. The crucial feature of our model is the coexistence of a unionised and non-unionised sector. Each sector consists of many firms competing for workers. The difference between the two sectors is that firms in the unionised sector have to pay at least the union wage, while firms in the non-unionised sector can pay any wage.

In Germany, the union wage depends on observable worker characteristics, such as training. In order to simplify the notation, we assume here that the union wage is the same for workers with and without training. Our results continue to hold if the union wage for trained workers exceeds that for untrained workers, as long as training increases productivity more than the union wage. In our model, the union wage does not apply to workers in training. In line with Germany's apprenticeship regulations we further assume that firms can lay off workers at the end of the training period without incurring any firing costs. Finally, we rule out the possibility that firms change their union status, although this is possible for German firms. Our key result that unionised firms are more likely to train than non-unionised firms continues to hold if firms that were unionised in the past are more likely to be unionised in the future. This is clearly in line with the data.

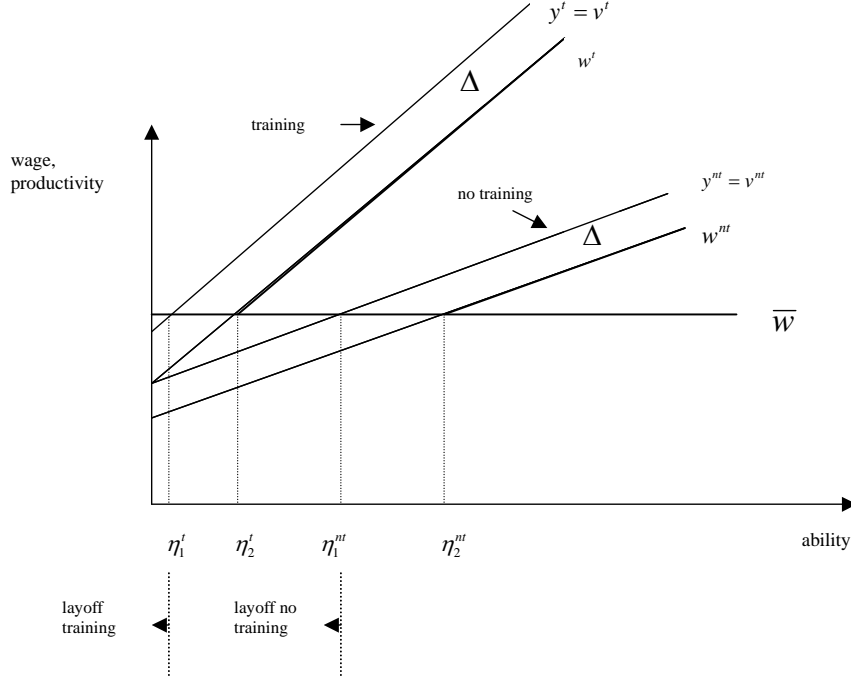
We commence by analysing wage determination in the second period. We then turn to firms' incentives to train. Finally, we analyse the sorting of workers into the unionised and non-unionised sectors.

Wage determination in the second period

Due to the free entry condition, unionised and non-unionised *outside* firms (i.e firms that do not employ a particular trainee) continue to pay wages equal to workers' productivity. Consequently, union agreements do not affect wage determination of *incumbent* non-unionised firms: Since the worker's outside option is unaffected by union agreements and union agreements do not apply to non-unionised firms, non-unionised incumbent firms continue to offer a wage equal to the worker's productivity minus a constant Δ .

However, union wages affect wage offers of unionised incumbent firms. Figure 1 illustrates how wages are set in these firms. In the figure, we consider untrained and trained workers. The wage and productivity of the worker are on the vertical axis, and her revealed ability on the

Figure 1: Wage determination in unionised firms



horizontal axis. Productivity and wages of untrained (trained) workers in the absence of any union agreement are indicated by the panels y^{nt} (y^t) and w^{nt} (w^t). From (1), they are equal to productivity minus a constant, Δ . The horizontal line indicates the union wage \bar{w} . It is useful to distinguish between three groups of workers.

First, consider workers with productivity below the union wage \bar{w} . In the figure these are workers with ability below η_1^t if trained ($\eta_1^t = \frac{\bar{w}}{h(\tau)}$) and η_1^{nt} if untrained ($\eta_1^{nt} = \bar{w}$). Union agreements leave these workers worse off. Unionised firms do not find it profitable to employ them. As there are no firing costs at the end of the apprenticeship, these workers are laid off. They find work in non-unionised firms and earn a wage equal to their productivity. Note that layoffs at the end of the training period occur because employers acquire new information about workers' ability during the training period. If unionised firms had known workers' ability in the first period, workers with an ability below η_1^{nt} (η_1^t) would not have been hired.

Next, consider workers with a productivity above the union wage, but whose wage in the absence of union agreements falls below the union wage. In the figure, this refers to all workers with ability between η_1^t and η_2^t if trained, and η_1^{nt} and η_2^{nt} if untrained. These workers are better

off due to unions, and earn a higher wage than they would in the absence of union agreements. Unionised incumbent firms would want to offer a wage below the union wage. As they are not allowed to do so, the best they can do is to offer just the union wage. Hence, workers with ability between η_1^t and η_2^t (η_1^{nt} and η_2^{nt}) are paid the union wage.

Finally, consider workers whose wage in the absence of union agreements exceeds the union wage. In the figure this applies to all workers with ability above η_2^t if trained, and η_2^{nt} if untrained. These workers are unaffected by union agreements. The union wage is not binding for these workers. They thus earn the same wage as in the absence of union agreements. Note that the probability that a worker turns out to be less able than η_1^t (η_1^{nt}) depends on the worker's expected ability, $\hat{\eta}$.

Training decision in the first period

We now turn to the training decisions of unionised and non-unionised firms in the first period. Wage determination in the first period is discussed in Appendix C. In equilibrium, non-unionised firms offer no training. This is because union agreements have no impact on wage determination of non-unionised firms. The future profit of non-unionised firms is thus the same as in the absence of union agreements, and is not increasing in training (Proposition 1).

Training, however, increases the future profits of unionised firms. An intuitive explanation can be given using figure 1. Consider a worker whose true ability is η_1^{nt} . Without training the firm would make zero profit on this worker. With training, the worker's productivity is higher than the union wage \bar{w} , and the firm makes positive profits. More generally, training increases the rent on all workers with ability between η_1^t and η_2^{nt} . Workers with ability below η_1^t are less productive than the union wage even after training. Workers with ability above η_2^{nt} are unaffected by union wages even without training. Observe that this argument relies on firms making positive profits in the second period. Although non-pecuniary job characteristics are not sufficient to induce firms to sponsor training, they are necessary for unions to have an impact on training.

We now formalise this argument. We first derive an expression for the second period profit of unionised firms. Let $E[\Pi_u(\tau, \eta)|\hat{\eta}]$ denote the future (i.e. second period) profit on a worker with expected ability $\hat{\eta}$. Define η_1 as $\eta_1 h(\tau) = \bar{w}$, i.e. workers with ability below η_1 have a productivity below the union wage. Similarly, define η_2 as $\eta_2 h(\tau) = \bar{w} + \Delta$, i.e. workers with

ability above η_2 are not affected by the union wage. Observe that η_1 and η_2 depend on the worker's training level. Unionised firms lay off workers with ability below η_1 and hence make zero profits on these workers. For workers with ability between η_1 and η_2 , unionised firms earn a rent of $y - \bar{w}$. These workers stay with the unionised firm after apprenticeship graduation with probability $1 - G(y - \bar{w})$. Finally, for workers with ability above η_2 , firms make a profit of $(1 - G(\Delta))\Delta$. Hence, unionised firms maximise

$$\begin{aligned} \max_{\tau} \quad & -c(\tau) + E[\Pi_u(\tau, \eta)|\hat{\eta}] = -c(\tau) + \int_{\eta_1}^{\eta_2} (1 - G(y - \bar{w}))(y - \bar{w})dF_1(\eta|\hat{\eta}) \\ & + (1 - F_1(\eta_2|\hat{\eta}))(1 - G(\Delta))\Delta. \end{aligned}$$

The training level unionised firms offer (in case they decide to train the worker), $\tilde{\tau}_u$, solves¹¹

$$\begin{aligned} c'(\tilde{\tau}_u) &= \frac{\partial E[\Pi_u(\tilde{\tau}_u, \eta)|\hat{\eta}]}{\partial \tau} \\ &= \int_{\eta_1}^{\eta_2} (1 - G(h(\tilde{\tau}_u)\eta - \bar{w}))h'(\tilde{\tau}_u)\eta dF_1(\eta|\hat{\eta}) \\ &\quad - \int_{\eta_1}^{\eta_2} g(h(\tilde{\tau}_u)\eta - \bar{w})(h(\tilde{\tau}_u)\eta - \bar{w})h'(\tilde{\tau}_u)\eta dF_1(\eta|\hat{\eta}). \end{aligned} \tag{2}$$

Training affects profits in two ways. First, training increases the rent on trained workers. This effect is represented by the first term in (2). Second, training decreases the probability that the worker stays with the firm. This effect is captured by the second term in (2). In Appendix B we show the first effect dominates the second effect. Hence, training increases the future profit of unionised firms, i.e. $\frac{\partial E[\Pi_u|\hat{\eta}]}{\partial \tau} \geq 0$ and $\tilde{\tau}_u \geq 0$.

