

TRAINING AND UNION WAGES

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Abstract—This paper investigates whether unions, through imposing wage floors that lead to wage compression, increase on-the-job training. Our analysis focuses on Germany. Based on a model of unions and firm-financed training, we derive empirical implications regarding apprenticeship training intensity, layoffs, wage cuts, and wage compression in unionized and nonunionized firms. We test these implications using firm panel data matched with administrative employee data. We find support for the hypothesis that union recognition, via imposing minimum wages and wage compression, increases training in apprenticeship programs.

I. Introduction

THIS paper addresses the question of how labor market institutions, in particular minimum wages imposed by unions, affect on-the-job training through wage compression. Our empirical investigation focuses on Germany, which provides an interesting context for this analysis. First, Germany has a large institutionalized youth training program, the German apprenticeship system,¹ training about 65% of each cohort of labor market entrants. Training is mostly in general skills, and financed partly by firms.² Second, Germany's collective bargaining system provides a unique opportunity for testing the hypothesis that unions increase training.

The German system differs in many aspects from those in the United States and United Kingdom. Most importantly, in Germany, union agreements are binding only in firms that belong to an employer federation (*Arbeitgeberverband*), and extend to all workers, regardless of whether they are union members. Firm membership in an employer federation is voluntary. In the late 1990s, an average of 44% of all firms did not belong to an employer federation. However, larger firms are more likely to join an employer federation, so only 27% of the workforce was not covered by union agreements (own calculations based on the IAB establishment panel, years 1995–1999). A second important feature

of the German collective bargaining system is that union wages act as minimum wages. Payment above the union wage appears to be common. In the late 1990s, about 48% of all firms that recognized a union paid (to some employees) wages above the union wage. On average, wages paid above the union wage were about 10% higher than the union wage (own calculations based on the IAB establishment panel, years 1995–1999).

To guide the empirical analysis, we first develop a model of firm-financed training. Our point of departure is the work by Acemoglu and Pischke (1999a, 1999b, 2003), Booth and Chatterji (1998), and Booth, Francesconi, and Zoega (2003). In contrast to these models, in our model a unionized and a nonunionized sector coexist. The difference between the two sectors is that firms in the unionized sector have to pay *at least* the union wage, while firms in the nonunionized sector are allowed to pay a lower wage. This mirrors the key features of the German collective bargaining system. We further extend the existing models of unions and training by allowing for endogenous worker mobility after training, as well as by allowing for worker heterogeneity.

Our empirical analysis begins with a test of the main assumption of our model: wages are more compressed in unionized than in nonunionized firms. This paper thus also adds to the large literature on how unions affect the wage structure. Our matched employer-employee data allow us to go beyond what has been possible for the United States and United Kingdom. In particular, we are able to condition on firm fixed effects when comparing the variance of log-wages and education wage differentials in unionized and nonunionized firms. Our results support the hypothesis that wages are more compressed in unionized than in nonunionized firms.

A more compressed wage structure in unionized firms should lead to more firm-financed training in those firms. In the second step of the empirical analysis, we investigate differences in apprenticeship training between unionized and nonunionized firms. The key issue here is that there is selection of workers and possibly firms into the unionized sector. Our identification strategy exploits the changes in union status over time, allowing us to control for unobserved time-invariant firm (and worker) heterogeneity, and uses firms that do not change union status to control for common time effects. We seek to eliminate changes in workforce and firm quality by conditioning on a rich set of observables. Our empirical evidence is compatible with our hypothesis that membership of firms in employer federations increases training in apprenticeship programs.³

³ For the United Kingdom, studies by Böheim and Booth (2004), Booth et al. (2003, 2006) and Green, Machin, and Wilkinson (1999) also indicate that workers covered by union agreements receive more training. For

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

² Typically, apprentices spend four 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. See studies by Acemoglu and Pischke (1999b) and Beicht, Herget, and Walden (2004), among others, on the cost of training apprentices.

In the third step of the empirical analysis, we test two novel implications that are unique to our model and thus help to distinguish it from existing models of unions and training. Both implications are a direct consequence of wage floors that are binding in unionized firms, but not in non-unionized firms. First, wage floors should prevent unionized 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 unionized than in nonunionized firms. Second, there should be more layoffs in unionized than in nonunionized firms: Since unionized firms are not allowed to pay wages below the union wage, they lay off workers who turn out to be less productive than the union wage. We find support for both implications.

Overall, the empirical evidence is compatible with our hypothesis that membership of firms in employer federations leads to wage compression and increases training in apprenticeship programs.

The structure of the paper is as follows. Section II develops a model of employer-financed training. Section III describes the data sources and samples we use. Section IV presents estimation results, and section V concludes with a discussion of our findings.

II. A Model of Firm-Financed Training

We begin by developing a model of union agreements and firm-financed training. The crucial feature of our model is the coexistence of unionized and nonunionized sectors. The difference between the two sectors is that firms in the unionized sector have to pay at least the union wage, while firms in the nonunionized sector can pay a lower wage.

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 & Pischke, 1999b; Franz & Soskice, 1995), and asymmetric information between incumbent and outside firms (Acemoglu & Pischke, 1998).⁴

A. Setup

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

Canada, in contrast, Green and Lemieux (2007) conclude that unions have little impact on training. Evidence on the impact of minimum wages on training is mixed. While Acemoglu and Pischke (2003) and Arulampalam, Booth, and Bryan (2004) find that minimum wages have no impact or even increase training, Neumark and Wascher (2001) conclude that minimum wages decrease training.

