Training and Union Wages*

Christian Dustmann † Uta Schönberg ‡

November 2005

Abstract

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 (and partly firm financed) apprenticeship programme and its collective bargaining system based on voluntary union recognition. We first develop a model of firm-financed training. In our model, a unionised and non-unionised sector coexist, and only unionised firms are bound by union wages. The model creates a rich set of empirical implications regarding apprenticeship training intensity, layoffs, wage cuts, and wage compression in unionised and non-unionised firms. We test these implications using firm panel data matched with administrative employee data. We find strong support for our hypothesis that union recognition, via imposing minimum wages and wage compression, increases training in apprenticeship programmes.

Keywords: Training, Unions, wage compression, matched firm-worker data

JEL: J24, j40, J51, I2

---

*We thank Jerome Adda, Joe Altonji, Bhaskar Bhaskar, David Card, Hide Ichimura, Thomas Lemieux, Steve Machin, Alan Manning, Costas Meghir, Steve Pischke, Chris Pissarides, Marco Ottaviani, James Sherk, and Robert Shimer for comments and suggestions. Parts of this paper were written while Christian Dustmann was visiting The Center for Labor Economics at Berkeley. He would like to thank the Center for its hospitality. We are grateful to Arndt Koelling and Holger Alda, and in particular to Johannes Ludsteck and Stefan Bender from the IAB for support with the data. We thank the DFG for financial support.

†Department of Economics, Gower Street, London WC1E 6BT, England. E-mail: c.dustmann@ucl.ac.uk

‡Department of Economics, University of Rochester, Harkness Hall, Rochester 14627, NY, USA. E-mail: utas@troi.cc. rochester.edu.

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 labour 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). For Canada, in contrast, Green and Lemieux (2001) conclude that unions have little impact on training.

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 interesting 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 en-

[1]See for instance Soskice (1994), Franz and Soskice (1995) and Winkelmann (1997) for a detailed description

trants. Training is mostly in general skills, and financed partly by firms[2]. Typically, 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 aspects 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. Unions and employer federations do not directly bargain over apprenticeship training (Bispinck 2001, Bispinck et al. 2002).

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 (Acemgolu 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. 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. Second, in our model union agreements act as minimum wages, and unionised firms are allowed to pay wages above the union wage. Third, we allow workers to be heterogenous and mobility to be endogenous.

---

of the German apprenticeship system.

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

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. 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 an appropriate one in the context of on-the-job training, as this type of training is not easily verifiable by a third party. 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 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 test of a key assumption of our model: There are binding wage floors in unionised, but not in non-unionised firms. Consequently, wages are more

compressed in unionised than in non-unionised firms. We test for two implications that are a direct consequence of wage floors. 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. We find empirical support for both implications, particularly for the low educated workers for whom wage floors should be most binding. We also compare the variance of log-wages and education wage differentials in unionised and non-unionised firms, conditional on worker and firm characteristics and firm fixed effects. We find strong evidence for higher wage compression in unionised firms according to these measures too.

We then turn to differences in the training intensity in unionised and non-unionised firms. 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. Thus, the empirical evidence supports our hypothesis that membership of firms in employer federations, 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. 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

Legal union recognition in the US is attained through a statutory system based on the majority principle. Recognition is granted if the union obtains a majority in elections held at establishment level (see DiNardo and Lee 2002 for details). In the UK, the recognition of trade unions for collective bargaining purposes has traditionally been at the discretion of employers; there was no legal obligation to employers to recognise and bargain with unions. This changed with the Employment Relations Act 1999 (coming into force in June 2000), which established a new statutory system for union recognition, enabling the trade union to obtain recognition by the

employer for collective bargaining purposes where the majority of the workforce want this.[3] In both countries, highly de-centralised firm-by-firm bargaining is the norm (see Card, Lemieux and Riddel 2002 for more details). Furthermore, beneficiaries of collective bargaining outcomes in firms that recognise unions are typically only workers who are union members.[4]

In Germany, recognition of trade unions for collective bargaining purposes is, similar to the UK before the 1999 Act, to the discretion of the employer. Different from the US and the UK, however, once a firm has recognised the union, collective bargaining outcomes apply to all workers in that firm, no matter whether they are union members or not. A firm recognises the union by either joining an employer federation (*Arbeitgeberverband*), or by engaging in bilateral negotiations with the union. In the first case, union wages are negotiated at a regional and industry level, typically on an annual basis.[5] Workers who are union members but work in firms that do not belong to an employer federation or do not engage in bilateral negotiations, are not entitled to union wages. This effectively segregates the labour market into a unionised and a non-unionised sector, where the firm's union recognition determines whether workers are covered by collectively bargained wages.

In Table 1 we show the proportion of West German firms choosing each option, for the years 1995 to 1999. Panel A reports numbers that are weighted so that they are representative for firms, while panel B uses weights that are representative for workers. Between 1995 and 1999, the proportion of firms that recognise industry-wide agreements was on average 48.7%. Since larger firms are more likely to join an employer federation, the fraction of workers who are covered by industry-wide agreements is considerably larger (at 65.0 %)[6]. The proportion of firms which bilaterally negotiate with unions is relatively small (7.3 %) Over the sample period, an average of 44% of all firms do not recognise the union; however, only 27% of the work force

[3]See the Department for Trade and Industry website www.dti.gov.uk/er/recognition.htm for details.

[4]There are exceptions in the UK where all employees are beneficiaries of collectively bargained wages (for instance in the UK teaching profession).

[5]While it is principally possible that an industry-wide agreement is extended to all firms in the industry, it happens only very rarely. In 2002, there were 11000 new union agreements, but only 55 were extended to all firms in the industry (Kirsch and Bispinck 2002). There were a further 227 contracts that contained regulations about working time and paid vacation, etc. and were extended to all firms in the industry.

[6]Because collectively bargained agreements apply to all workers in a firm that recognises the union, 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).

Table 1: Collective bargaining in Germany

	Panel A: representative for firms		
	industry-wide agreement (option 1)	firm-level agreement (option 2)	no agreement (option 3)
1995	53.4	8.2	38.4
1996	48.7	10.2	41.0
1997	49.6	9.9	40.6
1998	47.7	4.8	47.5
1999	44.4	3.3	52.4
all	48.7	7.3	44.0
	Panel B: representative for workers		
1995	72.2	10.9	16.9
1996	69.2	11.1	19.7
1997	68.1	12.6	19.3
1998	67.8	8.0	24.2
1999	65.0	7.8	27.1
all	68.5	10.1	21.4

Own calculations based on the IAB firm panel. Table entries are weighted.

Table 2: Percentage of Firms paying above union wages

Year	1995	1996	1997	1998	1999	Total
Above Union Wage	52.8	49.9	46.1	44.1	46.9	47.8

Table entries are the percentage of firms who recognise unions and report to pay some workers wages above the union wage.

are neither covered by industry-wide or firm-level agreements.

Table 1 also shows that the proportion of firms recognising industry-wide or firm-level agreements declined between 1995 to 1999. This trend is similar to the one in the UK, where the percentage of establishments with any union recognition decreased between 1990 and 1998 from 53% to 42% (see Machin 2000). It is not only driven by covered firms exiting and uncovered firms entering the market (in our sample, 49% of firms younger than 10 years recognise unions, compared to 59 % of firms that are older than 10 years), but also by firms changing their union status. Interestingly, there are movements in both directions. Between 1995 and 1999, 7.6% of firms previously covered by an industry-wide or bilateral agreements left the employer federation, while 5.2% of firms not previously covered by union agreements joined an employer federation.[7]

What do unions and employer federations or firms bargain over? The most important outcome of the negotiation is the union wage. There is no single union wage. Instead, union wages depend on observable worker characteristics, such as workers' skill, occupation, experience, or training status. Importantly, union wages act as minimum wages, and firms may pay wages above the union wage. Payment above the union wage appears to be common. In Table 2 we show the percentage of firms that report to pay wages above the union wage. Over the period considered, these are about 48 percent of all firms that recognise unions, with a slight decline over the observation period. On average, wages paid above the union wage are about 10 percent higher than the union wage.

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 do not directly bargain over training. Bispinck (2001) and Bispinck et al. (2002) analyse all union

[7]Our own calculations based on the IAB firm panel.

contracts in Germany since 1997 with respect to training agreements. Only very recently (and after 1999, the last year of our observation window) 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. The crucial feature of our model is the coexistence of a unionised and non-unionised sector. 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 a lower wage. Our main result is that union wages lead to wage compression, and hence to firm-financed training. 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.

3.1 Set-up

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.

Productivity: 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. We denote the variable cost of training 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 $\overline{\eta}$ and variance σ_η^2.

Information structure: Information about ability is imperfect. In the first period firms and workers receive a noisy signal $\widetilde{\eta} = \eta + \varepsilon_\eta$, which they use to update their beliefs about workers' ability. If ε_η is normally distributed with mean 0 and variance $\sigma_{\widetilde{\eta}}^2$, then the updated belief about the worker's productivity is also normally distributed (DeGroot 1970), and a weighted average of the prior mean, $\overline{\eta}$, and the signal, $\widetilde{\eta}$. We denote this updated belief by $\widehat{\eta}$. Let $F_1(\eta|\widehat{\eta})$ denote the ability distribution of a worker with expected ability $\widehat{\eta}$[8]. 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.

Training decision: 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 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. 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.

[8]From DeGroot (1970), $E[\eta|\widetilde{\eta}] = \frac{\overline{\eta}\sigma_{\widetilde{\eta}}^2 + \widetilde{\eta}\sigma_\eta^2}{\sigma_{\widetilde{\eta}}^2 + \sigma_\eta^2}$, and $V[\eta|\widetilde{\eta}] = \frac{1}{\frac{1}{\sigma_{\widetilde{\eta}}^2} + \frac{1}{\sigma_\eta^2}}$.

Mobility after training: At the end of the training period workers decide whether to switch firms. As in Acemgolu 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 $[\underline{\theta}, \overline{\theta}]$, with $\overline{\theta} > 0$. We assume that $G(.)$ 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, $\overline{\theta} > 0$, 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.

Wage determination: 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.