As the productivity of workers in training differs from the productivity of untrained workers, firms do not find it profitable to train every worker. The unionised firm will only offer training if the profit with training exceeds the profit without training. In Appendix B we show that there exist two thresholds which we denote by $\hat{\eta}_1$ and $\hat{\eta}_2$. The unionised firm trains the worker if her expected ability lies in between these two thresholds. The training choice of unionised firms therefore satisfies

$$\tau_u^* = \begin{cases} 0 & \text{if } \hat{\eta} < \hat{\eta}_1 \text{ or } \hat{\eta} > \hat{\eta}_2, \\ \tilde{\tau}_u & \text{if } \hat{\eta}_1 \leq \hat{\eta} \leq \hat{\eta}_2. \end{cases}$$

The intuition for these results is as follows. Recall from figure 1 that training increases future profits only for workers with ability between η_1^t and η_2^{nt} . Consider a worker with very low expected ability. This worker is likely to turn out to be less able than η_1^t . The probability that

¹¹Here, we have used that $y(\tau, \eta_2) = \bar{w} + \Delta$.

she will be laid off after training is therefore very high, and the firm is better off by not training (and not hiring) her. A worker with a very high expected productivity, on the other hand, is likely to turn out to be more able than η_2^{nt} . The probability that this worker will be affected by the union wage is therefore low even without training. Again, training has only a small impact on the firm's future profit. In other words, union agreements compress wages only for workers with a productivity around the union wage, and firms find it most profitable to train these workers. Consequently, the impact of union wage agreements on training is not uniform: Union wages have little or no impact on training for workers with very low and very high (expected) productivity, and the strongest impact for workers with expected productivity around the union wage¹².

Compare the training level unionised firms offer with the socially optimal training level. In the social optimum, the marginal cost of training is equal to the marginal product of training. Since there is a fixed cost of training, only workers with an expected ability above $\hat{\eta}^*$ are trained (see Appendix A for details). Since unionised firms choose training such that their profits are maximised, and ignore the impact of training on the utility of the worker, they offer less training than the socially optimal level. We summarise

Proposition 2 *Under limited commitment non-unionised firms offer no training. Unionised firms train workers with expected ability $\hat{\eta}_1 < \hat{\eta} < \hat{\eta}_2$. These workers are offered a training level of $\tilde{\tau}_u$. Training in unionised firms is less than socially optimal.*

Proof. See appendix B. ■

How can we interpret the result that union wages increase training in the economy? As we discussed in the previous section the reason that - in the absence of unions - the training market breaks down is because firms cannot fully commit to training provision. This problem can in principle be mitigated - though not eliminated - by a long-term wage contract that today specifies not only current but also future wages. In our model, unionised firms offer a particular type of a long-term wage contract: They guarantee to pay at least the union wage in the future. Although firms could offer such a contract without becoming unionised, it is not self-enforceable. Once training is completed, the firm has an incentive to deviate and pay a lower wage than the agreed

¹²Notice that other reasons for firm-financed general training, such as the complementarity between firm-specific and general training, may lead to more training for more able workers. Altonji and Spetzler (1991) find that aptitude and achievement measures positively affect the probability of receiving training.

minimum wage. Hence, the role unions play in our model is that they serve as a commitment device. Unionised firms credibly signal to workers that they will pay at least the agreed union wage in the future ¹³. This then provides an incentive for firms to train workers, and improves welfare in the economy. This argument relies on firms making - ex post - positive profits. In our model this is a consequence of non-pecuniary job characteristics.

Sorting into the unionised sector

Next, we discuss the sorting of workers into the unionised and non-unionised sector in the first period. We provide technical details in Appendix C, and discuss here only the key ideas. A worker bases her decision about which sector to work in on the training level as well as on the first and second period wage unionised and non-unionised firms offer. She chooses to work in the sector in which her utility is higher.

Consider first the impact of training on worker sorting. As it is the firm which bears the training cost, workers are better off if they receive training. Hence, workers for whom union agreements increase the probability of receiving training ($\hat{\eta}_1 < \hat{\eta} < \hat{\eta}_2$) typically prefer to work in the unionised sector. Therefore, workers sort into the unionised sector based on the impact unions have on training.

Second, consider the impact of the worker's expected ability on worker sorting. Suppose unionised and non-unionised firms offer the same training level. Then there exists an ability threshold such that workers with expected ability above this threshold prefer to work in unionised firms. Therefore, more able workers self-select into the unionised sector. The intuition for this result is simple. *Ex post*, workers who will be paid the union wage are better off, while workers who turn out to be less productive than the union wage are worse off when working in the unionised sector¹⁴. Workers with low expected ability are likely to be of lower productivity than

¹³In our model, we have ruled out that firms can change their union status, although this is possible in Germany (and, in fact, important for our identification strategy). Our argument here requires that changing the union status is costly for firms.

¹⁴To see this, consider the second period utility of a worker with productivity lower than the union wage. Recall that y denotes workers' productivity, and w and v denote workers' wage offer from the incumbent and outside firms, respectively. Utility from non-pecuniary job characteristics is captured by θ . If a worker started her job in a non-unionised firm, there is a chance that she will stay with the firm, and her utility is $\Pr(\text{stay})(w + E[\theta|\text{stay}]) + \Pr(\text{move})v = y + \int_{\Delta}^{\bar{\theta}} (\theta - \Delta) dG(\theta)$. If, in contrast, she started her job in a unionised firm, she is forced to leave the firm, and her utility is y .

the union wage, and thus choose to work in non-unionised firms. Note, however, that *ex ante* all workers are better off due to unions. Since a worker can always choose to work in a non-unionised firm, she is guaranteed at least the same payoff as in the absence of union agreements. This is due to our assumption that there are no spill-overs from unionised to non-unionised firms: Wage determination in non-unionised firms is unaffected by unionised firms. Also note that in our model firms are indifferent between becoming unionised or not since both unionised and non-unionised firms make zero profits in the long-run. Compared to non-unionised firms unionised firms make a lower profit in the second period and therefore a lower loss in the first period. There is thus less front-loading in unionised firms.

4 Empirical Implications

We next derive the empirical implications of our model. We begin with training in unionised and non-unionised firms. We then turn to wage compression in unionised and non-unionised firms.

4.1 Training in unionised and non-unionised firms

Our model predicts that non-unionised firms offer no training, while unionised firms offer some training, but less than the socially optimal level. The result that non-unionised firms offer no training hinges on the assumption that union agreements are the only source of wage compression¹⁵. Our key test therefore is whether unionised firms are more likely to train workers in apprenticeship programmes than non-unionised firms. Testing this hypothesis is not straightforward for a number of reasons. First, our model suggests that workers with a higher expected ability self-select into the unionised sector. If more able workers are more likely to receive training, a simple comparison of the mean training intensity in unionised and non-unionised firms will overstate the causal impact of unions on training. Second, our model suggests that the impact of unions on training depends on workers' expected ability, and that workers sort into the unionised sector based on the impact unions have on training. This may lead to an upward bias in the *average* impact unions have on training (i.e. the impact of unions on the training

¹⁵We have abstracted from other sources of wage compression, such as asymmetric information and firm-specific human capital accumulation, in order to focus on the implications of union agreements on training and wage determination.

probability of a randomly selected worker or firm). Finally, the firm’s decision to be unionised may also depend on firm characteristics. If these characteristics are correlated with the firm’s propensity to train, a simple comparison of mean training intensity is again misleading. Our model has nothing to say about the selection of firms into the unionised sector since we have assumed that all firms are identical. Introducing firm heterogeneity into the model would considerably complicate the analysis, and we believe that it would divert from the true focus of this paper, the impact of unions on training. Our empirical analysis, however, discusses a possible selection of firms into the unionised sector.

Our empirical test is based on firm panel data, supplemented by information about the firm’s workforce. Our key identifying variation is changes in firms’ union status over time. We thus analyse whether firms which switch from the non-unionised to the unionised sector increase apprenticeship training. We use a difference in difference estimator, assuming that changes over time are the same in firms that change union status, and in firms that remain non-unionised in both periods, conditional on changes in observed firm characteristics as well as workforce quality within the firm. We present details of our estimator below.

4.2 Wage determination in unionised and non-unionised firms

According to our model, unionised firms offer more training because union wages are binding only in unionised firms, but not in non-unionised firms, leading to wage compression only in unionised firms. We now derive several testable implications of a more compressed wage structure in unionised firms.

Ideally, we would like to compare the union wage that applies in unionised firms and would apply in non-unionised firms were they unionised with the wages these firms actually pay. In principle, the minimum union wage could be constructed for each worker. In practise, however, this turns out to be impossible, due to the excessively large number of co-existing union contracts even within a narrowly defined industry and region, and the lack of sufficiently detailed firm and worker information that classify the applicable union contract¹⁶. Instead, we indirectly test for the presence of wage floors in unionised firms, by deriving easily testable implications of wage floors.

¹⁶Currently, there are more than 50000 valid union contracts in Germany (Hans Boeckler Stiftung 2003).

First, wage floors affect layoffs and wage cuts in unionised and non-unionised firms. Since unionised firms are not allowed to offer wages below the union wage, but are free to lay off workers after training, they fire workers who turn out to be less productive than expected. Non-unionised firms, in contrast, respond to negative productivity shocks by cutting wages. Hence, layoffs should occur more frequently in unionised firms, while wage cuts should be observed more often in non-unionised firms. We test the first implication by comparing the probability of a layoff after training for workers trained in unionised and non-unionised firms. We test the second implication by comparing the probability of a wage cut for workers in unionised and non-unionised firms, separately for different education groups.