⁴ A further alternative explanation for wage compression is asymmetric information with respect to workers and firms (see Autor, 2001, and Bhaskar & Holden, 2002, for models of this type). For an alternative approach, see Stevens (1994).

Unlike existing models of unions and training, such as Acemoglu and Pischke (1999b), our model allows for worker heterogeneity. As we will see below, this implies that a unionized and nonunionized sector coexists in equilibrium. Workers' productivity y in period 2 depends not only on the amount of training received in period 1, but also on their (true) ability, $y = \eta h(\tau)$. We assume that human capital $h(\tau)$ is strictly increasing, differentiable, and concave in training τ (that is, $h'(\tau) < 0$) and that $h(\tau) > 1$ for $\tau > 0$. The productivity of an untrained worker is η (that is, $h(0) = 1$). For simplicity, we assume that the productivity of workers in training is the same as that of untrained workers. We denote the variable cost of training by $c(\tau)$ and assume that $c(\tau)$ is strictly increasing, differentiable, and convex (that is, $c''(\tau) > 0$) with $c(0) = c'(0) = 0$. We further assume that the firm's production function exhibits constant returns to scale, in other words, the total productivity of a firm is equal to the sum of each worker's productivity. A worker's ability η is drawn from a normal distribution with mean $\bar{\eta}$ and variance σ_{η}^2 .

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

In the first period, firms—as opposed to workers—decide how much training to offer to a worker. Training is continuous, and firms can condition their investment decision on workers' expected ability. We analyze the firm's decision to train under the assumption that firms can commit to only providing training, but not to the amount of training. This is what Acemoglu and Pischke (1999b) refer to as the *constrained regime*. For our particular application, this assumption seems reasonable. Trainees take centralized exams at the end of the apprenticeship period and receive a certificate. Hence, it is clearly verifiable whether a worker has received some apprenticeship training. However, an important part of apprenticeship training takes place inside the firm—which is not easily verifiable by outside parties, even if it is observable.

Unlike existing models of unions and training, we allow for endogenous worker mobility at the end of the training period. As in Acemoglu and Pischke (1998), we assume that during the training period workers experience a utility shock θ , capturing the worker's ex post evaluation of her work environment (such as nonmonetary personal perceptions of the work environment, location, and colleagues). The worker observes θ , but the firm does not. The utility shock

is drawn from a distribution G with the probability density function g and support $[\underline{\theta}, \bar{\theta}]$, where $\bar{\theta} > 0$. We assume that $G(\cdot)$ belongs to the family of log-concave distribution functions, i.e., $g(\theta)/(1 - G(\theta))$, is non-decreasing in θ . We also assume that the distribution of the utility shock depends on neither ability nor training. The worker's utility in period 2 at the incumbent firm, U , is a linear function of the incumbent firm's wage offer, w , and the utility θ from nonpecuniary job characteristics: $U = w + \theta$. The worker's utility at outside firms is equal to the wage offer, v .

In each period, firms simultaneously make wage offers to workers by maximizing 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.

In addition to endogenous worker mobility, a key feature that further distinguishes our model from those in the existing literature is the coexistence of unionized and non-unionized firms. In our model, the only difference between these two types of firms is that unionized firms have to pay at least the union wage (and may pay a higher wage) to workers who are not in training. This assumption mirrors the German collective bargaining system where union wages act as minimum wages and payment above the union wage is not uncommon. Since a nationwide minimum wage does not exist in Germany, no wage floor is binding in nonunionized firms. We further assume that firms can lay off apprentices at the end of the training period without cost; although firing costs in Germany are generally quite high, firms face no firing costs at the end of apprenticeship training. Finally, we assume that firms cannot switch union status, and that a single union wage applies to trained and untrained workers.⁵

We begin with wage determination in the second period in unionized and nonunionized firms. We then turn to firms' incentives to train and wage determination in the first period.

B. Wage Determination

Consider first wage determination in outside firms. Due to perfect competition in the outside market, outside firms—regardless of their union status—bid up workers' wage until it equals their (marginal) productivity, that is, $v = y = h(\tau)\eta$.⁶

⁵ Note that in Germany, unions and employer federations do *not* directly bargain over training; see Bispinck (2001) and Bispinck, Dorsch-Schweizer, and Kirsch (2002) for evidence.

⁶ Note, however, that unionized firms will not make a wage offer to workers with a productivity below the union wage. Also note that since outside wages equal productivity, there are no poaching externalities in our model, as for instance discussed by Stevens (1994). To keep the model as simple as possible, we also abstract from spillovers from the unionized to the nonunionized sector, as for instance discussed by Fitzenberger and Franz (1999).

Next, consider nonunionized incumbent (training) firms. Let w denote their wage offer. Incumbent firms set wages by maximizing expected profits, and trade off a higher chance of attracting workers with a lower rent per worker. A worker stays with the training firm if the utility $w + \theta$ from staying exceeds the utility $v = y$ from moving. Hence, the probability of staying is $\Pr(\text{stay}) = \Pr(\theta > y - w) = 1 - G(y - w)$. Incumbent firms therefore maximize