Union agreements: In our model, unionised firms have to pay at least the union wage, and may pay a higher wage, to workers who are not in training. Non-unionised firms, in contrast, may pay whatever wage they want. This is the only difference between unionised and non-unionised firms. Union agreements do not contain any regulations about employment or training. We further assume that firms can lay off apprentices at the end of the training period without cost. Finally, we assume that firms cannot switch union status.

These assumptions mirror the German collective bargaining system. In particular, we model the union wage as a wage floor because in Germany, union wages act as minimum wages and payment above the union wage is not uncommon, as shown in Table 2. Since a nation-wide minimum wage does not exist in Germany, no wage floor is binding in non-unionised firms.

Moreover, in Germany unions and employer federations do not directly bargain over training or employment. Finally, although firing costs are generally quite high in Germany, firms face no firing costs at the end of apprenticeship training.

We have made two simplifying assumptions that are not in line with the German collective bargaining system. First, in Germany union wages depend on -among other things- workers' skill, while we assume that a single union wage applies to trained and untrained workers. 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. Our empirical analysis is supportive of this assumption. Second, 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.

Timing: The sequence of events is as follows. At the beginning of the first period labour market participants receive a noisy signal about workers' ability. Firms offer a (first period) wage and choose whether and how much training to offer. 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 observe workers' ability as well as training. Both incumbent and outside firms make a wage offer to the worker. Unionised firms have to pay at least the union wage, while non-unionised firms may pay whatever wage they want. Workers then discover their utility shock, and decide whether to stay with the training firm or not. At the end of the second period workers retire.

We first analyse how wages in the second period are determined in unionised and non-unionised firms. We then turn to firms' incentives to train and wage determination in the first period.

3.2 Wage determination in the second period

We analyse wage determination separately for unionised and non-unionised outside (i.e. non-training) firms, as well as unionised and non-unionised incumbent (i.e. training) firms. In our economy, all types of firms observe workers' ability and training in the second period. Hence, wage offers depend on ability as well as on training.

Outside firms: Consider first outside firms. Let v denote their wage offer. Due to perfect competition in the outside market, outside firms bid up workers' wage until it equals their (marginal) productivity, i.e. $v = y = h(\tau)\eta$ - regardless of their union status[9].

Incumbent non-unionised firms: Next, consider non-unionised incumbent firms. Let w denote their wage offer. 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

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

Incumbent firms maximise

$$\max_{w} \quad (1 - G(y - w))(y - w).$$

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 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 non-unionised incumbent firm is equal to the worker's productivity minus a constant, Δ :

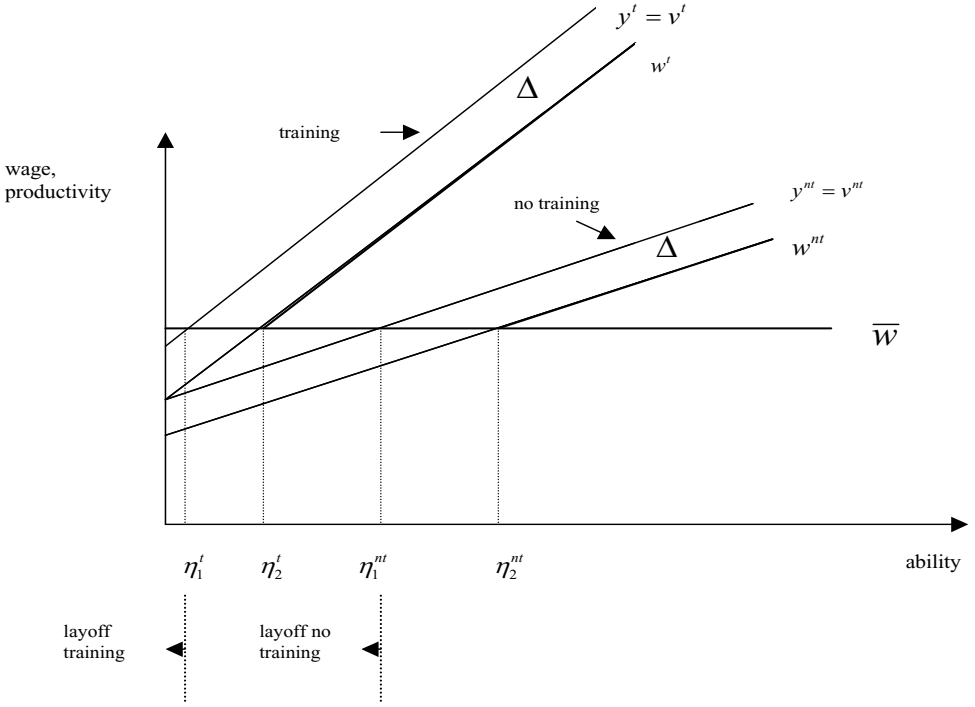
$$w = y - \Delta. \tag{1}$$

Incumbent unionised firms: Finally, consider unionised incumbent firms. Unlike non-unionised firms, unionised firms have to pay at least the union wage, $\overline{w}$, and may offer a higher wage.

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 horizontal axis. Productivity and wages of untrained (trained) workers

[9]Note, however, that unionised firms will not make a wage offer to workers with a productivity below the union wage.

Figure 1: Wage Determination in unionised firms



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 $\overline{w}$. It is useful to distinguish between three groups of workers.

First, consider workers with productivity below the union wage $\overline{w}$. In the figure these are workers with ability below η_1^t if trained ($\eta_1^t = \frac{\overline{w}}{h(\tau)}$) and η_1^{nt} if untrained ($\eta_1^{nt} = \overline{w}$). 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. 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. These workers are better off due to unions, and earn a higher wage than they would in the absence of union agreements.

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. Union wages lead therefore to wage compression for workers in the middle range of the wage distribution.

3.3 Training decision in the first period

Non-unionised firms: We begin with non-unionised firms. 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), non-unionised 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, profits do not depend on training, and firms offer no training in equilibrium[10]. We summarise:

Proposition 1 *Under limited commitment non-unionsed firms offer no training.*

The result that in the absence of wage compression the training market breaks down 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 training[11]. 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:

[10]To 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 $W = \widehat{\eta}+(1-G(\Delta))\Delta$.

[11]In 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).

Training increases workers' productivity, but not their wages, inducing firms to train workers[12]. 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 training.

Unionised firms: An intuitive explanation for why union agreements may increase training 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 $\overline{w}$, 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.

To formalise this argument, we first derive an expression for the second period profit of unionised firms. Let $E[\Pi_u(\tau,\eta)|\widehat{\eta}]$ denote the future (i.e. second period) profit on a worker with expected ability $\widehat{\eta}$. Define η_1 as $\eta_1 h(\tau) = \overline{w}$, i.e. workers with ability below η_1 have a productivity below the union wage. Similarly, define η_2 as $\eta_2 h(\tau) = \overline{w} + \Delta$, i.e. workers with ability above η_2 are not affected by the union wage. Notice 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 $y - \overline{w}$. These workers stay with the unionised firm after apprenticeship completion with probability $1 - G(y - \bar{w})$. Finally, for workers with ability above η_2, firms earn profits of $(1 - G(\Delta))\Delta$. Hence, unionised firms maximise

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

[12] As 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.

The training level unionised firms offer (in case they decide to train the worker), $\widetilde{\tau}_u$, solves[13]

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

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[14]. This effect is captured by the second term in (2). In Appendix A we show the first effect dominates the second effect. Hence, training increases the future profit of unionised firms, i.e. $\frac{\partial E[\Pi_u|\widehat{\eta}]}{\partial \tau} \geq 0$ and $\widetilde{\tau}_u \geq 0$.

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 under training exceeds the profit without training. In Appendix A we show that there exist two thresholds which we denote by $\widehat{\eta}_1$ and $\widehat{\eta}_2$. The unionised firm trains the worker if her expected ability lies in between these two thresholds. The training choice of unionised firms therefore satisfies

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

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 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 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,

[13]Note that terms that involve the integration boundaries cancel out since $y(\tau,\eta_1)=\overline{w}$, and $y(\tau,\eta_2)=\overline{w}+\Delta$.

[14]At first sight, this may seem counterintuitive. The reason is that training increases the probability that a worker is paid more than the union wage. At the same time, workers earning more than the union wage have a higher probability of leaving the firm than workers exactly earning the union wage.

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 wage.

Several studies[15] have found that aptitude and achievement measures positively affect the probability of receiving on-the-job training. This is at odds with our model in which it is workers in the middle range of the ability distribution who receive the most training. However, in the case of the German apprenticeship, this seems a good description of reality. Workers of low ability are likely to enter the labour market without post-secondary education, while workers of high ability are likely to attend university[16].

Finally, we compare the training level unionised firms offer with the socially optimal training level. Since unionised firms ignore the impact of training on the utility of the worker when deciding how much training to offer, they offer less training than the socially optimal level. We summarise

Proposition 2 *Unionised firms train workers with expected ability* $\widehat{\eta}_1 < \widehat{\eta} < \widehat{\eta}_2$. *These workers are offered a training level of* $\widetilde{\tau}_u$. *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 may not be self-enforceable. Once training is completed, firms have an incentive to deviate and pay a lower wage than the agreed 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

[15] See for instance Altonji and Spetzler (1991).

[16] Also note that these workers have the highest return to training, and thus the strongest incentive to get school-based training and finance training themselves.

least the agreed union wage in the future. 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.

To close the model, we have to analyse the sorting of workers into the unionised and non-unionised firms in the first period. We do this in Appendix B. Here, we only note that it is workers with a higher expected ability who prefer to work in unionised firms. The intuition for this result is simple. 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 sector. Workers with low expected ability are likely to have a lower productivity than the union wage, and thus choose to work in non-unionised firms.

4 Empirical Implications

What are the empirical implications of our model? A key assumption of our model is that wage floors are only binding in unionised, but not in non-unionised firms. This leads to wage compression in unionised firms, which induces these firms to finance training. We first discuss how we test for the presence of wage floors -and thus a more compressed wage structure- in unionised firms. We then turn to differences in training in unionised and non-unionised firms.