Second, wage floors affect the variance of wages in unionised and non-unionised firms for workers who stay with their employer. In Appendix D we show that for stayers, the variance of second period wages w is higher in non-unionised than in unionised firms, conditional on first period wages W :

Proposition 3
$$V^u(w^u|W^u, \text{stay}) \leq V^{nu}(w^{nu}|W^{nu}, \text{stay}).$$

Proof. See appendix D. ■

The reason for this result is that the wage distribution in unionised firms is truncated, as the least able workers leave the unionised sector and others earn exactly the union wage. It is important to condition on first period wages in order to account for the selection of workers into the unionised sector in the first period. We test this implication for workers who have just completed apprenticeship training in unionised and non-unionised firms. We also compare the variance of log-wages, conditional on the previous log-wage, for all stayers in unionised and non-unionised firms, separately for different education groups.

Finally, we would like to point out that our model is consistent with the key implication of an alternative model of wage compression and firm-financed training, asymmetric employer learning (see Acemoglu and Pischke 1998). Asymmetric employer learning implies that less able workers are more likely to leave the training firm. Our model is consistent with this prediction, as unionised firms fire the least able workers¹⁷.

¹⁷However, our model does not unambiguously predict a lower ability of movers in unionised firms. This is because among workers who are paid the union wage, it is the more able workers who are more likely to leave. Figure 1 illustrates this point. Consider a trained worker with ability η_1^t . This worker is offered the same wage

5 Empirical Analysis

5.1 Data sources and sample selection

Our empirical analysis is based on two primary data sources. The first is a panel of firms (the so-called IAB establishment panel) for the years 1996-1999, collected by the Federal Employment Office in Nuremberg. The data contains a rich set of background information on the firm and its workforce, such as the firm's financial situation, industry, geographical location, the firm's training intensity, and whether the firm accepts union wage agreements. The second data source is an administrative data set based on social security records, and provides information on individual workers, including daily wages, age, sex, nationality, education, occupation, as well as whether the worker is in apprenticeship training or not. Like most administrative data sets, the data on wages are top-coded at the highest level of earnings that are subject to social security contributions. The two data sources can be matched through a firm identifier. Appendix E describes the variables we use in more detail. We restrict all the empirical analysis to West-German firms in the private sector.

In the first step of our empirical analysis, we compare the training intensity of unionised and non-unionised firms. Our analysis is based on the firm panel, supplemented with the firm's average workforce characteristics, drawn from the individual administrative records. We match to each firm information on all workers who were employed at that firm at the first of July of each year.

In a second step, we compare the structure of wages in unionised and non-unionised firms. Here, we match the two primary data sources we described above. We create two samples. The first sample consists of all individuals who have been employed as apprentices in the years 1996-1999 in any of the firms in our firm panel. Combination of the two data sources allows us to match to each apprentice the union status of the training firm. We are able to follow these workers from labour market entry onwards (even if labour market entry was before 1996) until 2001. As the data does not distinguish between interns and apprentices, we consider an individual as an apprentice if he/she has been observed for at least 450 consecutive days on a training programme. We further exclude individuals who have had employment spells before starting an apprenticeship, as well as individuals who change firms during their training period.

by the training and outside firms (i.e. \bar{w}). Workers with ability above η_1^t , on the other hand, are offered a higher wage by outside firms than by the training firm, and are thus more likely to leave the training firm.

Furthermore, we restrict our analysis to individuals who are employed full time after the training period. There is a total of 93,669 individuals in our sample who fulfill our criteria. 89,660 individuals have been trained in a unionised firm, and 4,009 individuals in a non-unionised firm.

The second sample consists of all workers who were employed full-time at a firm in the firm panel at the first of July each year and who had less than 11 years of potential labour market experience. We refer to these workers as "young" workers. Workers in training are excluded from this sample. We distinguish between two skill groups: unskilled workers who have no further training after secondary school, and skilled workers who went through apprenticeship training after secondary school. University graduates are not included in our sample. The reason why we focus on young workers without college education is wage censoring, which may severely bias our estimates for the probability of wage drops and the variance of log-wages. Censoring affects 7.72 % of wage spells for all workers with an apprenticeship degree, but only 0.83 % of wage spells for young workers with an apprenticeship degree. For unskilled workers, 1.65 % of all wage spells are top-coded, compared to 0.28 % for young workers. Censoring is most severe for university graduates. Here, 20.33 % of wage spells are top-coded even for young workers. Our final sample consists of 555,743 skilled workers and 55,562 unskilled workers. 30,010 workers are employed in non-unionised firms, and 581,295 in unionised firms.

We define a unionised firm as a firm that either belongs to an employer federation, or engages in bilateral negotiations with the union. We have also performed all the analysis below defining unionisation as membership in an employer federation only. This did not change any of our conclusions, and the results were very similar to those we report below. We define the variables we use for our analysis in Appendix E.

We begin the empirical analysis with a comparison of apprenticeship training in unionised and non-unionised firms. We then turn to the structure of wages in the two types of firms.

5.2 Training in unionised and non-unionised firms

Table 1 displays information on union coverage, the proportion of trainees in unionised and non-unionised firms, and characteristics of firms and their workforce for the years 1996-1999. Entries are weighted so that they are representative for firms.

About 56 percent of all firms are unionised. However, as unionised firms are predominantly large firms, 76 percent of all workers are employed in unionised firms. The first panel of the table

Table 1: Unionised and non-unionised firms

	All		Unionised		Non-Unionised	
Proportion of firms unionised	56.20					
Proportion of workers in unionised firms	76.19					
	Mean	StdD	Mean	StdD	Mean	StdD
Firm trains (in percent)	28.79	<i>45.28</i>	37.59	<i>48.43</i>	17.50	<i>38.01</i>
Proportion trainees (in percent)	8.09	<i>17.98</i>	10.18	<i>19.17</i>	5.42	<i>15.93</i>
Proportion qualified workers	49.03	<i>29.72</i>	52.56	<i>28.43</i>	44.50	<i>30.71</i>
Average age workers	37.22	<i>8.36</i>	36.68	<i>8.06</i>	37.92	<i>8.69</i>
Ratio females	23.84	<i>63.86</i>	24.26	<i>31.21</i>	23.30	<i>89.78</i>
Number of new hires	0.99	<i>6.78</i>	1.16	<i>8.17</i>	0.783	<i>4.38</i>
Size	18.16	<i>125.80</i>	24.62	<i>164.39</i>	9.86	<i>36.60</i>
(Investment/worker)/1000*	18.77	<i>603.39</i>	11.81	<i>322.09</i>	27.66	<i>835.05</i>
(Turnover/worker)/1000*	383.42	<i>1735.44</i>	450.76	<i>2086.94</i>	294.61	<i>1107.63</i>
Daily Average Wage	88.73	<i>46.0</i>	93.74	<i>43.5</i>	82.29	<i>48.2</i>
Proportion young firms (≤ 5)	20.67	<i>40.49</i>	19.22	<i>39.40</i>	22.52	<i>41.78</i>
Proportion old firms (≥ 30)	30.08	<i>45.86</i>	36.85	<i>48.24</i>	21.39	<i>41.01</i>
Profit evaluation good/very good	30.07	<i>45.86</i>	28.24	<i>45.02</i>	32.42	<i>46.81</i>
Profit evaluation bad	9.77	<i>29.69</i>	9.03	<i>28.67</i>	10.72	<i>30.94</i>

Firm data and matched worker characteristics, 1996-1999. Entries are weighted so that they are representative for firms.

*: In 1996 German Marks

presents two measures of apprenticeship training intensity: whether the firm trains at all, and the proportion of apprentices on the firm's work force. The first variable comes from the firm panel survey; managers were asked whether the firm trains any workers on apprenticeship programmes. The second variable is obtained by aggregating all workers from the administrative records in each of the firms in our panel, and computing the ratio of apprentices to total workforce.

Overall, 29 percent of all firms train workers in apprenticeship programmes. Non-unionised firms are engaged in apprenticeship training, but unionised firms are considerably more likely to train than non-unionised firms (38 percent vs. 17.5 percent). Likewise, the proportion of apprentices is about twice as high in unionised than in non-unionised firms (10.18 percent vs 5.42 percent). The differences between unionised and non-unionised firms are highly statistically significant.

Such simple comparisons are likely to overstate the causal impact of unions on training for various reasons. First, as implied by our model, more able workers sort into the unionised sector, and may also be more likely to receive training. Table 1 illustrates that selection of workers into unionised firms is potentially important, as unionised firms employ considerably more qualified workers. Second, unionised firms may differ from non-unionised firms in characteristics that affect their training intensity. Our theoretical model abstracts from firm heterogeneity. In the

empirical analysis we take into account a possible selection of firms into the unionised sector. Table 1 illustrates that this is of potential concern: Unionised firms are considerably larger and older than non-unionised firms. There is also some evidence that turnover per worker is higher in unionised firms, while investment per worker and firms' evaluation of profits are higher in non-unionised firms. Unionised firms have hired more workers in the previous year, which may be explained by their larger average size. Workforce characteristics with respect to age and the female ratio are fairly similar between unionised and non-unionised firms.

To take account of heterogeneity in observable worker and firm characteristics, we regress our training indicators on a set of firm characteristics, characteristics of the firm's workforce, and year and geographical dummies, in addition to the firm's union status. We include in our regressions the number of overall new hires, the log firm size, the revenue per worker, the total investment per worker, the age of the firm, self-reported evaluation of current profitability, and industry- and region dummies. Furthermore, we control for the proportion of highly qualified workers, the proportion of female workers as well as the average age and wage of the firm's workforce. These variables are computed for each firm from the social security records by aggregating up all workers for the respective firm, and matched to our sample of firms. This set of firm's background information should absorb a lot of variation that is correlated with training intensity and union status alike.