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

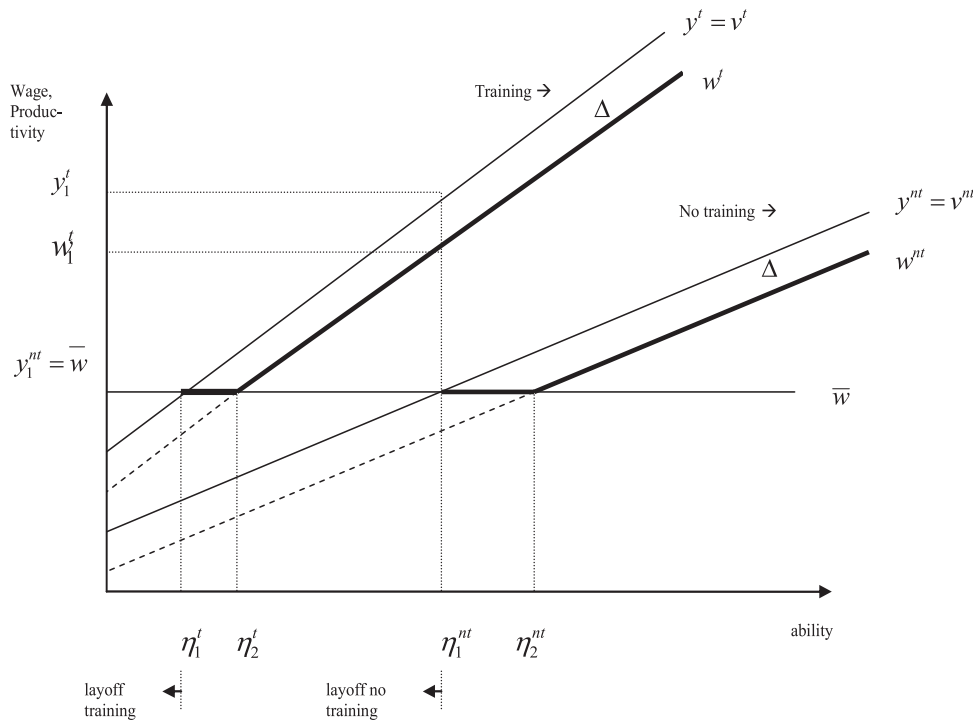
From the first-order condition, w satisfies $w = y - (1 - G(y - w))/g(y - w)$. Log-concavity of G guarantees that the second-order condition for a maximum is satisfied. Since workers stay with the incumbent firm with positive probability even if they receive a higher outside wage offer, firms pay wages below productivity. It can be easily verified that the wage offer of the nonunionized incumbent firms is equal to the worker's productivity minus a constant, $w = y - \Delta$. Consequently, due to nonpecuniary job characteristics, non-unionized firms earn (second period) rents on workers, but the rent does not vary with the worker's productivity. We would like to stress that nonpecuniary job characteristics are only one reason why firms may earn positive (second period) profits; other reasons include mobility costs and search frictions. Our arguments would apply in such environments as well.

Finally, consider unionized incumbent firms. Unlike non-unionized firms, unionized firms have to pay at least the union wage, \bar{w} , and may offer a higher wage. Figure 1 illustrates how wage floors change the wage determination process in unionized firms. In the figure, we consider untrained and trained workers. The wage and productivity of a worker are on the vertical axis, and her ability is on the horizontal axis. Productivity and wages of untrained (trained) workers in the absence of union agreements are indicated by the panels y^u (y^t) and w^u (w^t). From our previous arguments, they are equal to productivity minus a constant, Δ . The horizontal line indicates the union wage \bar{w} . The figure is drawn such that training increases the productivity of high-ability workers by more than that of low-ability workers; however, this is not essential for our key results.

Consider first workers with productivity below the union wage \bar{w} . In the figure these are workers with ability below η_1^t if trained and η_1^u if untrained. Unionized firms do not find it profitable to employ these workers. Since there are no firing costs at the end of the apprenticeship, these workers are laid off.⁷ Union agreements leave these workers worse off.

⁷ Note that layoffs at the end of the training period occur because employers acquire new information about workers' ability during the training period. If unionized firms had known workers' ability in the first period, workers with an ability below η_1^u (η_1^t) would not have been hired.

FIGURE 1.—WAGE DETERMINATION IN UNIONIZED FIRMS



The figure illustrates wage determination in unionized firms. Workers with ability lower than η_1^t (η_1^u) are laid off when trained (untrained). Workers with ability between η_1^t and η_2^t (η_1^u and η_2^u) earn the union wage when trained (untrained).

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 between η_1^u and η_2^u if untrained. Unionized incumbent firms would optimally like 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^u and η_2^u) are paid the union wage. These workers are better off because of 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 above η_2^u if untrained. For these workers, the union wage is not binding and they earn the same wage as in the absence of union agreements. These workers are no better or worse off because of unions.

Notice that wage floors lead to a compressed wage structure in unionized firms: for workers in the middle range of the ability distribution, firms earn higher profits on more productive workers.

C. Training

Next, we turn to the firm's training decision in the first period. It is easy to see that nonunionized firms do not finance training. Since firms cannot commit to training, the

only training level that workers consider credible is the one that maximizes firms' future profits. Nonunionized 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 nonunionized firms offer no training in equilibrium.

This is different in unionized firms. Figure 1 illustrates why wage floors induce unionized firms to finance training. Consider a worker whose realized ability is η_1^t . Without training, the firm would make zero profit on this worker. With training, in contrast, the worker's productivity increases to y^t , his wage increases to $w^t = y^t - \Delta$, and the firm makes positive profits. More generally, training increases the rent on all workers with (realized) ability between η_1^t and η_2^t . Workers with ability below η_1^t are less productive than the union wage even after training. Workers with ability above η_2^t are unaffected by union wages even without training. Notice that this argument relies on firms earning rents on workers; if wages were equal to a worker's (marginal) productivity, unions would have no impact on training. Hence, while nonpecuniary job characteristics are not sufficient for firms to provide training, they are necessary for unions to increase training.