4.1 Wage compression in unionised and non-unionised firms

Ideally, we would like to test for the presence of wage floors in unionised firms by comparing 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 contract[17]. Instead, we have to indirectly test for the presence of wage floors in unionised firms, by deriving easily testable implications of wage floors.

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

We derive two such implications. First, wage floors may prevent unionised firms from cutting wages in case of a negative productivity shock - at least for workers earning a wage equal or close to the union wage. We thus expect wage cuts to occur less frequently in unionised than in non-unionised firms. We test this 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 layoffs in unionised and non-unionised firms. This is just the other side of the coin: Since unionised firms are not allowed to pay wages below the union wage, they lay off apprentices who turn out to be less productive than the union wage. Non-unionised firms, in contrast, respond to a negative productivity shock by cutting wages. Hence, we expect more layoffs in unionised than in non-unionised firms. At the same time, voluntary turnover should be lower in unionised than in non-unionised firms since workers who are paid the union wage in unionised firms earn a higher wage than they would in a non-unionised firm. We test this implication by comparing the probability of a layoff and a voluntary job switch at the end of the apprenticeship, for workers trained in unionised and non-unionised firms.

We also test for wage compression in a more direct way, by comparing the (residual) variance of wages and wage differentials by education in unionised and non-unionised firms.

4.2 Training in unionised and non-unionised firms

The main implication of our model concerns training in unionised and non-unionised firms. Taken literally, 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 compression[18]. Our 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

[18]We 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.

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 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, addresses 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.

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 IAB establishment panel) for the years 1995-1999, 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 recognises 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, data on wages is 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. From these two primary data sources, we construct three samples (samples A-C) which we use for analysis below.

In the first step of the empirical analysis, we test for the key assumption of our model, i.e. the presence of wage floors in unionised firms. We first compare the returns to education, variance of wages, and probabilities of wage drops in unionised and non-unionised firms. Here,

we match the two primary data sources described above. We obtain a sample 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 concentrate on young workers to avoid the problem of top coding. Workers in training are excluded from this sample. We refer to this sample as "sample A". We distinguish between three skill groups, unskilled workers who have no further training after secondary school, skilled workers who went through apprenticeship training after secondary school, and workers who graduated from a college or a university. There are 835,518 wage spells in our sample; 8.2% belong to unskilled workers, 79% to skilled workers, and and 12.8% to university graduates. 45,953 wage spells are observed in non-unionised firms. Some wage spells are affected by top coding. Overall, censoring affects 3.9% of wage spells, but only 0.28% for unskilled workers and 0.83% for skilled workers. Censoring is most severe for university graduates, where 20.33% of all wage spells are top-coded. We neglect top coding in our analysis below, but we will concentrate on low and medium educated workers where top-coding is negligible.

We next test whether at the end of apprenticeship training, layoffs occur more and voluntary job quits less frequently in unionised than in non-unionised firms. For this purpose, we create a second sample that consists of all individuals who have been employed as apprentices in the years 1995-1999 in any of the firms in our firm panel. We are able to follow these workers from labour market entry onwards (even if labour market entry was before 1995) until 2001. There are 174,320 individuals in the sample that had at least one training spell in a firm that we can identify as unionised or non-unionised. We exclude individuals who start working as unskilled workers before enrolling on an apprenticeship scheme (25,265). As the data does not distinguish between interns and apprentices, we consider an individual as an apprentice if she has been observed for at least 450 consecutive days on a training programme, which eliminates 6,940 individuals. We further exclude individuals who start more than one apprenticeship (these are 2,073 individuals), as well as individuals who change firms during their training period (35,184 individuals). We end up with a sample of 104,838 workers. Of those, 93,669 are observed in at least one spell after the training period, with 89,660 individuals being trained in a unionised firm, and 4,009 individuals in a non-unionised firm. We refer to this sample as "sample B".

In the second step of our analysis, we test the main implication of our model that training occurs more frequently in unionised than in non-unionised firms. We test this implication using

data from the firm panel over the period 1995-1999, supplemented with information on the firm's work force. We match to each firm information on all workers who were employed at that firm at the first of July of each year. We restrict the empirical analysis to West-German firms in the private sector. Following Acemoglu and Pischke (1998), we also exclude firms in the construction sector [19]. We refer to this sample as "sample C".

We define a unionised firm as a firm that either belongs to an employer federation, or engages in bilateral negotiations with the union.[20] Appendix D describes the variables we use in the empirical analysis in more detail.

5.2 Unions and wage compression

A key assumption of our model is that wage floors are binding in unionised firms, but not in non-unionised firms. This leads to wage compression in unionised firms. This section provides evidence in favour of this assumption. We first compare the variance of log-wages and educational wage differentials in unionised and non-unionised firms. We then test for the presence of wage floors in unionised firms by comparing the occurrence of wage cuts as well as the occurrence of quits and layoffs in the two types of firms.

Returns to education and wage inequality

Table 3 compares education wage differentials in unionised and non-unionised firms, based on sample A. To control for observable firm and worker characteristics, we condition on potential labour market experience and its square, the log of firm size, a dummy for metropolitan area, as well as year and industry dummies. We run separate regressions for workers in the two types of firms. In panel A, we report results of simple OLS regressions. The estimates suggest that education wage differentials are strikingly larger in non-unionised firms. The difference between wages of low and medium educated workers is almost twice as high in non-unionised than in unionised firms. In the last pair of columns we report the difference in wage differentials between

[19] The reason is that in the construction industry firms that do not train apprentices have to pay a fine which is then redistributed to firms in the industry that do train.

[20] 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.

Table 3: Education wage differentials by union status

Education and experience wage differentials						
	Unionised N=680976		Non-Unionised N=39854		Δ	
	Coef	StdE	Coef	StdE	Coef	StdE
Panel A: Wage levels						
Medium-Low	0.2338	(0.0012)	0.4252	(0.0058)	0.1914	(0.0061)
High-Low	0.5862	(0.0012)	0.8975	(0.0067)	0.2813	(0.0078)
Panel B: Fixed Firm Effects						
Medium-Low	0.2080	(0.0011)	0.3300	(0.0059)	0.1220	(0.0060)
High-Low	0.5445	(0.0014)	0.7110	(0.0070)	0.1666	(0.0071)

Estimation results based on sample A. Dependent variable: Log real wages. Regressions include dummies for education (medium and high), potential labour market experience and its square, the log of firm size, year dummies, a dummy for metropolitan area, and 13 industry dummies. Panel A: OLS regressions. Panel B: fixed firm effect models.

unionised and non-unionised firms. The differences are highly significant.[21]

In panel B, we additionally condition on fixed firm effects, exploiting now variation within firms only. The wage differential between low and medium educated workers as well as low and highly educated workers decreases in both types of firms, indicating that sorting of workers into firms is important. While fixed firm effects reduce the difference in wage differentials between unionised and non-unionised firms, the difference continues to be large.

Wage variance by union status

Next, we compare wage inequality, measured as the variance of log-wages and log-wage residuals, in unionised and non-unionised firms. Due to wage censoring, we only present results for low and medium educated workers. Table 4 shows that the total variance of log-wages is about 40 % higher in non-unionised than in unionised firms, for both low and medium educated workers. Proportional differences in the residual variance are of similar magnitude[22]. In the next column

[21] This is in line with evidence for other countries: Card (1996) finds that in the US, wage differences between skill groups tend to be compressed in the union sector. Lemieux (1998) provides similar findings for Canada.

[22] See DiNardo, Fortin and Lemieux 1996 for similar evidence for the US.

Table 4: Variance of log wages by union status

	low education			medium education		
	unionised	non-unionised	Δ	unionised	non-unionised	Δ
# of observations	N=51412	N=4150		N=529883	N=25860	
Wage levels						
Total Variance	0.2238	0.3727	-0.1489	0.0669	0.1126	-0.0457
Residual Variance[1]	0.1516	0.2575	-0.1059	0.0499	0.0866	-0.0367
	(0.0029)	(0.0137)	(0.0140)	(0.0009)	(0.0065)	(0.0066)
Fixed Firm Effects						
Residual Variance[1]	0.0951	0.1319	-0.0365	0.0405	0.0570	-0.0165
	(0.0025)	(0.0093)	(0.0096)	(0.0009)	(0.0062)	(0.0063)

Estimation results based on sample A.

[1] Regressions include potential labour market experience and its square, gender, the log of firm size, year dummies, a dummy for metropolitan area, and 13 industry dummies.

we condition on workers and firm characteristics, and present residual variances. Again, the variance of log wages is substantially larger in non-unionised than in unionised firms.

The next panel compares the residual variance of log-wages within firms, conditional on firm fixed effects, for the two types of firms. The magnitude of the within-firm log-wage variance is substantially smaller than the overall residual variance for both unionised and non-unionised firms, as we would expect. Nevertheless, the difference between unionised and non-unionised firms remains sizeable and statistically significant for both groups of workers.

Wage cuts

The previous results are supportive of the idea that wages are more compressed in unionised than in non-unionised firms. In our model, this is the case is because there are binding wage floors in unionised firms, but not in non-unionised firms. Next, we test for an implication that is a direct consequence of wage floors: Wage cuts should be observed more often in non-unionised firms than in unionised firms. We base our analysis on sample A, but restrict our sample to workers who stay with the same employer between two successive periods, and who are employed

Table 5: Probability of wage cuts, by education group

	low education		medium education	
	Coef	StdE	Coef	StdE
# of observations	20,584		288,590	
Panel A: 1 %	-0.049	*0.010*	-0.027	*0.0041*
Panel B: 5 %	-0.040	*0.0100*	-0.021	*0.0020*
Panel C: 10 %	-0.013	*0.0060*	-0.0085	*0.0017*

Estimation results based on sample A. We exclude workers who switch employers between two successive periods. Dependent variable: Indicator variable, being equal to one if real wage of a worker dropped by at least 1 % (panel A), 5 % (panel B), or 10 % (panel C), between two successive periods. Reported coefficients are marginal effects of the firm's union status from a probit regression. Regressions are separately estimated for the two education groups. Regressions include potential labour market experience and its square, gender, log firm size, year dummies, a dummy for metropolitan area, and 13 industry dummies.

full-time in both periods. Because of wage censoring, we exclude university graduates from our sample. We define three variables. The first variable is equal to 1 if the worker's real wage decreases from one period to the next by at least 1%, and 0 otherwise. The other two variables are equal to 1 if the worker experiences a wage cut of at least 5% or at least 10%, respectively. In our sample, 18.8% of spells experience a wage cut of at least 1%, 7.3% of at least 5%, and 2.5% of at least 10%.