In table 2 we present results where we regress the binary variable whether the firm trains and the firm's proportion of apprentices on the union status as well as all the variables mentioned above. The table shows the coefficients on the union status variable. Controlling for observables reduces the impact of union status on training, compared with the difference in sample means in table 1. However, the effect remains strong, and is highly significant. Unionised firms are about 11 percentage points more likely to train than non-unionised firms; the proportion of apprentices in unionised firms is 3.2 percentage points higher than in non-unionised firms.

Although we condition on a wide variety of observable worker and firm characteristics, the coefficient on the firm's union status may still be biased due to selection on unobservable firm and worker characteristics. To address this problem, we utilise the variation in union status over time. There is considerable variation in this variable. Over the course of the panel, 11.6 percent (1602) of firms change their union status once, 4.8 percent twice, and 0.4 percent three times. We discard in the following those firms that change the union status more than once.

Table 2: The effect of unionisation on training

	<u>Firm trains</u>		<u>Proportion apprentices</u>	
	Coef	StdE	Coef	StdE
Firm unionised	0.1151	<i>0.0121</i>	0.0322	<i>0.0031</i>
No Obs	10634		10634	
No Unionised	8221		8221	

OLS regression results. Firm panel, matched with employee information, 1996-1999. All regressions include time dummies, firm size, investment per worker, revenue per worker, number of new hires, profit evaluation, age of the firm, the proportion of qualified workers in the firm, the average age of workers, the average daily wage of workers, the proportion of females, and industry and state dummies.

Of those firms that change the union status once, 73.3 percent (1174 firms) change from being unionised to being non-unionised, and 26.7 percent (428 firms) from being non-unionised to being unionised.

Figures 2 and 3 plot the proportion of apprentices as well as the probability that a firm trains by the number of years before and after the change in union status, for firms that change from being non-unionised to being unionised (NU-U), and for firms that change from being unionised to non-unionised (U-NU). The figures suggest that firms change their training policy when they change their status: The fraction of apprentices increases when firms change from being non-unionised to being unionised, and it decreases for firms that change from being unionised to non-unionised. Likewise, the probability to train increases for firms that change from being non-unionised to being unionised; it slightly decreases for firm that change from being unionised to being non-unionised.

For comparison, we plot in figures 4 and 5 the training intensity and the probability of providing training against time for firms that are unionised and non-unionised for the entire observation period. Both the training intensity and the training probability remain basically constant, with a large difference between unionised and non-unionised firms, as suggested in table 1.

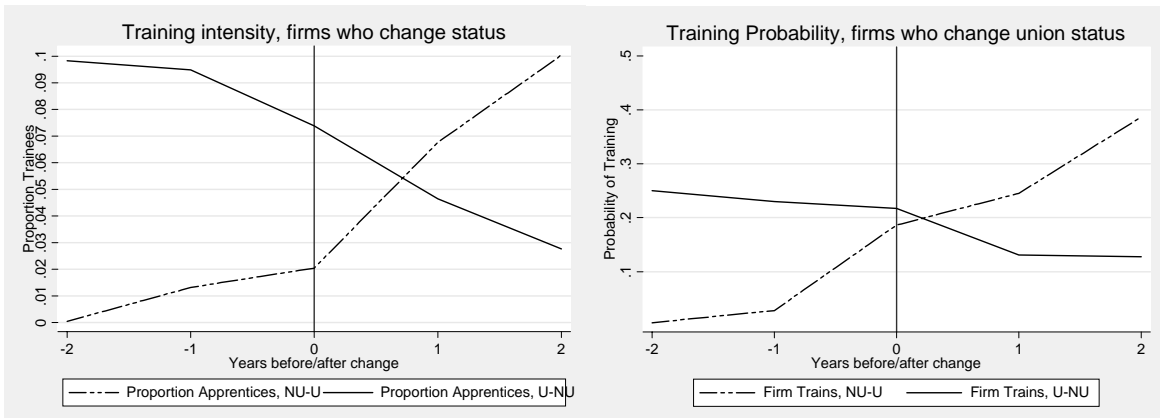


Figure 2: Proportion of Apprentices

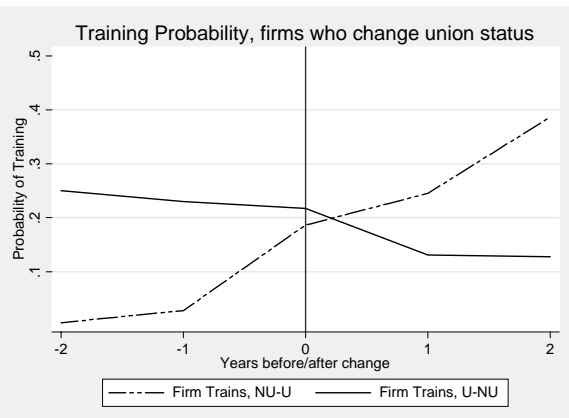


Figure 3: Probability that firm trains

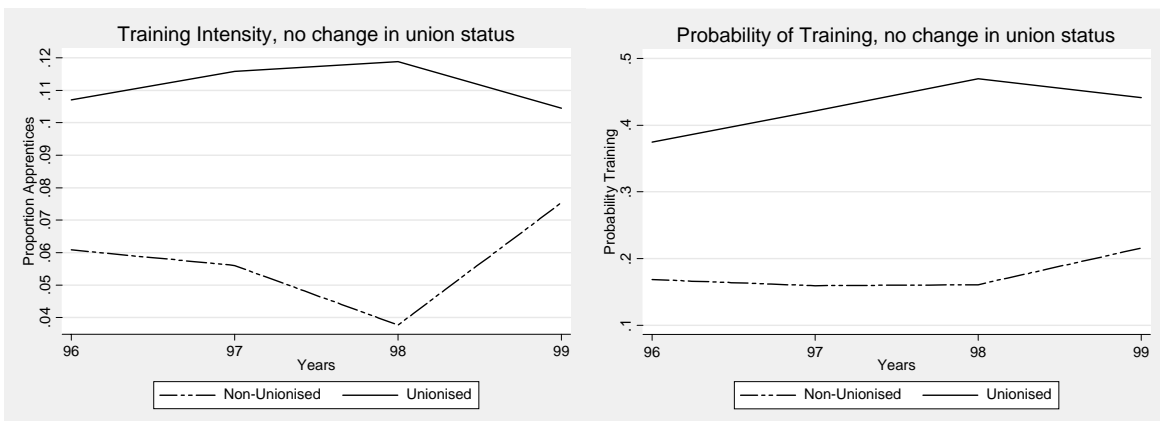


Figure 4: Proportion of Apprentices

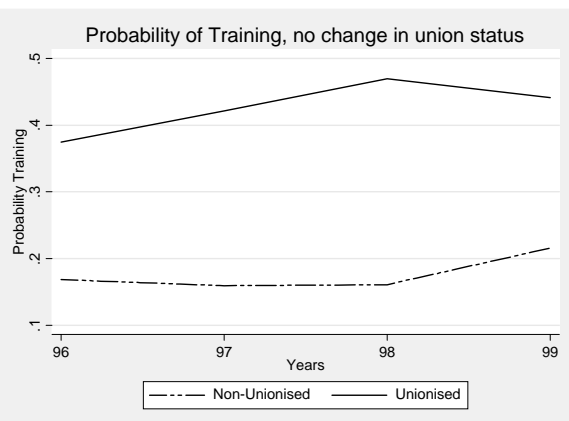


Figure 5: Probability that firm trains

We now describe our estimation strategy and highlight the assumptions that allow us to identify the causal impact of unions on training. Define \bar{y}_{jt} as the proportion of apprentices at time t in firm j . The proportion of workers in apprenticeship programmes depends on the union status of the firm U_{jt} , a time effect θ_t , observed and unobserved average worker characteristics, $\bar{\eta}_{jt}$, as well as observed and unobserved firm characteristics, f_{jt} . Both $\bar{\eta}_{jt}$ and f_{jt} are defined as deviations from the population mean. Assuming linearity, this relationship can be written as

$$\bar{y}_{jt} = \beta + \lambda_{jt} U_{jt} + \theta_t + \bar{\eta}_{jt} + f_{jt} + v_{jt}, \quad (3)$$

where v_{jt} is an i.i.d. error term. A simple difference estimator (as displayed in the above figures) may confound the causal effect of unionisation on training with common time effects, changes in firm characteristics, as well as changes in the composition of the workforce. We assume that changes in common time effects ($\Delta\theta_t$) are the same in firms that are not unionised in both time periods, and in firms that change from being non-unionised to being unionised, conditional on

changes in observables. Furthermore, we assume that any variation in changes in the workforce ($\Delta \bar{\eta}_{jt}$) and firm quality (Δf_{jt}) that are correlated with changes in the union status are absorbed by changes in observed worker and firm characteristics. These assumptions imply that

$$\begin{aligned} & \mathbb{E}(\Delta \theta_t + \Delta \bar{\eta}_{jt} + \Delta f_{jt} + \Delta v_{jt} | U_{jt} = 0, U_{jt-1} = 0, \Delta X_{jt}) \\ &= \mathbb{E}(\Delta \theta_t + \Delta \bar{\eta}_{jt} + \Delta f_{jt} + \Delta v_{jt} | U_{jt} = 1, U_{jt-1} = 0, \Delta X_{jt}), \end{aligned}$$

where X_{jt} is a vector of observed characteristics of the firm's workforce as well as observed firm characteristics. Under these assumptions, a difference-in-difference estimator identifies:

$$\begin{aligned} & \mathbb{E}(\bar{y}_{jt} - \bar{y}_{jt-1} | U_{jt} = 1, U_{jt-1} = 0, \Delta X_{jt}) - (\bar{y}_{jt} - \bar{y}_{jt-1} | U_{jt} = 0, U_{jt-1} = 0, \Delta X_{jt}) = \\ & \mathbb{E}(\lambda_{jt} | U_{jt} = 1, U_{jt-1} = 0, \Delta X_{jt}). \end{aligned}$$

This is the impact of unionisation on training for those firms that choose to become unionised. We could also define firms that are unionised in both periods as an alternative comparison group. This yields the same estimate if $\mathbb{E}(\lambda_{jt} - \lambda_{jt-1} | U_{jt} = 1, U_{jt-1} = 1, \Delta X_{jt}) = 0$.