Formally, let $E[\Pi_u(\tau, \eta)|\hat{\eta}]$ denote the expected second-period profit from employing a worker with expected ability $\hat{\eta}$. Unionized firms lay off workers with realized ability below η_1 and hence make zero profits on these workers. For

workers with (realized) ability between η_1 and η_2 , unionized firms earn a rent of $y - \bar{w}$. These workers stay with the unionized 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, unionized firms maximize

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

The training level unionized firms offer, $\tilde{\tau}_u$, solves $c'(\tilde{\tau}_u) = \partial E[\prod_u(\tilde{\tau}_u, \eta) | \hat{\eta}] / \partial \tau$. It is straightforward to show that $\partial E[\prod_u(\tau, \eta) | \hat{\eta}] / \partial \tau \geq 0$, and hence $\tilde{\tau}_u \geq 0$. Compare this training level with the socially optimal level, τ^* . The socially optimal training level equates the marginal cost of training with the marginal return to training, and thus satisfies $c'(\tau^*) = \partial E[h(\tau^*)\eta | \hat{\eta}] / \partial \tau$. It is easy to see that $\partial E[h(\tau^*)\eta | \hat{\eta}] / \partial \tau > \partial E[\prod_u(\tilde{\tau}_u, \eta) | \hat{\eta}] / \partial \tau$. Hence, unionized firms offer a lower training level than the socially optimal level.

It is important to stress that the training level unionized firms choose depends on the worker's expected ability. Note from figure 1 that it is workers in the middle of the realized ability distribution who are affected most by the wage floor. Consequently, unions increase training most for workers in middle of the expected ability distribution. Wage floors hardly increase training for workers with very low and very high expected ability: workers with a very low expected productivity are likely to turn out to be less productive than the union wage even with training; workers with a very high expected ability are likely to be unaffected by the wage floor even in the absence of training.

To close the model, we have to analyze the sorting of workers into the unionized and nonunionized firms in the first period. A formal analysis is available from the authors on request. Here, we only note that workers with a low expected ability prefer to work in nonunionized 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 unionized sector. Workers with low expected ability are likely to have a lower productivity than the union wage, and thus choose to work in nonunionized firms. Since union wages do not affect wage offers of the very able (see figure 1), workers with very high expected ability are essentially indifferent between joining the unionized or nonunionized sector.

This argument also highlights why unionized and non-unionized firms coexist in our model. This is due to worker heterogeneity: while workers with low expected ability prefer to work in the nonunionized sector, workers in the

middle range of the expected ability distribution are strictly better off in the unionized sector.

How can we interpret the result that union wages increase training in the economy? In our model, unionized 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 unionized, 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. Unionized firms credibly signal to workers that they will pay at least the agreed union wage in the future. This then provides an incentive for firms to train workers, and may improve welfare in the economy.⁸

Our empirical analysis begins with a test of the key assumption of our model: wages are more compressed in unionized than in nonunionized firms. We then turn to differences in apprenticeship training between unionized and nonunionized firms. In the third step of the empirical analysis, we test two additional implications that are unique to our model, and thus help to distinguish our model from existing models. We describe our estimation strategy in detail below.

III. Data Sources and Samples

Our empirical analysis is based on two primary data sources. The first is a panel of establishments⁹ (the IAB establishment panel), collected by the Federal Employment Office in Nuremberg.¹⁰ The data contain a rich set of background information on the firm and its workforce, such as the firm's financial situation, industry, geographical location, the proportion of apprentices, and whether the firm recognizes 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. Like most administrative data sets, data on wages are top-coded at the highest level of earnings that are subject to social security contributions. The two data sources can be matched through an establishment identifier. From these two primary data sources, we construct three samples (A through C).

Sample A is a panel of establishments over the period 1995–1999, obtained from the IAB establishment panel, supplemented with information on the firm's workforce, obtained from the social security records. For the years 1996 to 1999, we are able to match to each establishment infor-

⁸ Unions as a commitment device have also been discussed by—among others—Malcomson (1983), Hogan (2001), and, in the case of training, Booth and Chatterji (1998).

⁹ For the remaining part of the paper, we use the terms establishments and firms interchangeably.

¹⁰ See Kölling (2000) for a detailed description of the data.

TABLE 1.—DIFFERENCES BETWEEN UNIONIZED AND NONUNIONIZED FIRMS

	All		Unionized		Nonunionized	
	Mean	StdD	Mean	StdD	Mean	StdD
Panel A: Training						
Firm trains	26.90%		36.15%		15.46%	
Proportion apprentices	4.89%		6.50%		2.91%	
Panel B: Firm Characteristics						
Size	17.02	120.79	23.66	159.44	8.82	32.96
Number of new hires	0.96	6.63	1.17	8.14	0.68	4.06
Proportion young firms (≤ 5)	0.30	0.46	0.27	0.44	0.34	0.47
Proportion old firms (≥ 30)	0.28	0.45	0.35	0.48	0.20	0.40
(Investment/worker)/1,000*	16.62	509.73	11.47	275.23	22.96	697.80
(Revenue/worker)/1,000*	374.70	1,640.66	443.98	1,951.81	286.37	1,119.46
Panel C: Worker Characteristics						
Proportion qualified workers	47.24%		51.71%		41.70%	
Ratio females	23.81%		24.22%		23.27%	
Daily average wage*	102.08	45.84	106.25	42.81	96.74	48.94

The table compares observable firm and worker characteristics in unionized and nonunionized firms. Entries are weighted and representative for firms. Columns "StdD" report the standard deviation of the listed variables.