Table 5 reports the marginal effect of the firm's union status on the probability of a wage cut from a probit regression, where we condition on potential labour market experience and its square, gender, log firm size, year and industry dummies, and a dummy for metropolitan area. The incidence of a wage cut is significantly higher in non-unionised than in unionised firms for both low and medium educated workers, conditional on worker and firm characteristics, and for all three definitions. The sector difference is smaller for very large wage cuts, but still 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 tend to be stronger for unskilled workers than for skilled workers. This is in line with our expectation, as the union wage should be more binding for low skilled workers. The difference between workers in the unionised and non-unionised sectors is significant for the 1% and 5% percent wage drops.

Layoffs and quits

A further consequence of wage floors is that layoffs should occur more frequently, while voluntary quits should occur less frequently in unionised than in non-unionised firms. We test this implication by comparing the probability of a layoff and voluntary job quits 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 (sample B).

Unfortunately, we do not observe whether workers who leave the training firm were laid off or left the firm because they received better offers. 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 and 66% move directly to another job. On average, unemployment spells last for 134 days, with a median duration of 74 days. We use job-to-unemployment spells as a proxy for layoffs. In appendix D, we show that this makes it harder for us to detect differences in layoff and quit rates between unionised and non-unionised firms. Moreover, we show that if we observe a higher job-to-unemployment and a lower job-to-job quit rate in unionised firms, then it must be the case that workers in unionised firms are more likely to be laid off and less likely to quit. This follows under two assumptions. First, laid off workers are more likely to become unemployed than workers who quit voluntarily. Second, conditional on a layoff or a quit, otherwise identical workers from unionised and non-unionised firms have the same probability of becoming unemployed. There is empirical evidence for the first assumption[23]. The second assumption seems plausible as unionised and non-unionised workers are eligible for the same amount of unemployment benefits.[24]

Table 6 reports results from linear probability models. Reported coefficients are the impact of the firm's union status on the probability that a trainee moves from job-to-job after completing training (panel A), and on the probability that he/she becomes unemployed (panel B). Results in the first pair of columns include time dummies only. Contrary to our hypothesis, these estimates suggest that workers trained in unionised firms are more likely to move from job-to-job, and are

[23]For instance, Nagypal (2004) reports that the fraction of workers who were laid off is substantially higher among job-to-unemployment than among job-to-job movers.

[24]A trainee who successfully completes an apprenticeship training scheme is eligible for unemployment benefits. The amount is based on the average union wage in the industry.

Table 6: Probability of a job-to-unemployment and job-to-job transition after apprenticeship training

	Panel A: Probability of job-to-job transition					
	Coef	StdE	Coef	StdE	Coef	StdE
Training firm unionised	0.0144	*0.0061*	0.0052	*0.0062*	-0.0261	*0.0110*
Time dummies	Yes		Yes		Yes	
Size training firm/worker characteristics[a]	No		Yes		Yes	
Fixed Training firm effects	No		No		Yes	
No. Observations	93,669		90,881		90,881	
No. Movers	16,735		16,118		16,118	
	Panel B: Probability of a job-to-unemployment					
	Coef	StdE	Coef	StdE	Coef	StdE
Training firm unionised	-0.0493	*0.0047*	-0.0190	*0.0046*	0.0265	*0.0089*
Time dummies	Yes		Yes		Yes	
Size training firm/worker characteristics[a]	No		Yes		Yes	
Fixed Training firm effects	No		No		Yes	
No. Observations	93,669		90,881		90,881	
No. Non-Employment Spells	8,809		8,489		8,489	

Estimations based on sample B. Linear Probability Models. Reported parameters are marginal effects.
[a]: Includes age and age squared, gender, the log of the apprenticeship duration, dummies for lower and higher secondary degrees.

less likely to become unemployed.

There are at least two reasons for why these estimates are biased. First, as implied by our model, unionised firms may employ more able workers than non-unionised firms, and more able workers are less likely to become unemployed after apprenticeship training, and possibly more likely to move from job-to-job[25]. Second, unionised firms may be of higher quality than non-unionised firms and thus lay off less workers after apprenticeship training. In order to account for differences in firm and worker quality, in column 2 we control for the size of the training firm, as well as for the following worker characteristics: age and age squared, gender, the log of the apprenticeship duration, and a dummy for a lower secondary degree. This reduces the size of both coefficients. Workers trained in unionised firms are not significantly more likely any more to experience a job-to-job transition, but still less likely to become unemployed than workers trained in non-unionised firms.

These observed characteristics may only partly take account of unobserved worker and firm characteristics. To control for these, we add fixed training firm effects (columns 3), exploiting variation in the firm's union status over time. We now find a significantly higher job-to-unemployment and a significantly lower job-to-job transition rate for workers trained in unionised firms. Our estimates indicate that unionisation increases the probability of becoming unemployed after apprenticeship training by 2.7 percentage points, or by nearly 8 percent. On the other side, it decreases the probability of experiencing a job-to-job transition by 2.6 percentage points. This is strong evidence in favour of our model that workers in unionised firms are more likely to be laid off, but less likely to quit voluntarily[26]. Notice that the coefficients on the job-to-job and job-to-unemployment transition rate are of opposite sign, but of similar magnitude. Hence, unionisation appears to have little impact on the total turnover rate.

To sum up, these results demonstrate that wage determination and the structure of wages differ substantially in unionised and non-unionised firms in a way that is consistent with the

[25]There 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 Acemoglu and Pischke (1998). In a recent paper on the German apprenticeship system, von Wachter and Bender (2005) provide convincing evidence that apprentices who leave the training firm are of lower ability than workers who stay with the training firm.

[26]Using industry-level data, Medoff (1979) also concludes that unions increase layoffs relative to voluntary quits and wage reductions.

idea that wage floors and wage compression are more important in unionised firms.

5.3 Unions and training

The main implication of our model is that unionised firms offer more training than non-unionised firms. In this section, we test this. Our analysis is based on sample C.

Table 7: Unionised and non-unionised firms

	All		Unionised		Non-Unionised	
Proportion of firms unionised	55.3					
Proportion of workers in unionised firms	76.8					
	Mean	StdD	Mean	StdD	Mean	StdD
Firm trains	28.69	*44.34*	36.15	*48.04*	15.46	*36.15*
Proportion workers in firms that train	58.96	*49.19*	67.11	*46.98*	31.90	*46.61*
Proportion trainees	4.89	*10.41*	6.49	*11.53*	2.90	*8.41*
Proportion qualified workers	47.23	*30.55*	51.71	*28.85*	41.70	*31.67*
Number of new hires	0.95	*6.63*	1.17	*8.13*	0.68	*4.05*
Size	17.02	*120.79*	23.65	*159.43*	8.82	*32.96*
(Investment/worker)/1000*	16.61	*509.73*	11.47	*275.23*	22.95	*697.79*
(Turnover/worker)/1000*	374.69	*1640.66*	43.97	*1951.80*	86.37	*1119.45*
Proportion young firms ($\leq$5)	23.32	*42.29*	20.71	*40.53*	26.71	*44.25*
Proportion old firms ($\geq$30)	32.99	*47.02*	39.62	*48.91*	24.37	*42.93*
Profit evaluation good/very good	30.35	*45.98*	29.25	*45.49*	31.71	*46.54*
Profit evaluation bad	10.05	*30.07*	9.27	*29.00*	11.02	*31.31*
Average age workers	37.22	*8.36*	36.68	*8.06*	37.92	*8.69*
Ratio females	23.80	*63.81*	24.22	*31.20*	23.26	*89.71*
Daily Average Wage *	88.65	*46.01*	93.68	*43.57*	82.21	*48.22*
Work Council	8.45	*27.82*	13.51	*34.19*	2.58	*15.87*

Firm data and matched worker characteristics, 1995-1999. Entries are weighted and representative for firms. *: In 1996 German Marks

Table 7 provides some descriptive information on our sample C. The table provides means for all firms in our sample, and for firms that do and do not recognise unions. Entries are weighted so that they are representative for firms.

About 55% of all firms over the observation period are unionised, i.e. recognised either industry-wide or firm-level agreements. These firms employed 76 % of the work force. The

second number exceeds the first one because unionised firms are larger: the average workforce size of unionised firms is about 24, compared to 9 of non-unionised firms.

The next three rows report different measures on apprenticeship training. The first row reports the proportion of firms that provide apprenticeship training. This proportion is surprisingly low (at about 29 percent), given that about two in three workers go through apprenticeship training in Germany. There is a clear difference in training provision between unionised and non-unionised firms, with 36 percent of unionised firms providing training, but only 15 percent of non-unionised firms. Firms that do provide training are larger: although only 29 percent of all firms do provide apprenticeship training, these firms employ about 59 percent of all workers. As before, there is a marked difference between unionised and non-unionised firms. The next row reports the proportion of apprentices. Overall, about 4.9 % of firms' workforce are individuals on apprenticeship schemes; this number is at 6.5% far higher in unionised firms than in non-unionised firms (2.9%).

These numbers suggest that apprenticeship training occurs much more frequently in firms that recognise a union. However, simple comparisons of this type 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. Second, unionised firms may differ from non-unionised firms in characteristics that affect their training intensity.

Table 7 illustrates that a selection of workers into unionised firms is potentially important, as unionised firms employ more qualified workers (52 percent vs. 42 percent). Unionised firms also have hired more workers in the previous year, which may be explained by their larger average size. There is also some evidence that revenue per worker is higher in unionised firms, while investment per worker is higher in non-unionised firms. The proportion of young firms is lower among unionised than non-unionised firms, while the proportion of old firms is larger among unionised firms - a finding that is similar to findings for other countries.[27] Profit evaluations are fairly similar between the two types of firms, as are workforce characteristics with respect to age and the ratio of females.