Table 3: The effect of unionisation on training: Diff-in-Diff/Matching Estimation

Comparison Group	Change Nonunion-Union				Change Union-Nonunion			
	Coef	StdE	Coef	StdE	Coef	StdE	Coef	StdE
	NU-NU		U-U		NU-NU		U-U	
Proportion Apprentices	0.0267	0.0104	0.0306	0.0067	0.0071	0.0059	0.0032	0.0041
Firm Trains	0.0677	0.0327	0.0657	0.0297	-0.0015	0.0192	0.0020	0.0181
	1100		1513		4478		4891	

Source: Firm panel, matched with employee information, 1996-1999. All regressions include time dummies, and changes in: firm size, investment per worker, revenue per worker, number of new hires, evaluation of profit, the proportion of qualified workers, the average age of workers, the average daily wage, and the proportion of females.

We present our results in table 3. All regressions include time dummies, changes in firm size, investment per worker, revenue per worker, number of new hires, and evaluation of profit; furthermore, changes in the proportion of qualified workers, the average age of workers, the average daily wage, and the proportion of females. The first two pairs of columns report results for firms that change from being non-unionised to being unionised, and the second two pairs of columns firms that change from being unionised to being non-unionised. Entries under $NU - NU$

use firms that are non-unionised in both periods as the comparison group; this corresponds to the specification above. Entries under $U - U$ use firms that are unionised in both periods as the comparison group.

Estimates in the first pair of columns show that firms that change from being non-unionised to being unionised increase their probability of training as well as their proportion of apprentices relative to firms that are always non-unionised. Both differences are significant. These results suggest that the difference in training probability between being unionised and non-unionised for those firms that choose to be unionised is 6.8 percentage points, and the difference in the proportion of apprentices is 2.7 percent. Results are very similar when firms that are always unionised are used as a comparison group (second pair of columns). Overall, these results support the hypothesis that unionisation affects training positively.

The last two pairs of columns refer to firms that change into the opposite direction: from being unionised to being non-unionised. Results here are less conclusive; parameter estimates are very small and generally insignificant. One explanation is that the possibility of adaption is quite limited, as apprenticeship programmes last usually three years. Our window of four years (with many changes taking place in the last two years) may not allow us to assess the full extent to which these firms adapt.

5.3 Wage determination in unionised and non-unionised firms

According to our model, the reason why unionised firms offer more training is that union wages are binding only in unionised firms, but not in non-unionised firms, leading to a more compressed wage structure in unionised firms. This section provides empirical evidence that wage floors and wage compression indeed play a more important role in unionised firms. We begin with a comparison of the probability of a layoff and a wage cut in unionised and non-unionised firms. We then turn to the variance of wages for job stayers in the two types of firms.

Layoffs in unionised and non-unionised firms

If wage floors play a more important role in unionised than in non-unionised firms, then we should observe more layoffs in unionised firms. In this section, we compare the probability of a layoff after apprenticeship training in the two types of firms, using our sample of workers who completed apprenticeship training in one of the firms in our firm panel. We would like

to remind the reader that in Germany, there are no firing costs after apprenticeship training. Hence, any differences in layoff rates between unionised and non-unionised firms will not be driven by differences in firing costs.

We do not observe whether workers who leave the training firm were laid off or left the firm because they received a better offer. We do, however, observe whether workers experience an unemployment spell after leaving the training firm, and we use this as a proxy for a layoff. In our sample, 27.27% of apprentices leave their training firm at the end of the training period. Of those, 34 % experience an unemployment spell. On average, unemployment spells last for 134 days, with a median duration of 74 days.

Table 4 reports results from linear probability models. Reported coefficients are the impact of the firm's union status on the probability that a trainee leaves the training firm (panel 1), and on the probability that he/she becomes unemployed (panel 2). Results in the first pair of columns include time dummies only. Estimated coefficients indicate that - contrary to our hypothesis - the probability of changing the firm after apprenticeship training as well as the probability of a job-to-unemployment transition is significantly higher for workers who were trained in non-unionised firms. One explanation for this finding is worker sorting. Our model implies that more able workers select into unionised firms. More able workers may also be less likely to become unemployed after apprenticeship training, even in the absence of wage floors¹⁸. In a recent paper on the German apprenticeship system, von Wachter (2002) provides convincing evidence that apprentices who leave the training firm are of lower ability than workers who stay with the training firm. This indicates that worker selection may potentially bias our results. In order to account for worker selection into training firms and unemployment, we control for the size of the training firm, as well as worker characteristics (column 2). The size of both coefficients decrease substantially, but remain positive and statistically significant.

In order to eliminate all remaining differences in firm and worker quality, we finally add fixed training firm effects (column 3), exploiting variation in the firm's union status over time. This eliminates the difference in the overall turnover rate between unionised and non-unionised firms. Moreover, we now find a significantly higher job-to-unemployment transition rate in unionised firms. The estimate indicates that unionisation increases the probability of becoming unemployed after apprenticeship training by 2.7 percentage points, or nearly 10 percent. These

¹⁸There are several theoretical models that predict a lower ability of job-to-unemployment movers, including the asymmetric information model by Gibbons and Katz (1992), and the search model by Moscarini (2003).

Table 4: Probability of moving and experiencing unemployment after training

	<u>Probability of moving</u>					
	Coef	StdE	Coef	StdE	Coef	StdE
Training firm non-unionised	0.0636	<i>0.0071</i>	0.0138	<i>0.0070</i>	-0.0004	<i>0.0130</i>
Time dummies	Yes		Yes		Yes	
Size training firm/worker characteristics ^a	No		Yes		Yes	
Fixed Training firm effects	No		No		Yes	
No. Observations	93669		90881		90881	
No. Movers	25547		24607		24607	

	<u>Probability of moving to unemployment</u>					
	Coef	StdE	Coef	StdE	Coef	StdE
Training firm non-unionised	0.0493	<i>0.0047</i>	0.0190	<i>0.0046</i>	-0.0265	<i>0.0089</i>
Time dummies	Yes		Yes		Yes	
Size training firm/worker characteristics ^a	No		Yes		Yes	
Fixed Training firm effects	No		No		Yes	
No. Observations	93669		90881		90881	
No. Non-Employment Spells	8809		8489		8489	

Linear Probability Models. Sample refers to movers and stayers. Reported parameters: Marginal effects.

^a: Includes age and age squared, gender, the log of the apprenticeship duration, a dummy for lower secondary degree and intermediate secondary degree (higher secondary degree is reference category).

results suggest that worker sorting into unionised and non-unionised firms takes place, and, more importantly, that layoffs after training occur more frequently in firms that become unionised. These results also cast some doubt on an alternative explanation for why unions increase training, a lower turnover rate in unionised firms. This explanation has been suggested by, among others, Booth et al. (2003) who argue unions provide a more pleasant work environment¹⁹, and thus reduce turnover, which in turn makes it more profitable for unionised firms to train.

Wage cuts in unionised and non-unionised firms

A further consequence of wage floors is that wage cuts should be observed more frequently in non-unionised firms. We test this implication by comparing the probability of a wage cut in unionised and non-unionised firms for workers who stay with the same employer between two successive periods. We define a variable that is equal to 1 if the workers' real wage decreases from one period to the other by at least 5 %, and 0 otherwise. In our sample 7.27 % of workers experience a wage decrease of at least 5%. We do not include smaller wage decreases as they may reflect measurement error rather than actual wage cuts. However, our results are robust to alternative definitions of wage cuts.

Table 5 reports the marginal effect of the firm's union status on the probability of a wage cut from a probit regression. In line with our hypothesis, the incidence of a wage cut is significantly higher in non-unionised than in unionised firms for both skilled and unskilled workers, conditional on several worker and firm characteristics. The difference between unionised and non-unionised firms is substantial, given the low overall incidence of wage cuts in our sample. Interestingly, the impact of the firm's union status on the probability of a wage cut is stronger for unskilled workers than for skilled workers (4 versus 2 percentage points), i.e. for the group of workers for which we expect the union wage to be most binding. This difference is statistically significant at the 10 % level (t-statistic of 1.86).

Variance of log-wages in unionised and non-unionised firms

Wage floors also affect the variance of wages. From proposition 3, the variance of wages should be higher in non-unionised than in unionised firms, conditional on wages in the previous period and on staying. We test this implication first for workers who have just completed apprenticeship

¹⁹This claim has been made by, among others, Freeman and Medoff (1984).

Table 5: Probability of wage cuts, by education group

	<u>Unskilled</u>		<u>Skilled</u>	
	Coef	StdE	Coef	StdE
Unionised	-0.040	<i>0.0100</i>	-0.021	<i>0.0020</i>
No. observations	20584		288590	

Dependent variable: Indicator variable, being equal to one if real wage of a worker dropped between two successive periods within the same firm. Reported coefficients are marginal effects of the firm’s union status from a probit regression. Regressions are separately estimated for the two education groups. Results refer to all full time employees with less than 11 years of potential experience who were employed in one of the firms in the firm panel for two consecutive periods. Regressions include potential labour market experience and its square, gender, log firm size, year dummies, a dummy for metropolitan area, and 13 industry dummies.

training. We then repeat the analysis for all young workers, distinguishing between the skilled and the unskilled.