*In 1996 German marks. Results are based on sample A.

mation on all workers who were employed at the firm at the first of July of each year. We restrict the empirical analysis to West German firms in the private sector to firms outside the agricultural sector. In Germany, firms can recognize the union either by 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. The proportion of firms that bilaterally negotiate with unions is relatively small: 7.3%, compared with 48% that recognize industry-wide agreements (own calculations). We define a unionized firm as a firm that either belongs to an employer federation or engages in bilateral negotiations with the union. Our results are similar for an alternative definition that classifies only firms that belong to an employer federation as unionized.

Sample B is 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 eleven years of potential labor market experience. We concentrate on young workers to avoid the problem of top-coding. Workers in training are excluded from this sample. We distinguish between three skill groups: low-skilled workers who have no further training after secondary school, medium-skilled workers who went through apprenticeship training after secondary school, and workers who graduated from a college or a university. There are 724,089 wage spells in our sample: 9.1% belong to low-skilled workers (those without postsecondary education), 73.0% to medium-skilled workers (those who completed an apprenticeship), and 17.9% to university graduates. Overall, top-coding affects 5.7% of wage spells, but only 0.39% for the low-skilled and 0.98% for the medium-skilled workers. Censoring is most severe for university graduates, where 27.6% of all wage spells are top-coded. For this reason, we concentrate on low- and medium-skilled workers where top-coding is negligible. For 5,422 individuals, key variables such as firm size, industry, or union status are missing. This leaves us with 718,667

individuals, of whom 41,489 are observed in nonunionized firms.

Sample C consists of all individuals who were employed as an apprentice in the years 1996–1999 in any of the firms in our firm panel. We are able to follow these workers from labor market entry onward (even if labor market entry was before 1996) 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 unionized or nonunionized. We exclude 25,263 individuals who start working as a low-skilled worker before enrolling on an apprenticeship scheme. As the data do 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 program, which eliminates 6,959 individuals. We further exclude individuals who change firms during the training period (35,185 individuals), as well as individuals who start more than one apprenticeship (2,073 individuals). We end up with a sample of 104,840 workers. Of those, 93,678 are observed in at least one spell after the training period, with 89,676 individuals being trained in a unionized firm, and 4,002 individuals in a nonunionized firm.

IV. Empirical Analysis

A. Unionized versus Nonunionized Firms

Our empirical analysis begins with a descriptive overview of unionized and nonunionized firms. Table 1 compares the incidence and amount of apprenticeship training (panel A), key firm characteristics (panel B), as well as key worker characteristics (panel C) in unionized and nonunionized firms. Results are based on sample A, and entries are weighted so that they are representative for firms.

The first two rows in the table provide preliminary evidence that unionized firms are indeed more likely to train apprentices than nonunionized firms, just as our model predicts. There is a clear difference in training provision

between unionized and nonunionized firms, with 36.15% of unionized firms, but only 15.46% of nonunionized firms providing training (row 1). The second row compares the fraction of employees that are apprentices in unionized and nonunionized firms. Again, this fraction is far higher in unionized firms (6.50%) than in nonunionized firms (2.91%).¹¹

In our formal model, we do not explicitly model heterogeneity between firms and thus the sorting of firms into the unionized sector—this would be beyond the scope of our paper. However, panel B in table 1 highlights that unionized firms differ from nonunionized firms. The single most important difference is firm size: the average workforce size in unionized firms is about 24, compared with only 9 in nonunionized firms. Unionized firms also have hired more workers in the previous year, which may be explained by their larger average size. The proportion of young firms (younger than five years) is lower among unionized than nonunionized firms, while the proportion of old firms (older than thirty years) is larger among unionized firms—a finding that is similar to findings for other countries.¹² Investment per worker is somewhat larger, while the revenue per worker is somewhat smaller, in nonunionized than unionized firms.

In contrast to *firm* heterogeneity and *firm* sorting, our model does take into account heterogeneity between workers and the selection of workers into the unionized sector. The findings in panel C are broadly consistent with the prediction of our model that more able workers sort into unionized firms: unionized firms employ more qualified workers (51.71% versus 41.70%) and pay 9% higher wages. The average fraction of women, in contrast, is similar in unionized and nonunionized firms.

These differences in firm and worker characteristics cast some doubt on whether a simple comparison in apprenticeship training between unionized and nonunionized firms reflects a causal relationship. The remaining empirical analysis proceeds in three steps. First, we test for the key assumption of our model that wages are more compressed in unionized than in nonunionized firms. Unlike studies for the United States and United Kingdom, we are able to condition on firm fixed effects when comparing the variance of log-wages and education wage differentials in unionized and nonunionized firms. In the second step, we revisit differences in apprenticeship training between unionized and nonunionized firms, and address the endogenous selection of both workers and firms into the unionized sector. Our results so far are also compatible with alternative models of unions and training, such as Acemoglu and Pischke (1999b, 2003) and Booth and Chatterji (1998).¹³ In the third step of

the empirical analysis, we test two additional implications concerning wage cuts and layoffs in unionized and nonunionized firms that are unique to our model, and thus help to distinguish our model from existing models. To the best of our knowledge, this is the first paper that provides direct evidence on how unions affect wage cuts and layoffs using individual-level data.¹⁴

B. Unions and Wage Compression

Are wages more compressed in unionized than in nonunionized firms, as our model predicts? Table 2, panel A, compares education wage differentials in unionized and nonunionized firms. Results are based on sample B. To control for observable firm and worker characteristics, we condition on potential labor 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. To deal with censoring (which is a problem only for university graduates; see section III), we estimate tobit models. The education wage differential between the medium- and the low-skilled is about 40% larger in nonunionized firms, compared with about 30% for the education wage differential between university graduates and the medium-skilled. These differences are highly significant (see last pair of columns).¹⁵ Next, we additionally condition on fixed firm effects, now exploiting only variation within firms. Due to censoring, we focus on the low- and medium-skilled. The wage differential between these two groups of workers decreases in both types of firms, indicating that sorting of workers into firms is important. However, the difference in wage differentials continues to be large and statistically significant.