In the last row of the table, we present the proportion of firms that have a work council.

[27]For instance, Machin (2000) establishes a similar relationship between firm age and union recognition for the UK.

Works councils in Germany are established by vote in establishments with at least five employees. Details on the establishment of work councils and their rights can be found in the German Works Constitution Act (Betriebsverfassungsgesetz) of 1972, which has been amended in 2001 (see Addison et al. 2004 for details). Work councils consult with the management and have co-determination rights on payments methods, leave arrangements, overtime work, and monitoring of effort.[28] Work councils do not affect management decisions to set up apprenticeship schemes. The figures in Table 7 show that work councils are established in 8.5% of all firms. If we break this figure down by firm size (not reported), then work councils can be found in only 6% of firms with below 50 employees, but in 88% of firms with above 200 employees. This strong relationship with firm size partly explains why only 2.6% of non-unionised firms have work councils, but 13.5% of unionised firms.

Training intensity and unionisation

In Table 8 we take account of heterogeneity in observable worker and firm characteristics by regressing the proportion of workers on apprenticeship schemes on a set of firm and worker characteristics, in addition to the firm's union status. In the first set of columns of the table we condition on year dummies and firm size only.[29] The estimates suggest that the proportion of individuals on apprenticeship training schemes is about 2.8 percentage points higher in unionised firms.[30] When we include the number of new hires, 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, the coefficient hardly changes. In the third set of columns, we control in addition for characteristics of the firm's workforce, like the ratio of females, the average age of the workforce, and the average daily salary. 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. We also add a dummy indicating whether the firm has a work council. This variable is not available for 1995, which explains the decrease in sample size. Including these variables does not affect the overall coefficient estimate. Interesting is the sign of the work

[28] See Huebler and Jirjahn (2003) and Zwick (2003) for analysis of the productivity impact of work councils.

[29] We include firm size and firm size dummies (0-50, 51-200, 201-800, and > 800) and allow the impact of firm size to change linearly within each of the categories.

[30] See Beckmann 2002 for similar estimations.

Table 8: Unionisation and the proportion of apprentices

	Firm size + year		+ firm characteristics		+ firm and worker characteristics	
	Coef	StdE	Coef	StdE	Coef	StdE
	0.028	0.002	0.027	0.002	0.027	0.002
No Obs	18,264		13,668		10510	
No Unionised	13,594		10,494		8,126	
R^2	0.03		0.06		0.12	

OLS regression results. Firm panel, matched with employee information, 1995-1999. Columns 1 controls for time and firm size only. Column 2 controls in addition for industry dummies, region dummies, investment per worker, revenue per worker, number of new hires, profit evaluation, and age of the firm. The third column (which uses years 1996-1999 only) additionally includes the average age of workers, the proportion of qualified workers in the firm, the average daily wage of workers, the proportion of females, and a dummy for work council.

council dummy: It is significantly negative, with a point estimate of -0.011, suggesting that the presence of a work council is negatively associated with the proportion of apprentices.

Changes in union status and training intensity

Our set of firm's background information should absorb a lot of variation that is correlated with training intensity and union status alike. Nevertheless, 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. 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.

In the left panel of Figure 2 we plot the proportion of apprentices 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 first year of the new status is the zero line. The figure suggest that firms change their training policy when they change their status: The fraction of apprentices increases when

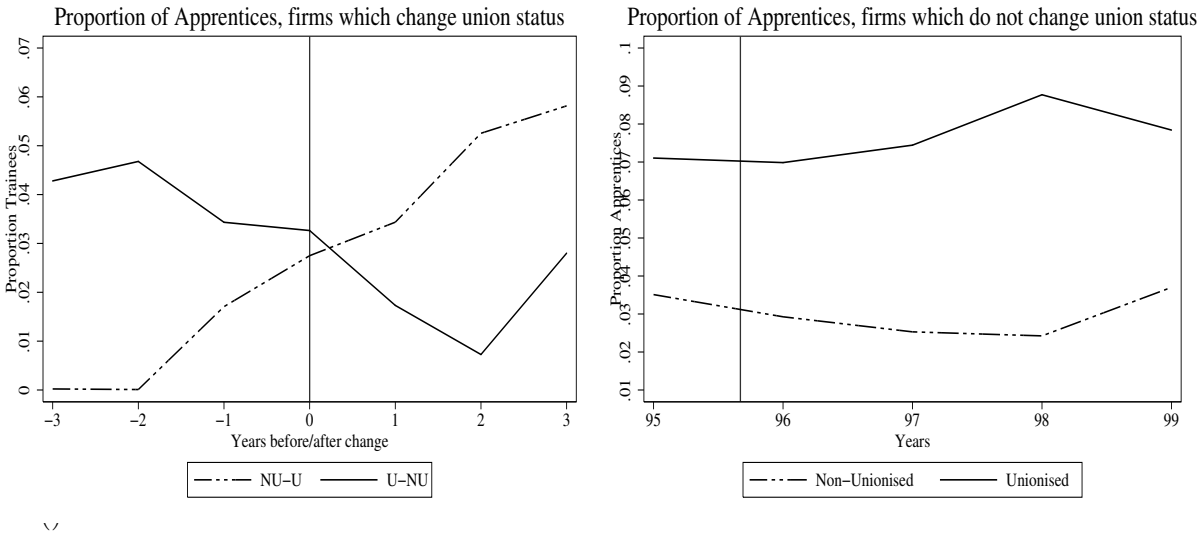


Figure 2: Proportion of Apprentices Trained

firms change from being non-unionised to being unionised, and decreases for firms that change from being unionised to non-unionised. The figure also shows that the increase in the fraction of apprentices starts before the actual change in union status, and continues after the change. This is not surprising, given that a change in union status is likely to be a long-term decision that is planned well in advance. For firms that change form being unionised to non unionised, there is a drop in the proportion of apprentices. Again, the process is not immediate. As apprenticeship training takes between two and three years, firms can not reduce their apprentice training programme immediately, and the proportion of apprentices should decline gradually - as suggested in the figure.

For comparison, we plot in the right panel of Figure 2 the proportion of apprentices against time for firms that are unionised and non-unionised for the entire observation period. This figure is markedly different, with the fraction of apprentices remaining basically constant over the observation window, and with a sizeable difference between unionised and non-unionised firms.

Difference in difference estimation

We now use the variation in union status over time to estimate the impact of unions on training using difference estimation and utilising information of changes in observable characteristics.

Define $\bar{y}_{jt}$ as the proportion of apprentices at time t in firm $\dot{j}$. 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, $\overline{\eta}_{jt}$, as well as observed and unobserved firm characteristics, f_{jt}. Assuming linearity, this relationship can be written as

$$\bar{y}_{jt} = \beta + \lambda_{jt} U_{jt} + \theta_t + \overline{\eta}_{jt} + f_{jt} + v_{jt}\,, \tag{3}$$

where v_{jt} is an i.i.d. error term.

The parameter we want to estimate is the difference in the training intensity between unionised and non-unionised firms for those firms that choose to be unionised. The simple difference estimator (as displayed in the figure above) may confound the effect of unionisation on training with common time effects, changes in firm characteristics, as well as changes in the composition of the workforce.

We estimate regressions of the following type:

$$\Delta\overline{y}_{jt} = \lambda_{jt}\,\Delta U_{jt} + \Delta X_{jt} d + \Delta\theta_t + \Delta v_{jt}, \tag{4}$$

where Δ is the first-difference operator, and X_{jt} is a vector of observed characteristics of the firm's work force as well as observed firm characteristics. Our sample consists of firms that join the unionised sector, and firms that are always non-unionised. This will identify the causal impact of unions on training under two assumptions. First, changes in common time effects ($\Delta\theta_t$) have to be 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. Second, any variation in changes in the workforce ($\Delta\,\overline{\eta}_{jt}$) and firm quality ($\Delta f_{jt}$) that are correlated with changes in the union status must be absorbed by changes in observed worker and firm characteristics.

Under these assumptions, the difference-in-difference estimator in (4) identifies:

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

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 $E(\lambda_{jt} - \lambda_{jt-1}|U_{jt} = 1, U_{jt-1} = 1, \Delta X_{jt}) = 0$. Finally, we could identify the causal impact of unions on training from firms that leave the unionised sector, using firms that are always non-unionised or firms that are always unionised as comparison groups.

Table 9: The effect of unionisation on training: Diff-in-Diff/Matching Estimation

Comparison Group	Always Non-unionised				Always Unionised			
Specification	I		II		I		II	
	Coef.	StdE.	Coef.	StdE.	Coef.	StdE.	Coef.	StdE
Change NU-U	0.015	*0.007*	0.014	*0.008*	0.015	*0.005*	0.014	*0.006*
# of observations	1487		941		6189		4314	
Change U-NU	0.003	*0.004*	0.002	*0.004*	0.005	*0.003*	0.003	*0.003*
# of observations	2080		1365		6782		4738	

Source: Firm panel, matched with employee information, 1995-1999. Specification I includes time dummies, and changes in: firm size (see footnote 5.3 for definition), investment per worker, revenue per worker, number of new hires, evaluation of profit, the proportion of qualified workers. Specification II (which uses only years 1996-1999) includes in addition changes in the average age of workers, the average daily wage, and the proportion of females, and the presence of a work council.

We display our results in Table 9. We present two specifications: specification I includes time dummies, and changes in: firm size, investment per worker, revenue per worker, number of new hires, the proportion of qualified workers, and evaluation of profit. Specification II includes in addition changes in: the the average age of workers, the average daily wage, the proportion of females, and the presence of a work council. Although, as we discuss above, work councils do not influence management decision regarding apprenticeship schemes, we include the latter variable to take account of any possible relationship between the introduction of work councils, unionisation and an increase in training intensity. This specification uses only years 1996-1999, as work council information is not available before 1996.

The first two pairs of columns report results where firms that are non-unionised in all periods are the comparison group; the second two pairs of columns uses firms that are unionised throughout as a comparison group. Estimates in the first row refer to firms that change from being non-unionised to being unionised. The coefficients suggest an increase in the proportion of apprentices relative to firms that are always non-unionised. The point estimate is smaller than the one we have obtained in our OLS estimations above, but significantly different from

zero. Results are very similar when we add worker characteristics and the work council variable (specification II). The last two pairs of columns use firms that are always unionised as a comparison group. Estimates are basically identical.