For apprentices, we compute the conditional variance of log-wages as follows. First, we regress the log-wage after apprenticeship completion on the last log-wage as an apprentice as well as on worker and firm characteristics. We do this separately for workers who were trained in unionised and non-unionised firms, and restrict the analysis to apprentices who stay with their training firm. We then compute the variance of the residual for workers trained in unionised and non-unionised firms.

Table 6 reports results. The estimates confirm our hypothesis that the conditional variance of log-wages is higher for workers trained in non-unionised firms (0.0537 vs 0.0783, or a 30 percent difference). This difference is statistically significant at the 5 percent level.

We next repeat the analysis for all workers with less than 11 years of potential experience who remain with the same firm in two subsequent periods. Here, we regress current log-wages on the previous log-wage as well as on a similar set of control variables as before, separately for workers employed in unionised and non-unionised firms. We again find a higher residual variance in non-unionised firms, for both unskilled and skilled workers. However, these differences are not significantly different from zero.

We have also compared other commonly used measures for wage compression in unionised and non-unionised firms. Although they do not directly follow from our model, we believe that they

Table 6: The variance of log-wages for stayers, by education group

	<u>apprentices</u>			<u>young workers</u>					
	U	NU	Δ	<u>unskilled</u>			<u>skilled</u>		
				U	NU	Δ	U	NU	Δ
Variance									
residual log wage	0.0537	0.0784	-0.0247	0.0116	0.0176	-0.0060	0.0079	0.0105	-0.0026
StdE.	<i>0.0022</i>	<i>0.0139</i>	<i>0.0113</i>	<i>0.0011</i>	<i>0.0043</i>	<i>0.0044</i>	<i>0.0006</i>	<i>0.0017</i>	<i>0.0018</i>
No. of observations	61358	2495		19361	1223		278097	10493	

The table shows the residual variance of log-wages in unionised and non-unionised firms. The first set of columns refers to workers who completed an apprenticeship between 1996 and 1999 in one of the firms in our firm panel and stayed with the training firm. The second set of columns refers to all full time employees with less than 11 years of potential experience who were employed in one of the firms in the firm panel for two consecutive periods. Regressions are separately estimated for the two education groups. Regressions include potential labour market experience and its square (age in the case of apprentices), log firm size, year dummies, a dummy for metropolitan area, and 13 industry dummies. For apprentices, regressions additionally include the log of the length of apprenticeship duration.

add further support to our hypothesis that the reason why unionised firms offer more training is a more compressed wage structure. We find that not only the variance of log wages, conditional on the previous wage and staying, but also the variance of log wages, unconditional on the previous wage and staying, is considerably lower in unionised firms. This holds both for the total and the within-firm variance. Moreover, the return to apprenticeship training is strikingly larger in non-unionised firms. Put differently, the union-non-union wage differential, conditional on a variety of firm and worker characteristics, is substantially larger for unskilled workers than for workers with an apprenticeship degree (13 percent vs. 4 percent). Returns to (potential) experience are likewise significantly higher in non-unionised firms. Overall, these results demonstrate that wage determination differs substantially between unionised and non-unionised firms in a manner that is consistent with the idea that wage floors and wage compression are more important in unionised firms.

6 Discussion and Conclusion

This paper tests the hypothesis that unions, by imposing wage floors that lead to wage compression, increase training in the economy. Our investigation focuses on Germany which provides an interesting context to test this hypothesis, due to its large scale apprenticeship programme and its unique collective bargaining system based on voluntary union recognition. Our empirical results indicate that unionised firms are substantially more likely to train. We also find considerable evidence that wage floors and wage compression play a more important role in unionised than in non-unionised firms. These results are consistent with the idea that unions move training closer to the socially optimal level, as they help to overcome one particular type of market failure, the infeasibility of long-term contracts. Thus, one role unions may play in Germany is that they serve as a commitment device, by guaranteeing workers at least the union wage in the future.

It is important to point out that we have purposely abstracted from alternative explanations for firm-financed training, such as the complementarity between general and firm-specific human capital accumulation (Acemoglu and Pischke (1999b), Franz and Soskice (1995) and Stevens (1994)), and asymmetric information with respect to incumbent and outside firms (Acemoglu and Pischke (1998)). We have done so in order to focus on the impact of unions on training. Clearly, our results do not imply that unions are the only reason for apprenticeship training in Germany. On the contrary, our finding that non-unionised firms also train workers in apprenticeship programmes suggest that firm-specific human capital or asymmetric information may also contribute to firm-financed apprenticeship training.

7 Appendix

A Socially optimal training

At the social optimum the marginal cost of training is equal to the marginal product of training:

$$\int_{-\infty}^{\infty} h'(\tilde{\tau})\eta dF_1(\eta|\hat{\eta}) = c'(\tilde{\tau}).$$

The assumptions on the cost and production function ensure that the second order condition is satisfied. As the productivity of workers during training is smaller than the productivity of untrained workers (fixed cost of training), it is not optimal to train every worker. A worker should only be trained if her productivity when trained exceeds her productivity when not trained, i.e. if

$$\int_{-\infty}^{\infty} h(\tilde{\tau})\eta dF_1(\eta|\hat{\eta}) - c(\tilde{\tau}) - k - \int_{-\infty}^{\infty} \eta dF_1(\eta|\hat{\eta}) \geq 0. \quad (4)$$

We next show that only workers with expected ability above $\hat{\eta}^*$ are trained. Totally differentiating the left hand side of (4) with respect to $\hat{\eta}$ yields

$$\int_{-\infty}^{\infty} (h(\tilde{\tau}) - 1)dF_1(\eta|\hat{\eta}) > 0$$

due to the complementarity between ability and training. There thus exists an ability threshold $\hat{\eta}^*$ such that all workers with expected ability greater than $\hat{\eta}^*$ are trained, where $\hat{\eta}^*$ is implicitly defined as

$$\int_{-\infty}^{\infty} h(\tilde{\tau})\eta dF_1(\eta|\hat{\eta}^*) - \int_{-\infty}^{\infty} \eta dF_1(\eta|\hat{\eta}^*) = c(\tilde{\tau}) + k.$$

The socially optimal training level τ^* therefore satisfies

$$\tau^* = \begin{cases} 0 & \text{if } \hat{\eta} < \hat{\eta}^*, \\ \tilde{\tau} & \text{if } \hat{\eta} \geq \hat{\eta}^*. \end{cases}$$

B Proof of proposition 2

Proposition 2 *Under limited commitment non-unionised firms offer no training. Unionised firms train workers with expected ability $\hat{\eta}_1 < \hat{\eta} < \hat{\eta}_2$. These workers are offered a training level of $\tilde{\tau}_u$. Training in unionised firms is less than socially optimal.*

We first show that the future profit of the unionised firm, $E[\Pi_u(\tau, \eta)|\hat{\eta}]$, is increasing in

training. The increase in $E[\Pi_u(\tau, \eta)|\hat{\eta}]$ due to training equals

$$\begin{aligned} \frac{\partial E[\Pi_u(\tau, \eta)|\hat{\eta}]}{\partial \tau} &= \int_{\eta_1}^{\eta_2} (1 - G(h(\tau)\eta - \bar{w}))h'(\tau)\eta dF_1(\eta|\hat{\eta}) \\ &\quad - \int_{\eta_1}^{\eta_2} g(y(\tau, \eta) - \bar{w})(h(\tau)\eta - \bar{w})h'(\tau)\eta dF_1(\eta|\hat{\eta}). \end{aligned}$$

Recall that for workers with expected ability between η_1 and η_2 the union wage is higher than the wage the firm would choose optimally. Hence, from the first order condition of the second period wage, $1 - G(y - \bar{w}) \geq g(y - \bar{w})(y - \bar{w})$. Consequently, $\frac{\partial E[\Pi_u(\tau, \eta)|\hat{\eta}]}{\partial \tau} \geq 0$, and $\tilde{\tau}_u \geq 0$.