In panel B, we compare wage inequality, measured as the variance of log-wages and log-wage residuals, in unionized and nonunionized firms, for low- and medium-educated workers. The results show that the total variance of log-wages is about 30% to 40% higher in nonunionized than in unionized firms, for both education groups.¹⁶ In the next row we condition on workers and firm characteristics, and present residual variances. Again, the variance of log-wages is substantially larger in nonunionized than in unionized firms. Next, we again compare the residual variance of log-wages within firms, conditional on firm fixed effects, in unionized and nonunionized firms. The magnitude of the within-firm log-wage variance is substantially smaller than

wage applies to all firms and workers. Consequently, these models do not have direct implications for the wage structure in unionized and nonunionized firms.

¹⁴ Medoff (1979) analyzes the impact of unions on layoffs and quits only at the industry level.

¹⁵ This is in line with evidence for other countries. For instance, Card (1996) and Card, Lemieux, and Riddell (2004) find that in the United States, wage differences between skill groups tend to be compressed in the union sector. Lemieux (1998) provides similar findings for Canada.

¹⁶ See for instance DiNardo, Fortin, and Lemieux (1996) for similar evidence for the United States.

¹¹ Beckmann (2002) reports similar results.

¹² For instance, Machin (2000) establishes a similar relationship between firm age and union recognition for the United Kingdom.

¹³ Note, however, that in these models either all firms are unionized (Acemoglu & Pischke, 1999b; Booth & Chatterji, 1998), or a minimum

TABLE 2.—WAGE COMPRESSION IN UNIONIZED AND NONUNIONIZED FIRMS

Panel A: Education Wage Differentials						
	Unionized		Nonunionized		Difference	
	Coef	StdE	Coef	StdE	Coef	StdE
(a) Tobit	$N = 677,178$		$N = 41,489$			
Medium-low	0.204	(0.001)	0.347	(0.005)	0.143	(0.006)***
High-low	0.562	(0.001)	0.805	(0.005)	0.243	(0.006)**
(b) Within firm	$N = 560,083$		$N = 29,910$			
Medium-low	0.174	(0.001)	0.252	(0.004)	0.078	(0.005)**
Panel B: Variance of Log-Wages						
	Unionized		Nonunionized		Difference	
	Coef	StdE	Coef	StdE	Coef	StdE
1: Low-skilled	$N = 61,069$		$N = 4,721$			
(a) Total variance	0.139	(0.002)	0.199	(0.005)	0.061	(0.005)**
(b) Residual variance	0.093	(0.001)	0.126	(0.002)	0.033	(0.004)**
(c) Within-firm variance	0.057	(0.001)	0.074	(0.003)	0.017	(0.003)**
1: Medium-skilled	$N = 499,014$		$N = 25,189$			
(a) Total variance	0.050	(0.001)	0.087	(0.001)	0.036	(0.002)**
(b) Residual variance	0.034	(0.001)	0.061	(0.001)	0.027	(0.001)**
(c) Within-firm variance	0.026	(0.001)	0.035	(0.001)	0.010	(0.001)**

Panel A, row (a), reports the medium-low-skilled as well as the high-low-skilled wage differential from a log-wage regression that additionally controls for potential labor market experience and its square, the log of firm size, year dummies, a dummy for metropolitan area, thirteen industry dummies, gender, and foreign status. Due to wage censoring, we estimate tobit models. In row (b), we control for the same variables and include fixed firm effects; we delete the high-skilled from our sample due to wage censoring. In panel B, we report the variance of log-wages in unionized and nonunionized firms, separately for the low-skilled (row 1) and medium-skilled (row 2). We first show the total variance (row a), then the residual variance, where we again condition on potential labor market experience and its square, the log of firm size, year dummies, a dummy for metropolitan area, thirteen industry dummies, gender, and ethnicity (row b). We finally include fixed firm effects, and report the within-firm residual variance (row c). Results are based on sample B.

the overall residual variance for both unionized and nonunionized firms, as we would expect. Nevertheless, the difference between unionized and nonunionized firms remains sizable and statistically significant for both groups of workers.

C. Unions and Training

Estimation strategy. In the previous section, we illustrate that there is strong evidence for a compressed wage structure in unionized firms, relative to nonunionized firms. But does that lead unionized firms to train more than nonunionized firms, as our model predicts? Table 1 provided some preliminary evidence that it does: the proportion of unionized firms that train at least one apprentice is 36.15%, but only 15.46% of nonunionized firms provide training (row 1). The fraction of apprentices in unionized and nonunionized firms is also much higher in unionized firms (6.50%) than in nonunionized firms (2.91%).

However, table 1 also highlights that unionized and nonunionized firms differ with respect to a wide variety of firm and worker characteristics, suggesting that there is nonrandom selection of firms and workers into the unionized sector. If the characteristics that determine the firms' and workers' sector choices are correlated with firms' propensities to train workers, then a simple comparison of mean training intensity in unionized and nonunionized firms is misleading. One way to address the endogenous selection of workers and firms into sectors would be an IV type strategy that makes use of exogenous variation that allocates firms to the unionized/nonunionized sector. Unfortunately,

we were not able to identify any allocation mechanism for firms that is plausibly exogenous.