In the second row we report results for firms that change from being unionised to not being unionised. Coefficient estimates are now smaller, and, although having the expected sign, not significantly different from zero. This is not surprising: the decline in apprenticeship programme size should be gradual, as apprenticeship programmes last usually three years.

Long differences

To take account of the possibly gradual adaptation of apprenticeship training, we construct "long" differences by excluding the year in which a change took place. Thus we compare the year before a change with the year after a change. As our observation period is only 5 years, this reduces our sample of firms that change status. We report results for specification I in Table 10.

Table 10: The effect of unionisation on training: Diff-in-Diff/Matching Estimation, long differences

Comparison Group	Always Non-unionised		Always Unionised	
	Coef.	StdE.	Coef.	StdE
Change NU-U	0.021	*0.010*	0.017	*0.008*
# of observations	1392		6215	
Change U-NU	0.006	*0.006*	0.008	*0.004*
# of observations	6782		4738	

Source: IAB Firm panel, 1995-1999. Specifications as I in Table 9.

The coefficient estimate for firms changing from being non-unionised to being unionised increases to 0.021 when using firms that are always non-unionised as reference group, and to 0.017 when firms that are always unionised are the reference category. Both coefficients are significant.

The second row reports results for changes from being unionised to being non-unionised. Also here the point estimates increase in size, and the estimate is significant in the second pair of columns.

Robustness checks

These results provide support for our hypothesis that union recognition leads to an increase in apprenticeship training. Our estimates in Table 9 and Table 10 identify the causal impact of union recognition on training under the assumption that changes in unobserved worker and firm characteristics are uncorrelated with changes in the union status. The rich set of of firm and worker characteristics included in our regressions should absorb most of the variation in changes in the workforce and firm quality that are possibly correlated with changes in the union status. It may nevertheless be argued that firms which become unionised increase training because they now hire more qualified workers who are more likely to receive training. If this is the case, we would expect that a change union status also leads to a change in the observed quality of the workforce. To check this, we have estimated the same regressions as in Table 9 and Table 10, where our dependent variable is now the change in the proportion of qualified workers. The point estimate is equal to 0.012, but insignificant, with a standard error of 0.026. If we use long differences, the estimate equals 0.003, with a standard error of 0.027. It thus seems unlikely that the significant increase in the proportion of apprentices in firms that become unionised is purely driven by the selection of more qualified workers into these firms.

In our estimation results, we use all firms. Acemoglu and Pischke (1998) argue that training in small firms is likely to be worker-financed, and they eliminate small firms from their analysis. All our regressions condition on a flexible specification of firm size. To check whether exclusion of small firms affects our estimates, we re-run specification I in Table 9 only for firms that employ more than 30 employees. The point estimate equals 0.012, with a standard error of 0.003. If we use long differences, the estimate increases to 0.018, with a standard error of 0.005.

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 collective bargaining system based on voluntary union recognition. This effectively creates a unionised and non-unionised sector, defined by the firm's union recognition.

We first provide strong evidence that wage floors and wage compression play a more important role in unionised than in non-unionised firms. Furthermore, our empirical results support the key implication of our model that unionised firms are substantially more likely to train workers in apprenticeship schemes. 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.

We also find that non-unionised firms train apprentices. There are several explanations for this. First, it is possible that collective bargaining does not only lead to wage compression (and thus firm-financed traning) in unionised firms, but also in non-unionised firms, because of spill-overs from the unionised sector to the non-unionised sector [31]. To model spill-overs within the structure we have set out above, and to test for it would be an interesting project for future work.

Second, we have purposely abstracted from alternative explanations for wage compression and thus 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). Clearly, our results do not imply that unions are the only reason for apprenticeship training in Germany. Our finding that non-unionised firms also train workers in apprenticeship programmes suggests that firm-specific human capital or asymmetric information also contribute to firm-financed apprenticeship training. However, both reasons for wage compression should apply in unionised and non-unionised firms alike. Hence, models of firm-specific human capital accumulation and asymmetric information cannot account for the strong differences in the structure of wages and training intensity between unionised and non-unionised firms. This suggests that union recognition in the German system of centralised bargaining is an important reason for why firms support apprenticeship training schemes.

[31] Fitzenberger and Franz (1999) argue in favour of such spill-overs.

7 Appendix

A Proof of proposition 2

Proposition 2 *Unionised firms train workers with expected ability* $\widehat{\eta}_1 < \widehat{\eta} < \widehat{\eta}_2$. *These workers are offered a training level of* $\widetilde{\tau}_u$. *Training in unionised firms is less than socially optimal.*

We first show that the future profit of the unionised firm, $E[\Pi_u(\tau,\eta)|\widehat{\eta}]$, is increasing in training. The increase in $E[\Pi_u(\tau,\eta)|\widehat{\eta}]$ due to training equals

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

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, $\frac{\partial E[\Pi_u(\tau,\eta)|\widehat{\eta}]}{\partial \tau} \geq 0$, and $\widetilde{\tau}_u \geq 0$.

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

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

As $\frac{\partial E[\Pi_u(\tau,\eta)|\widehat{\eta}]}{\partial \tau} \geq 0$, $E[\Pi_u(0,\eta)|\widehat{\eta}] \leq -c(\widetilde{\tau}_u) + E[\Pi_u(\widetilde{\tau}_u,\eta)|\widehat{\eta}]$. Hence, if the fixed cost of training is equal to 0, $(k=0)$, every worker would get trained. Figure 7 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, $\widehat{\eta}$. It is first convex, then concave in $\widehat{\eta}$. To prove this, we first show that $E[\Pi_u(\tau,\eta)|\widehat{\eta}]$ is increasing in workers' expected ability. Differentiating $E[\Pi_u(\tau,\eta)|\widehat{\eta}]$ with respect to $\widehat{\eta}$ yields

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

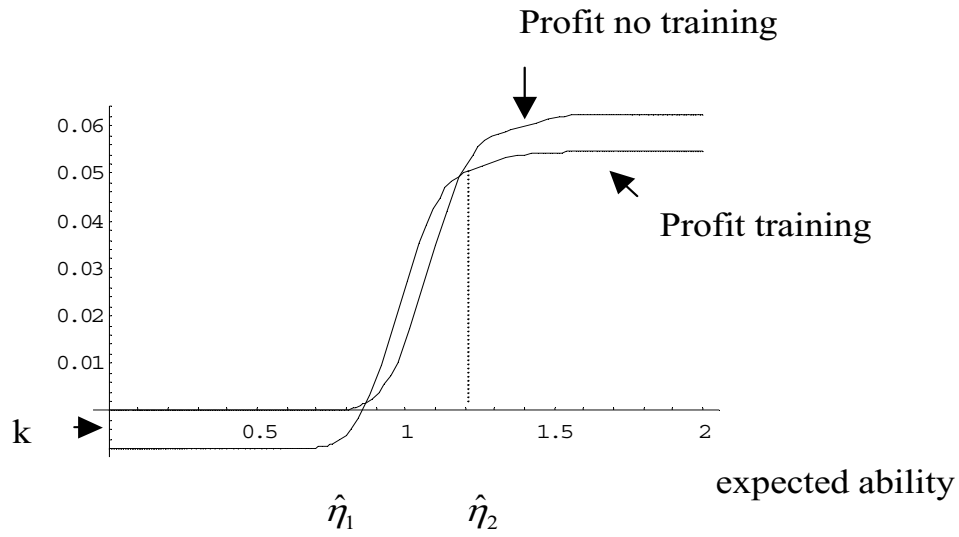
We next show that Π_u is first convex and then concave in $\widehat{\eta}$. Taking the second derivative yields

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

Observe that $\frac{\partial f_1(\eta|\widehat{\eta})}{\partial \widehat{\eta}} > 0$ if $\widehat{\eta} < \eta$, and $\frac{\partial f_1(\eta|\widehat{\eta})}{\partial \widehat{\eta}} < 0$ if $\widehat{\eta} > \eta$. Hence, the second derivative is positive for low and negative for high values of $\widehat{\eta}$. $E[\Pi_u(\tau,\eta)|\widehat{\eta}]$ is thus first convex, then

concave in $\widehat{\eta}$. Note that $\lim_{\widehat{\eta}\to-\infty} E[\Pi_u(\tau,\eta)|\widehat{\eta}] = 0$: 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, $\lim_{\widehat{\eta}\to\infty} E[\Pi_u(\tau,\eta)|\widehat{\eta}] = (1-G(\Delta))\Delta$: 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 $\widehat{\eta}_1$ and $\widehat{\eta}_2$ such that expected profits with training exceed expected profits without training if $\widehat{\eta}_1 < \widehat{\eta} < \widehat{\eta}_2$. See figure 7 for an illustration[32].

Figure 7: Profit with and without training by expected ability



We next show that unionised firms offer less training than the socially optimal level. Let $\widetilde{\tau}$ denote the socially optimal training level. It satisfies $c\prime(\widetilde{\tau}) = \frac{\partial E[h(\widetilde{\tau})\eta|\widehat{\eta}]}{\partial\tau}$ (conditional on the worker receiving training). The training level unionised firms offer, however, satisfies $c\prime(\widetilde{\tau}_u) = \frac{\partial E[\Pi_u(\widetilde{\tau}_u,\eta)|\widehat{\eta}]}{\partial\tau}$. It is easy to see that $\frac{\partial E[y(\widetilde{\tau})\eta|\widehat{\eta}]}{\partial\tau} > \frac{\partial E[\Pi_u(\widetilde{\tau}_u)\eta|\widehat{\eta}]}{\partial\tau}$. Hence, unionised firms offer a lower training level than the socially optimal level.