We next show that only workers with expected ability between $\hat{\eta}_1$ and $\hat{\eta}_2$ are trained. A unionised firm trains if profits with training exceed profits without training, i.e. if

$$E[\Pi_u(0, \eta)|\hat{\eta}] < -c(\tilde{\tau}_u) - k + E[\Pi_u(\tilde{\tau}_u, \eta)|\hat{\eta}].$$

As $\frac{\partial E[\Pi_u(\tau, \eta)|\hat{\eta}]}{\partial \tau} \geq 0$, $E[\Pi_u(0, \eta)|\hat{\eta}] \leq -c(\tilde{\tau}_u) + E[\Pi_u(\tilde{\tau}_u, \eta)|\hat{\eta}]$. Hence, if the fixed cost of training is equal to 0, ($k = 0$), every worker would get trained. Figure 6 plots the firm's profit with and without training as a function of the worker's expected ability. The firm's profit is increasing in the worker's expected ability, $\hat{\eta}$. It is first convex, then concave in $\hat{\eta}$. To prove this, we first show that $E[\Pi_u(\tau, \eta)|\hat{\eta}]$ is increasing in workers' expected ability. Differentiating $E[\Pi_u(\tau, \eta)|\hat{\eta}]$ with respect to $\hat{\eta}$ yields

$$\frac{\partial E[\Pi_u(\tau, \eta)|\hat{\eta}]}{\partial \hat{\eta}} = \int_{\eta_1}^{\eta_2} \{(1 - G(y - \bar{w})) - g(y - \bar{w})(y - \bar{w})\}h'(\tau)\eta dF_1(\eta|\hat{\eta}) > 0.$$

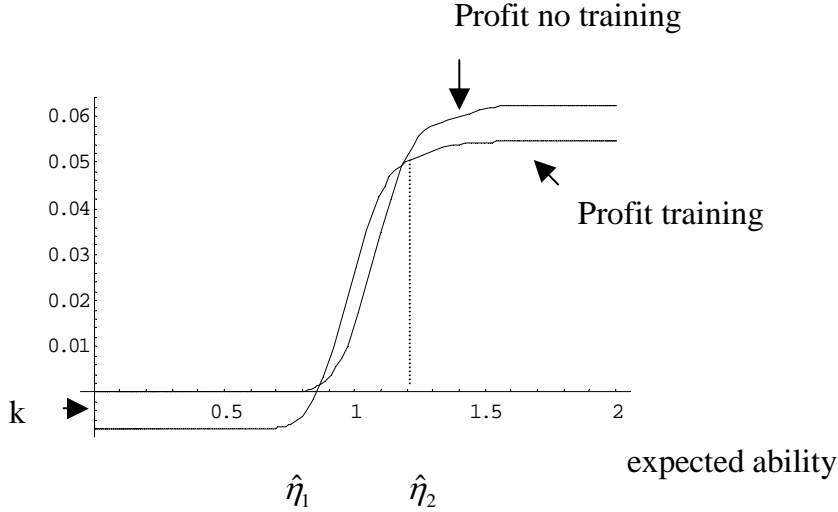
We next show that Π_u is first convex and then concave in $\hat{\eta}$. Taking the second derivative yields

$$\frac{\partial^2 E[\Pi_u(\tau, \eta)|\hat{\eta}]}{\partial \hat{\eta}^2} = \int_{\eta_1}^{\eta_2} \{(1 - G(y - \bar{w})) - g(y - \bar{w})(y - \bar{w})\}h'(\tau)\eta \frac{\partial f_1(\eta|\hat{\eta})}{\partial \hat{\eta}} d\eta.$$

Observe that $\frac{\partial f_1(\eta|\hat{\eta})}{\partial \hat{\eta}} > 0$ if $\hat{\eta} < \eta$, and $\frac{\partial f_1(\eta|\hat{\eta})}{\partial \hat{\eta}} < 0$ if $\hat{\eta} > \eta$. Hence, the second derivative is positive for low and negative for high values of $\hat{\eta}$. $E[\Pi_u(\tau, \eta)|\hat{\eta}]$ is first convex, then concave in $\hat{\eta}$. Note that $\lim_{\hat{\eta} \rightarrow -\infty} E[\Pi_u(\tau, \eta)|\hat{\eta}] = 0$: For a worker with very low expected ability, the probability of being more productive than the union wage is 0, independently of her training level. Furthermore, $\lim_{\hat{\eta} \rightarrow \infty} E[\Pi_u(\tau, \eta)|\hat{\eta}] = (1 - G(\Delta))\Delta$: For a worker with very high ability, the probability of being sufficiently productive so that the union wage is not binding is 1, independently of her training level. Hence, when workers' expected ability is very low, profits without training exceed profits with training by k . Similarly, when workers' expected ability is very high, profits without training also exceed profits with training by k . Consequently, there

are two ability thresholds $\hat{\eta}_1$ and $\hat{\eta}_2$ such that expected profits with training exceed expected profits without training if $\hat{\eta}_1 < \hat{\eta} < \hat{\eta}_2$. See figure 6 for an illustration²⁰.

Figure 6: Profit with and without training by expected ability



We next show that unionised firms offer less training than the socially optimal level. At the socially optimal level, $cI(\tilde{\tau}) = \frac{\partial E[h(\tilde{\tau})\eta|\hat{\eta}]}{\partial \tau}$, while the training level unionised firms offer satisfies $cI(\tilde{\tau}_u) = \frac{\partial E[\Pi_u(\tilde{\tau}_u, \eta)|\hat{\eta}]}{\partial \tau}$. It is easy to see that $\frac{\partial E[y(\tilde{\tau})\eta|\hat{\eta}]}{\partial \tau} > \frac{\partial E[\Pi_u(\tilde{\tau}_u, \eta)|\hat{\eta}]}{\partial \tau}$. Hence, unionised firms offer a lower training level than the socially optimal level.

Wage determination in the first period It remains to analyse wage determination in the first period. Wages in the first period are determined by the firm's zero profit condition. Since union agreements do not affect profits and wage determination in non-unionised firms, non-unionised firms offer the same first period wage as in the absence of union agreements. Hence,

$$W_{nu} = \hat{\eta} + (1 - G(\Delta))\Delta. \quad (5)$$

²⁰Note that if the fixed costs of training, k , are high, it may be optimal not to train any worker.

The wage offer of unionised firms can be similarly derived as

$$W_u = \begin{cases} \min\{\bar{w}, \hat{\eta} + E[\Pi_u(0, \eta)|\hat{\eta}]\} & \text{if } \hat{\eta} < \hat{\eta}_1 \text{ or } \hat{\eta} > \hat{\eta}_2 \text{ (no training).} \\ \hat{\eta} - k + E[\Pi_u(\tilde{\tau}_u, \eta)|\hat{\eta}] - c(\tilde{\tau}_u) & \text{if } \hat{\eta}_1 \leq \hat{\eta} \leq \hat{\eta}_2 \text{ (training).} \end{cases} \quad (6)$$

It is now apparent that firms bear the training cost. As the unionised firm only trains if the profit with training, $-k + E[\Pi_u(\tilde{\tau}_u, \eta)|\hat{\eta}] - c(\tilde{\tau}_u)$, exceeds the profit without training, $E[\Pi_u(0, \eta)|\hat{\eta}]$, the worker's training wage is higher than her first period wage would be without training.

C Worker sorting into the unionised sector

A worker chooses to work in the unionised sector if her utility from working in the unionised sector exceeds that from working in the non-unionised sector. Recall that non-unionised firms offer no training, while unionised firms offer τ_u^* . Hence,

$$W_u(\tau_u^*, \hat{\eta}) + E[U_u(\tau_u^*, \eta)|\hat{\eta}] \geq W_{nu}(0, \hat{\eta}) + E[U_{nu}(0, \eta)|\hat{\eta}],$$

where $W_j(\tau_j, \hat{\eta})$, $j = u, nu$ denotes the worker's first period wage in a unionised or non-unionised firm, and $E[U_j(\tau_j^*, \eta)|\hat{\eta}]$, $j = u, nu$ denotes her second period utility when working in a unionised or non-unionised firm in the first period. We first derive the worker's second period utility when working in a non-unionised firm in the first period, $E[U_{nu}(0, \eta)|\hat{\eta}]$. If the worker leaves her employer, she is paid a wage equal to her productivity, $y(0, \eta)$. If she stays, her utility is equal to the wage the incumbent firm offers, $\eta - \Delta$, plus the draw of non-pecuniary job characteristics, θ . The worker stays if $\theta > \Delta$. Hence, the worker's expected utility in the second period equals

$$E[U_{nu}(0, \eta)|\hat{\eta}] = \hat{\eta} + \int_{\Delta}^{\bar{\theta}} \theta - \Delta dG(\theta).$$

Using that the worker's first period wage equals $W_{nu}(0, \eta) = \hat{\eta} + (1 - G(\Delta))\Delta$ (expression (5)), her utility from working in a non-unionised firm can be computed as

$$W_{nu}(0, \hat{\eta}) + E[U_{nu}(0, \eta)|\hat{\eta}] = 2\hat{\eta} + \int_{\Delta}^{\bar{\theta}} \theta dG(\theta). \quad (7)$$

Next, we derive the worker's second period utility when working in a unionised firm in the first period, $E[U_u(\tau_u^*, \eta)|\hat{\eta}]$. Workers who turn out to be less productive than η_1 leave the unionised

firm and are paid a wage equal to their productivity y . Workers whose ability is revealed to be between η_1 and η_2 get $\bar{w} + \theta$ if they stay and y if they leave. The probability that they stay is $1 - G(y - \bar{w})$. Finally, the utility of workers who turn out to be more able than η_2 is equal to y if they leave, and $y - \Delta + \theta$ if they stay. The probability of staying is $1 - G(\Delta)$. Hence, $E[U_u(\tau_u^*, \eta)|\hat{\eta}]$ can be computed as

$$\begin{aligned} E[U_u(\tau_u^*, \eta)|\hat{\eta}] &= \int_{-\infty}^{\eta_1} y dF_1(\eta|\hat{\eta}) + \int_{\eta_1}^{\eta_2} (1 - G(y - \bar{w}))\bar{w} dF_1(\eta|\hat{\eta}) + \\ &\quad \int_{\eta_1}^{\eta_2} G(y - \bar{w})y dF_1(\eta|\hat{\eta}) + \int_{\eta_1}^{\eta_2} \int_{y-\bar{w}}^{\bar{\theta}} \theta dG(\theta) dF_1(\eta|\hat{\eta}) + \\ &\quad \int_{\eta_2}^{\infty} y dF_1(\eta|\hat{\eta}) + (1 - F_1(\eta_2|\hat{\eta})) \int_{\Delta}^{\bar{\theta}} \theta - \Delta dG(\theta). \end{aligned}$$