The avenue that we follow instead is to use variation in union status within firms that change union recognition, that is, that either change from being nonunionized to being unionized, or vice versa. As a comparison group, and to eliminate common time trends, we use firms that are unionized (or not unionized) over the entire period. More formally, our estimation strategy can be described as follows. Let T_{jt} denote apprenticeship training (that is, the proportion of apprentices in the firm, or an indicator variable for whether the firm trains) in firm j in period t . It depends on the union status U_{ijt} (being equal to 1 for firms that are unionized, and 0 otherwise), common time effects θ_t , the quality of the firm's workforce, and time-variant firm-specific characteristics η_{jt} , as well as time-invariant firm effects f_j (both defined as deviations from the population mean). Assuming linearity, this relationship can be written as $T_{jt} = a + \lambda_j U_{jt} + \theta_t + \eta_{jt} + f_j$, where λ_j is the effect of unionization on training. Since our model predicts that the impact of unions on training differs across workers, we allow this parameter to be firm-specific, with $\lambda_j = \lambda + \varepsilon_j$. The parameter we seek to estimate is the difference in the training intensity between unionized and nonunionized firms for those firms that choose to become unionized (which is a "treatment on the treated" effect): $E(\lambda + \varepsilon_j) | U_{jt} = 1 := \lambda_T$.

A difference-in-difference estimator that compares the firm's proportion of apprentices before and after unionization, and uses firms that are never unionized as a control

TABLE 3.—ARE UNIONIZED FIRMS MORE LIKELY TO TRAIN APPRENTICES?

Panel A: OLS Estimates								
	Firm Size + Year		Firm Characteristics		Firm and Worker Characteristics			
	Coef	StdE	Coef	StdE	Coef	StdE	Coef	StdE
1: Proportion apprentices	0.029	(0.002)**	0.028	(0.002)**	0.027	(0.002)**		
<i>N</i>		11,174		11,174		11,174		
2: 1 if firm trains	0.165	(0.010)**	0.121	(0.010)**	0.116	(0.010)**		
<i>N</i>		11,174		11,174		11,174		
Panel B: Difference-in-Difference Estimates								
Comparison group	Always Unionized				Always Nonunionized			
	I		II		I		II	
1: Proportion apprentices	Coef	StdE	Coef	StdE	Coef	StdE	Coef	StdE
a: Change NU-U	0.017	(0.005)**	0.015	(0.006)	0.020	(0.007)**	0.013	(0.008)
<i>N</i>		6,189		4,319		1,487		942
b: Change U-NU	0.004	(0.003)	0.006	(0.003)	0.001	(0.004)	0.002	(0.004)
<i>N</i>		6,782		4,743		2,080		1,366
2: 1 if firm trains	Coef	StdE	Coef	StdE	Coef	StdE	Coef	StdE
a: Change NU-U	0.088	(0.028)**	0.070	(0.035)*	0.092	(0.031)**	0.072	(0.039)
<i>N</i>		6,189		4,319		1,487		942
b: Change U-NU	0.01	(0.018)	0.015	(0.020)	0.003	(0.019)	0.004	(0.022)
<i>N</i>		6,782		4,743		2,080		1,366
Panel C: Long Differences								
Comparison group	Always Unionized				Always Nonunionized			
	I		II		I		II	
1: Proportion apprentices	Coef	StdE	Coef	StdE	Coef	StdE	Coef	StdE
a: Change NU-U	0.018	(0.008)*	0.030	(0.010)**	0.022	(0.010)*	0.044	(0.013)**
<i>N</i>		6,073		4,233		1,371		856
b: Change U-NU	0.008	(0.005)	0.005	(0.006)	0.005	(0.006)	0.002	(0.007)
<i>N</i>		6,490		4,496		1,788		1,119

Panel A reports OLS estimates of the impact of unionization on the proportion of apprentices as well as the probability that the firm trains. The first pair of columns only controls for firm size. The second pair of columns additionally controls for thirteen industries, state, investment and revenue per worker, number of new hires, profit evaluation, and age of the firm. We then add the proportion of qualified workers, the average age of workers, the average daily wage of workers, and the proportion of females. Panel B reports difference-in-difference estimates for firms that switch from being nonunionized to unionized (NU-U) or from being unionized to nonunionized (U-NU), using firms that are always or never unionized as a control group. Specification I includes year dummies and changes in firm size, in investment and revenue per worker, in the number of new hires, and in the evaluation of profit. Specification II includes in addition changes in the proportion of qualified workers, in the average age of workers, in the average daily wage, and in the proportion of females. In panel C, we report “long” difference-in-difference estimates that exclude the year in which the union change took place; same specification as in panel B. Results are based on sample A. * and ** indicate statistical significance at the 5% and 1% level, respectively.

group, identifies: $\lambda_T + E(\Delta\eta_{jt}|\Delta U_{jt} = 1) - E(\Delta\eta_{jt}|\Delta U_{jt} = 0)$. For the last terms to disappear, $\Delta\eta_{jt}$ has to be mean independent of ΔU_{jt} , that is, changes in firm-specific shocks η_{jt} must be the same for firms that change and do not change union status. One reason for why this might be violated is that—as suggested by our model—firms that join the union now attract more able workers, and thus increase training. We deal with these concerns by conditioning on a large set of observable firm and worker characteristics. The assumption underlying our strategy is that *conditional on changes in observable variables*, the change in training intensity of those firms that do not change union status equals the change in training intensity of those firms that do change union status, had they not changed. Using the notation above, this assumption implies that

$$E(\Delta\eta_{jt}|\Delta U_{jt} = 1, X_{jt}) = E(\Delta\eta_{jt}|\Delta U_{jt} = 0, X_{jt}). \quad (1)$$