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

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,

$$W_{nu} = \widehat{\eta} + (1 - G(\Delta))\Delta. \tag{7}$$

The wage offer of unionised firms can be similarly derived as

$$W_u = \begin{cases} \min\{\overline{w}, \widehat{\eta} + E[\Pi_u(0,\eta)|\widehat{\eta}]\} \\ \qquad\qquad \text{if } \widehat{\eta} < \widehat{\eta}_1 \text{ or } \widehat{\eta} > \widehat{\eta}_2 \quad \text{(no training)}. \\ \widehat{\eta} - k + E[\Pi_u(\widetilde{\tau}_u,\eta)|\widehat{\eta}] - c(\widetilde{\tau}_u) \\ \qquad\qquad \text{if } \widehat{\eta}_1 \leq \widehat{\eta} \leq \widehat{\eta}_2 \quad \text{(training)}. \end{cases} \tag{8}$$

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

B 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,

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

where $W_j(\tau_j, \widehat{\eta})$, $j = u, nu$ denotes the worker's first period wage in a unionised or non-unionised firm, and $E[U_j(\tau_j^*,\eta)|\widehat{\eta}]$, $j = u, nu$ 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, $E[U_{nu}(0,\eta)|\widehat{\eta}]$. 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

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

Using that the worker's first period wage equals $W_{nu}(0,\eta) = \widehat{\eta} + (1 - G(\Delta))\Delta$ (expression (7)), her utility from working in a non-unionised firm can be computed as

$$W_{nu}(0,\widehat{\eta}) + E[U_{nu}(0,\eta)|\widehat{\eta}] = 2\widehat{\eta} + \int_{\Delta}^{\overline{\theta}} \theta dG(\theta). \tag{9}$$

Next, we derive the worker's second period utility when working in a unionised firm in the first period, $E[U_u(\tau_u^*,\eta)|\widehat{\eta}]$. 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 $\overline{w} + \theta$ if they stay and y if they leave. The probability that they stay is $1 - G(y - \overline{w})$. 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, $E[U_u(\tau_u^*,\eta)|\widehat{\eta}]$ can be computed as

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

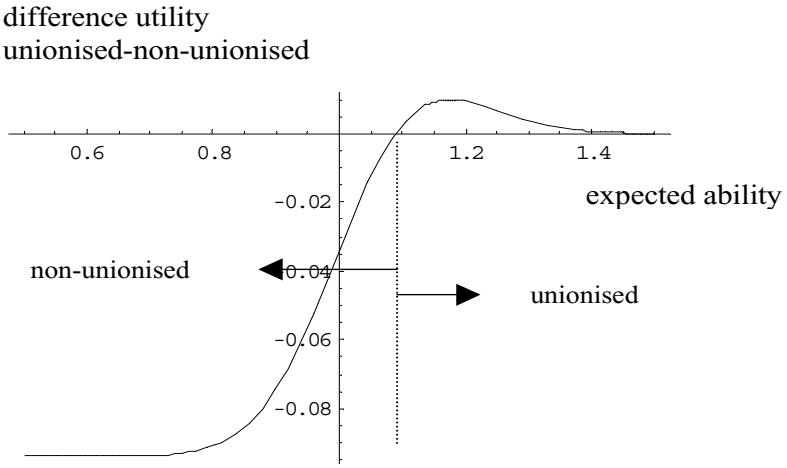
Using expression (8) for the worker's wage in the first period, her utility from working in a unionised firm can be computed as

$$W_u(\tau_u^*,\widehat{\eta}) + E[U_u(\tau_u^*,\eta)|\widehat{\eta}] = \begin{cases} 2\widehat{\eta} + \int_{\eta_1}^{\eta_2} \int_{\eta-\overline{w}}^{\overline{\theta}} \theta dG(\theta) dF_1(\eta|\widehat{\eta}) & \\ +(1 - F_1(\eta_2|\widehat{\eta})) \int_{\Delta}^{\overline{\theta}} \theta dG(m) & \text{if } \tau_u^* = 0, \\ \widehat{\eta} - k - c(\widetilde{\tau}_u) + \int_{-\infty}^{\infty} f(\widetilde{\tau}_u)\eta dF_1(\eta|\widehat{\eta}) & \\ + \int_{\eta_1}^{\eta_2} \int_{y-\overline{w}}^{\overline{\theta}} \theta dG(\theta) dF_1(\eta|\widehat{\eta}) & \text{if } \tau_u^* = \widetilde{\tau}_u. \\ +(1 - F_1(\eta_2|\widehat{\eta})) \int_{\Delta}^{\overline{\theta}} \theta dG(m) & \end{cases} \tag{10}$$

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: $c'(\widetilde{\tau}_u) = \frac{\partial E[\Pi_u(\widetilde{\tau}_u,\eta)|\widehat{\eta}]}{\partial \tau_u}$. Also note that the worker's utility from working in a unionised firm can be written as $W_u(\tau_u,\widehat{\eta}) + E[U_u(\tau_u,\eta)|\widehat{\eta}] = -k - c(\tau_u) + E[\Pi_u(\tau_u,\eta)|\widehat{\eta}] + E[U_u(\tau_u,\eta)|\widehat{\eta}]$. Hence, the training level that maximises the worker's utility, τ_u^w, satisfies $c'(\tau_u^w) = \frac{\partial E[\Pi_u(\tau_u^w,\eta)|\widehat{\eta}]}{\partial \tau_u} + \frac{\partial E[U_u(\tau_u^w,\eta)|\widehat{\eta}]}{\partial \tau_u}$. Clearly, $\tau_u^w \geq \widetilde{\tau}_u$. Workers thus prefer to receive training level $\widetilde{\tau}_u$ 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.

Figure 8: Utility difference from working in a unionised and non-unionised firm



Next, consider the impact of ability on worker sorting. Suppose unionised and non-unionised firms offer the same amount of training. Figure 8 plots the difference between the utility from working in a unionised and non-unionised firm as a function of workers' expected ability. First observe that from (10), the utility from working in a unionised firm converges to $2\widehat{\eta}$ as the worker's ability becomes very low. In contrast, from (9), the utility from working in a non-unionised firm converges to $2\widehat{\eta}+\int_{\Delta}^{\overline{\theta}}\theta dG(\theta)$ as expected ability becomes low. Low ability workers are therefore better off in non-unionised firms. Second, observe that $\int_{y-\overline{w}}^{\overline{\theta}}\theta dG(\theta) > \int_{\Delta}^{\overline{\theta}}\theta dG(\theta)$: 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.

C Using job-to-unemployment movers as a proxy for a layoff

Consider two identical workers. One worker is employed in a unionised firm, the other in a non-unionised firm. Let q^u (q^{nu}) and l^u (l^{nu}) denote the probability that the worker in the unionised firm (non-unionised firm) quits or is laid off, respectively. Our model predicts that the worker in the unionised firm is more likely to be laid off and less likely to quit, i.e. $q^u < q^{nu}$ and $l^u > l^{nu}$. In the data, however, we do not observe whether a worker was laid off or quit. We only observe whether the worker who leaves the firm after apprenticeship training becomes unemployed or moves to another firm without an intervening unemployment spell. How does this affect our results?

Suppose that conditional on a layoff or a quit, otherwise identical workers in unionised and non-unionised firms have the same probability of becoming unemployed. This assumption is reasonable since both workers are eligible for the same amount of unemployment benefits. Further suppose that the probability of becoming unemployed is higher for workers who have been laid off than for workers who quit voluntarily[33]. Under these assumptions, we show that if the unionised worker is more likely to become unemployed and less likely to move from job-to-job, it necessarily must be the case that the unionised worker is more likely to be laid off and less likely to quit.

Let u^l and u^q denote the probability that a laid off worker and a worker who quit voluntarily become unemployed. According to our second assumption, $u^l > u^q$. The probability that a worker in a unionised or non-unionised firm becomes unemployed, conditional on being trained in a unionised or non-unionised firm, then equals

$$\begin{aligned} \Pr(\text{u}|\text{union}) &= l^u * u^l + q^u * u^q, \text{ and} \\ \Pr(\text{u}|\text{non-union}) &= l^{nu} * u^l + q^{nu} * u^q. \end{aligned}$$

Similarly, the probability that a worker in a unionised or non-unionised firm moves from job-to-

[33]For instance, Nagypal (2004) reports that the fraction of workers who were laid off is substantially higher among job-to-unemployment and job-to-job movers.

job equals

$$\begin{aligned} \Pr(\text{jtj}|\text{union}) &= l^u * (1-u^l) + q^u * (1-u^q), \text{ and} \\ \Pr(\text{jtj}|\text{non-union}) &= l^{nu} * (1-u^l) + q^{nu} * (1-u^q). \end{aligned}$$

Hence, the difference between the probability of a unionised and non-unionised worker to become unemployed or move from job-to-job equals

$$\Pr(\text{u}|\text{union}) - \Pr(\text{u}|\text{non-union}) = u^l(l^u - l^{nu}) + u^q(q^u - q^{nu}), \text{ and} \quad (11)$$

$$\Pr(\text{jtj}|\text{union}) - \Pr(\text{jtj}|\text{non-union}) = (1-u^l)(l^u - l^{nu}) + (1-u^q)(q^u - q^{nu}). \quad (12)$$

First note that the first difference (equation 11) may be negative even if $l^u > l^{nu}$ since $q^u < q^{nu}$. Similarly, the second difference (equation 12) may be positive even if $q^u < q^{nu}$ since $l^u > l^{nu}$. Hence, using job-to-job and job-to-unemployment movers as proxies for quits and layoffs make it harder for us to detect differences in layoff and quit rates between unionised and non-unionised firms. Suppose that in the data we nevertheless observe $\Pr(\text{u}|\text{union}) - \Pr(\text{u}|\text{non-union}) > 0$ and $\Pr(\text{jtj}|\text{union}) - \Pr(\text{jtj}|\text{non-union})$. Note that if one difference is positive while the other is negative, there are two possible cases:

(a) $l^u > l^{nu}$ and $q^u < q^{nu}$, i.e. unionised workers are more likely to be laid off and less likely to quit, or

(b) $l^u < l^{nu}$ and $q^u > q^{nu}$, i.e. unionised workers are less likely to be laid off and more likely to quit.