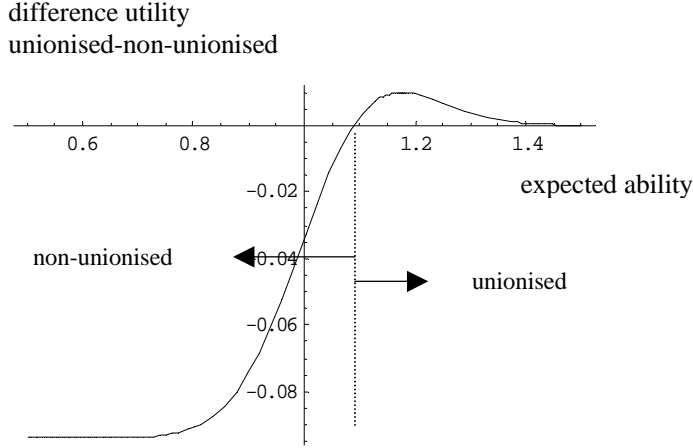
Using expression (6) for the worker's wage in the first period, her utility from working in a unionised firm can be computed as

$$W_u(\tau_u^*, \hat{\eta}) + E[U_u(\tau_u^*, \eta)|\hat{\eta}] = \begin{cases} 2\hat{\eta} + \int_{\eta_1}^{\eta_2} \int_{y-\bar{w}}^{\bar{\theta}} \theta dG(\theta) dF_1(\eta|\hat{\eta}) \\ \quad + (1 - F_1(\eta_2|\hat{\eta})) \int_{\Delta}^{\bar{\theta}} \theta dG(m) & \text{if } \tau_u^* = 0, \\ \hat{\eta} - k - c(\tilde{\tau}_u) + \int_{-\infty}^{\infty} f(\tilde{\tau}_u)\eta dF_1(\eta|\hat{\eta}) \\ \quad + \int_{\eta_1}^{\eta_2} \int_{y-\bar{w}}^{\bar{\theta}} \theta dG(\theta) dF_1(\eta|\hat{\eta}) \\ \quad + (1 - F_1(\eta_2|\hat{\eta})) \int_{\Delta}^{\bar{\theta}} \theta dG(m) & \text{if } \tau_u^* = \tilde{\tau}_u. \end{cases} \quad (8)$$

The sorting of workers into unionised firms depends on the training level unionised firms offer as well as on their expected ability. First, consider the impact of training on worker sorting. Recall that unionised firms choose training such that the marginal cost of training is equal to the marginal profit of training: $c'(\tilde{\tau}_u) = \frac{\partial E[\Pi_u(\tilde{\tau}_u, \eta)|\hat{\eta}]}{\partial \tau_u}$. Also note that the worker's utility from working in a unionised firm can be written as $W_u(\tau_u, \hat{\eta}) + E[U_u(\tau_u, \eta)|\hat{\eta}] = -k - c(\tau_u) + E[\Pi_u(\tau_u, \eta)|\hat{\eta}] + E[U_u(\tau_u, \eta)|\hat{\eta}]$. Hence, the training level that maximises the worker's utility, τ_u^w , satisfies $c'(\tau_u^w) = \frac{\partial E[\Pi_u(\tau_u^w, \eta)|\hat{\eta}]}{\partial \tau_u} + \frac{\partial E[U_u(\tau_u^w, \eta)|\hat{\eta}]}{\partial \tau_u}$. Clearly, $\tau_u^w \geq \tilde{\tau}_u$. Workers thus prefer to receive training level $\tilde{\tau}_u$ over no training at all. Hence, workers who receive training are more likely to work in the unionised sector, and workers sort into the unionised sector based on the impact unions have on training.

Next, consider the impact of ability on worker sorting. Suppose unionised and non-unionised firms offer the same amount of training. Figure 7 plots the difference between the utility from working in a unionised and non-unionised firm as a function of workers' expected ability. First

Figure 7: The difference between the utility from working in a unionised and non-unionised firm



observe that from (8), the utility from working in a unionised firm converges to $2\hat{\eta}$ as the worker's ability becomes very low. In contrast, from (7), the utility from working in a non-unionised firm converges to $2\hat{\eta} + \int_{\Delta}^{\bar{\theta}} \theta dG(\theta)$ as expected ability becomes low. Low ability workers are therefore better off in non-unionised firms. Second, observe that $\int_{y-\bar{w}}^{\bar{\theta}} \theta dG(\theta) > \int_{\Delta}^{\bar{\theta}} \theta dG(\theta)$: Workers whose ability turns out to be between η_1 and η_2 are better off because of unions. Workers with expected productivity around the union wage therefore prefer to work in the unionised sector. Finally, workers who turn out to be more able than η_2 are unaffected by the union wage. Hence, as the worker's expected ability becomes very high, the difference between the utility from working in a unionised or non-unionised firm converges to 0. This implies that there exists an ability threshold such that workers with an expected ability above this threshold prefer to work in the unionised sector.

D Proof of proposition 3

Proposition 3 $V^u(w^u|W^u, \text{stay}) \leq V^{nu}(w^{nu}|W^{nu}, \text{stay})$.

Consider workers who have not been trained. In non-unionised firms, second period wages are equal to workers' productivity minus a constant. Workers' mobility decisions are not affected by their productivity. Hence, the variance of second period wages, conditional on the first period

wages and staying equals

$$V^{nu}(w^{nu}|W^{nu}, \text{stay}) = V(\eta - \Delta|\hat{\eta} + (1 - G(\Delta)\Delta)) = \int_{-\infty}^{\infty} (\eta - \hat{\eta})^2 dF(\eta|\hat{\eta}).$$

In unionised firms, in contrast, workers who turn out to be less able than η_1 are laid off, and workers with ability between η_1 and η_2 receive the union wage. The variance of second period wages, conditional on the first period wage and staying equals

$$V^u(w^u|W^u, \text{stay}) = \frac{\int_{\eta_1}^{\eta_2} (1 - G(y - \bar{w})) (\bar{w} - \bar{w}^u)^2 dF(\eta|\hat{\eta}) + (1 - G(\Delta)) \int_{\eta_2}^{\infty} (\eta - \Delta - \bar{w}^u)^2 dF(\eta|\hat{\eta})}{\int_{\eta_1}^{\eta_2} (1 - G(y - \bar{w})) dF(\eta|\hat{\eta}) + (1 - G(\Delta))(1 - F(\eta_2))},$$

where \bar{w}^u is the average wage stayers earn in unionised firms. It can be easily verified that $V^u(w^u|W^u, \text{stay}) \leq V^{nu}(w^{nu}|W^{nu}, \text{stay})$

Why is it important to condition on first period wages? In order to compute the variance of wages unconditional on the previous wage, we have to integrate over the distribution of expected ability in unionised and non-unionised firms. This distribution differs in unionised and non-unionised firms, and is determined by the sorting of workers in the first period. Unconditional on the union wage, it is thus ambiguous whether the variance of wages is higher in unionised or non-unionised firms.

E Data description

Social security records

We define variables as follows.

- *Education* We distinguish between two education groups, workers without an apprenticeship, and workers with a completed apprenticeship. Workers with a college degree and workers for whom the education variable is missing are excluded.
- *Apprentices* The identifier for apprentices does not distinguish between workers in apprenticeship training and interns. We require an apprentice to be reported on a training programme for least 450 days. Workers who are reported on apprenticeship programmes for less than 450 days are considered unskilled workers.
- *Wages* Our wage measure is the average daily wage, computed as the total wage bill for each single spell, divided by the number of days worked. We deflate wages using the Consumer Price Index, with 2002 as the base year.

- *Job-to-unemployment transition* We classify a worker as a job-to-unemployment mover if he claimed unemployment benefits and report as unemployed after apprenticeship training. In Germany, workers are entitled to unemployment benefits after apprenticeship training. It is therefore likely that workers who are searching for a job also report as unemployed.
- *Potential experience* Potential experience is calculated as age minus age at labour market entry. Labour market entry is defined as the first time the worker is observed working full time and paying social security contributions.

The IAB-establishment panel

IAB-establishment panel is a yearly panel on establishments, available for the years 1993-2000. The base population are all firms with at least one employee who pays social security contributions. In 1993 the panel started with about 4,000 establishments; in 2000 around 13,000 firms participated in the survey (see Kölling (2000)). Large firms are over-sampled. We restrict our analysis to West German firms in the private sector. Furthermore, we only use data from 1996-1999, as we are only able to match information on workers for these years. Information on firms is collected through person-to-person interviews with firms' management. In addition to the union status, the data contains a large array of background characteristics, including firm size, industry, investment, revenue, etc. For each firm and year, we match average worker characteristics, computed from the social security records for each firm in our sample as of July 1st each year. Table 7 lists and defines the variables of the firm data used in the empirical analysis.

Table 7: Variable definitions: Firm data

Variable	Definition
union status	1 if firm is bound to industry or firm level agreement, 0 otherwise
Firm size	Total number of employees in the firm
Industry	10 industry dummies: Energy/mining/water industry; chemical industry; metal industry/machines; electro-technical industry/automobiles/optical industry; wood/printing/paper; construction/capentry; retail/wholesale; traffic/news; credit/insurance; other services agriculture, charities/private households and public sector dropped
Revenue/worker	Total turnover in the firm in the previous year divided by number of employees
Investment/worker	Total sum of investments in the previous year divided by number of employees
Age of firm	Distinguishes between 5 years and younger, 6-15 years, 16-30 years, older than 30 years
Evaluation of profit	Firm's current evaluation of profits; from 1 (very good) to 5 (very bad)
Proportion apprentices	Number of apprentices divided by number of employees;
Firm trains	1 if firm employs at least one apprentice, 0 otherwise;

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