Suppose the second case is true. Rearranging equation (12) implies $\frac{1-u^q}{1-u^l} < \frac{l^{nu}-l^u}{q^u-q^{nu}}$, while rearranging equation (11) implies $\frac{u^q}{u^l} > \frac{l^{nu}-l^u}{q^u-q^{nu}}$. Both conditions are jointly satisfied only if $\frac{1-u^q}{1-u^l} < \frac{u^q}{u^l}$, or if $u^l > u^q$. However, this possibility, we have ruled out. Hence, if workers in unionised firms are more likely to become unemployed and less likely to move from job-to-job, it necessarily must be the case that they are more likely to be laid off and less likely to quit.

D Data description

Social security records

We define variables as follows.

- *Education* We distinguish three education groups, workers without an apprenticeship, and workers with a completed apprenticeship, and workers with a college degree. We use the *bild* variable in the data set to classify workers into these three groups. 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. Large firms are oversampled. 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. Firms in the construction sector are excluded. 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 1^{st} each year. Table 11 lists and defines the variables of the firm data used in the empirical analysis.

Table 11: 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 revenue 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)
work council	1 if establishment has a work council
Proportion apprentices	Number of apprentices divided by number of employees;

References

[1] Acemoglu, D. and J.-S. Pischke (1998), "Why Do Firms Train: Theory and Evidence", Quarterly Journal of Economics, 113, 79-119.

[2] Acemoglu, D. and S. Pischke (1999a), "Beyond Becker: Training in Imperfect Labour Markets", Economic Journal Features, 109, F112-F142.

[3] Acemoglu, D. and S. Pischke (1999b), "The Structure of Wages and Investment in General Training", Journal of Political Economy, 107, 539-573.

[4] Acemoglu, D. and S. Pischke (2001), "Minimum Wages and On-the-Job Training", IZA Discussion Paper No. 384.

[5] Acemoglu, D., Aghion, P. and G. Violante (2001), "Deunionization, Technical Change and Inequality ", Carnegie-Rochester Conference Series of Public Policy, 55, 229-264.

[6] Addison, J., Bellmann, L., Schnabel, C. and J. Wagner, "The Reform of the German Works Constitution Act: A Critical Assessmnet", Industrial Relations, 43, 392-420.

[7] Altonji, J.G. and J.R. Spetzler (1991), "Worker Characteristics, Job Characteristics, and the Receipt of On-the-Job Training", Industrial and labour Relations Review, 45, 58-71.

[8] Arulampalam, W., A.L. Booth, and M.L. Bryan, "Work-related Training and the New National Minimum Wage in Britain", mimeo, Australian National University, 2003.

[9] Autor, D. (2001), "Why Do Temporary Help Firms Provide Free General Skills Training?" Quarterly Journal of Economics, 116, 1409-1448.

[10] von Bardeleben, R., Beicht, U. and Feher, K. (1995), "Betriebliche Kosten und Nutzen der Ausbildung. Repräsentative Ergebnisse aus Industrie, Handel und Handwerk", Berichte zur beruflichen Bildung, Heft 187, Bielefeld: Bertelsmann.

[11] Becker, G. (1964), "Human Capital", Chicago: The University of Chicago Press.

[12] Beckmann, M. (2002), "Firm-sponsored Apprenticeship Training in Germany: Empirical Evidence from Establishment Data", Review of Labour Economics and Industrial Relations, 16, 287-310.

[13] Bhaskar, V. and S. Holden (2002), "Wage Differentiation vs Generalised Training", mimeo, University of Essex.

[14] Bispinck, R. (2001), "Qualifizierung und Weiterbildung in Tarifverträgen - Bisherige Entwicklung und Perspektiven", in: Rolf Dobischat/Hartmut Seifert (Hrsg.), "Lernzeiten neu organisieren. Lebenslanges Lernen durch Integration von Bildung und Arbeit", Berlin, 153-180.

[15] Bispinck, R., M. Dorsch-Scweizer and J. Kirsch (2002), "Tarifliche Ausbildung begrenzt erfolgreich - eine empirische Wirkungsanalyse", WSI-Mitteilungen.

[16] Booth, A. L. and M. Chatterji (1998), "Unions and Efficient Training", Economic Journal, 108, 328-343.

[17] Booth, A. L., Francesconi, M., and G. Zoega (2002), "Oligopsony, Institutions and the Efficiency of General Training", IZA Discussion Paper No. 618..

[18] Booth, A. L., Francesconi, M., and G. Zoega (2003), "Unions, Work-Related Training, and Wages: Evidence for British Men", Industrial and Labor Relations Review, 57, 68-91.

[19] Card, D. (1996), The Effect of Unions on the Structure of Wages: A longitudinal analysis, Econometrica, 64, 057-980.

[20] Card, D, T. Lemieux, and C Riddell (2004), "Unions and Wage Inequality, Journal of Labor Research, Symposium on What Do Unions Do A Retrospective After Two Decades

[21] DeGroot, M.H. (1970), "Optimal Statistical Decisions", New York: McCraw-Hill.

[22] Dinardo, J., Fortin, N. and T. Lemieux (1996), "Labor Market Institutions and the Distribution of Wages: A Semi-Parametric Approach", Econometrica, 64, pp. 1001-1044.

[23] DiNardo, J. and D.S. Lee (2002), "The Impact of Unionization on Establishment Closure: A Regression Discontinuity Analysis of Representation Elections", NBER Working Paper #8993.

[24] Fitzenberger, B. and W. Franz (1999), "Industry-Level Wage Bargaining: A Partial RehabilitationThe German Experience" Scottish Journal of Political Economy, 46, 437-457

[25] Franz, W. and D. Soskice (1995), "The German Apprenticeship System", in: F. Buttler, W. Franz, R. Schettkat, and D. Soskice (eds.), Institutional frameworks and labor market performance, London and New York: Routledge, 208-304.

[26] Freeman and Lazear (1995), "An Economic Anlaysis of Works Councils", in: Works Councils: Consultation, Representation, and Cooperation in Industrial Relations", J. Rogers and W. Streek (ed.), University of Chicago Press for the NBER.

[27] Freeman, R.B., and J. L. Medoff (1984), "What Do Unions Do?", New York: Basic Books.

[28] Fortin, N. and T. Lemieux (1997), "Institutional Change and Wage Inequality: Is there a Linkage?", Journal of Economic Perspectives, 11, pp. 75-96.

[29] Gibbons, R. and L.F. Katz (1991), "Layoffs and Lemons", Journal of labour Economics, 9, 351-380.

[30] Green, D. A, and T. Lemieux (2001), " The Impact of Unionisation on the Incidence of and Sources of Payment for Training in Canada: A Study based on the Adult Education and Training Survey", Working Paper, University of British Columbia.

[31] Green, F., S. Machin, D. Wilkinson (1996), "Trade Unions and Training Practices in British Workplaces", Industrial and Labor Relations Review, 52, 179-195.

[32] Grossberg, A. J. and P. Sicilian (1999), "Minimum Wages, On-the-Job Training, and Wage Growth", Southern Economic Journal, 65, 539-56.

[33] Hans Boeckler Stiftung (2003), WSI-Tarifarchiv, http://www.boeckler.de/cps/rde/xchg/SID-3D0AB75D-50FCE228/hbs/hs.xsl/563_20980.html.

[34] Hashimoto, M. (1982), "Minimum Wage Effects on Training on the Job ", American Economic Review 72, 1070-1087.

[35] Hogan, C. (2001), "Enforcement of Implicit Contracts through Unionization", Journal of Labor Economics, 19, 171-195.

[36] Hbler, Ol and U Jirjahn (2003), "Works Councils and Collective Bargaining in Germany: The Impact on Productivity and Wages", Scottish Journal of Political Economy 50 (4), 471-491.

[37] Kirsch, J. and R. Bipinck (2002), "Kurzinformation: Allgemeinverbindliche Tarifverträge", WSI, Informationen zur Tarifpolitik.

[38] Kölling, A. (2000), "The IAB-Establishment Panel", Zeitschrift für Wirtschafts- und Sozialwissenschaften, 120, 291-300.

[39] Lemieux, T. (1998), "Estimating the Effects of Unions on Wage Inequality in a Panel Data Model with Comparative Advantage and Nonrandom Selection", Journal of Labor Economics, 16, pp. 261-291.

[40] Nagypal, E. (2004), Worker Reallocation over the Business Cycle: The Importance of Job-to-Job Transitions, mimeo, Northwestern University

[41] Machin, S (2000), Union Decline in Britain, British Journla of Industrial Relations, 38, 631-645

[42] Medoff, J.L. (1979), "Layoffs and Alternatives under Trade Unions in U.S. Manufacturing", American Economic Review, 69, 380-395.

[43] Malcomson, J. M. (1983), "Trade Unions and Economic Efficiency", Economic Journal (Conference Papers Supplement), 93, 50-65.

[44] Mincer, J. (1983), "Union Effects: Wages, Turnover, and Job Training", Research in Labor Economics, 217-252.

[45] Neumark, D. and W. Wascher (2001), "Minimum Wages and Training Revisited", Journal of Labor Economics, 19, 563-595.

[46] Rosen, S (1972), "Learning and Experience in the Labor Market", Journal of Human Resources, 7, 326-342.

[47] Schnabel, C. and J. Wagner (2003), "Trade Union Membership in Eastern and Western Germany: Convergence or Divergence? "Applied Economics Quaterly, 49, 213-232.

[48] Soskice, D. (1994), "Reconciling Markets and Institutions: The German Apprenticeship System", in: L.M. Lynch (ed.) Training and the Private Sector, International Comparisons, NBER Series in Comparative Labor Markets, Chicago: University of Chicago Press, 1-24.

[49] Stevens, M (1994), "A Theoretical Model of On-the-job training with Imperfect competitions ", Oxford Economic Papers, 46, 537-562.

[50] von Wachter, T. and S. Bender (2005), " In the Right Place at the Wrong Time: The Role of Firms and Luck in Young Workers' Careers", American Economic Review, forthcoming.

[51] Winkelmann, R. (1997), "How Do Young Workers Get Their Training: A Survey of Germany vs the US", Journal of Population Economics, 10, 159-170.

[52] Zwick, T (2003), "Work Councils and the Productivity Impact of Direct Employee Participation", ZEW discussion paper No. 03-47