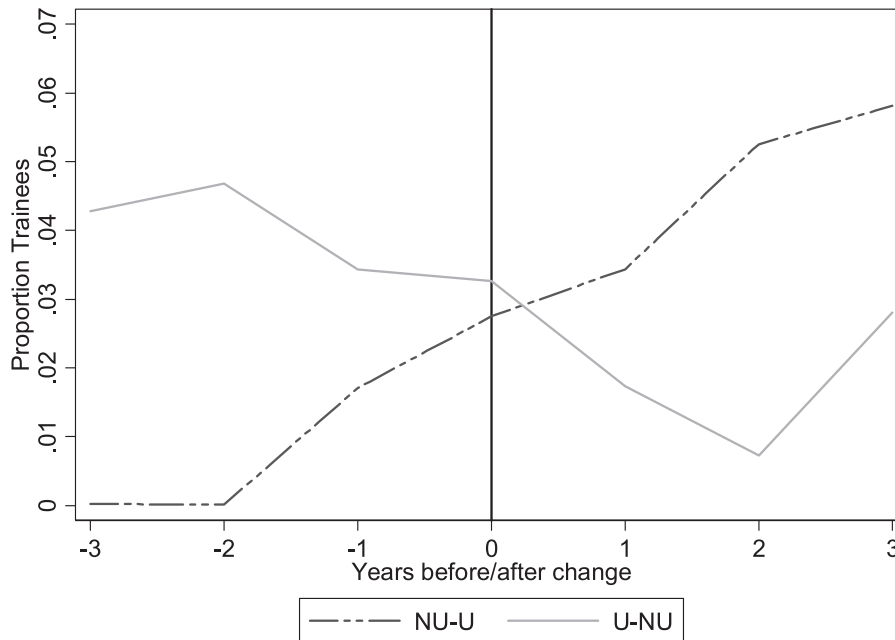
While we acknowledge that this strategy may not fully eliminate the selection problem, we would like to stress that

it improves on the existing literature—which typically uses only cross-sectional variation in the firm’s or the worker’s union status and, due to data constraints, controls for fewer observable firm and worker characteristics.¹⁷

OLS results. Before we present results using the difference-in-difference strategy outlined above, we display results from OLS regressions that successively control for more and more firm and worker characteristics as a baseline (table 3, panel A). We report results for two dependent variables, the proportion of apprentices (row 1) and a dummy variable indicating that a firm trains apprentices (row 2). To make sure that changes in the coefficient are driven by the additional controls and not by changes in the sample size, we keep the number of observations constant

¹⁷ Some papers use plausibly exogenous variation in the minimum wage over time and across regions to analyze the impact of wage floors on training (for example, Neumark & Wascher, 2001; Acemoglu & Pischke, 2003). So far, however, these studies lead to conflicting results.

FIGURE 2.—PROPORTION OF APPRENTICES TRAINED AND CHANGE IN UNION STATUS



The figure plots the share of apprentices in firms that switch from the union to the nonunion sector (U-NU) as well as firms that switch from the nonunion to the union sector (NU-U), before and after the switch. Results are based on sample A.

across specifications. Our conclusions are unchanged when we let the number of observations vary across specifications.

In the first set of columns, we control for year dummies as well as firm size in a flexible manner.¹⁸ The estimate indicates that the proportion of apprentices is 2.9 percentage points larger in unionized firms, compared with the raw difference of 3.6 percentage points. We then include a large number of firm characteristics: the number of new hires, the revenue per worker, the total investment per worker, the age of the firm, and industry and region dummies. The coefficient on the union status hardly changes. In the third set of columns, we control in addition for characteristics of the firm's workforce, like the ratio of qualified workers, the ratio of females, and the average daily salary. Including these variables does not affect the overall coefficient estimate. Our conclusions are unchanged when our dependent variable is merely an indicator of whether the firm trains apprentices. After controlling for firm and worker characteristics (third set of columns), unionized firms are 11 percentage points more likely to train apprentices than nonunionized firms.

Difference-in-difference estimates. Next, we identify the impact of unions on training using firms that change their union status. In our sample, 8.9% (567) of firms change their union status once, 4.3% twice, and 0.9% three times. We discard in the following those firms that change

union status more than once. Of those firms that change union status once, 71.4% (405 firms) change from being unionized to being nonunionized, and 28.5% (162 firms) from being nonunionized to being unionized.

Figure 2 provides some first evidence that changes in the union status are related to changes in apprenticeship training. The figure plots the proportion of apprentices against the number of years before and after the change in union status, for firms that change from being nonunionized to being unionized (NU-U), and for firms that change from being unionized to nonunionized (U-NU). The first year of the new status is the zero line. The fraction of apprentices increases substantially when firms change from being nonunionized to being unionized, and decreases for firms that change from being unionized to being nonunionized. The figure also shows that the change 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 may be planned in advance. Moreover, as apprenticeship training takes between two and three years, firms cannot reduce their apprentice training program immediately, and the proportion of apprentices should decline gradually, as is suggested in the figure.

Panel B of table 3 displays estimation results from our difference-in-difference estimator, conditional on a large set of observable firm and worker characteristics. Again, we report results for two dependent variables: the proportion of apprentices (row 1) and an indicator variable that is equal to 1 if the firm trains apprentices (row 2). We present two specifications: specification I includes time dummies, and

¹⁸ 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.

changes in firm size, in investment per worker, in revenue per worker, in the number of new hires, and in evaluation of profits. Specification II includes, in addition to these, changes in the proportion of qualified workers, in the average daily wage, and in the proportion of females.¹⁹ The first four columns report results where firms that are nonunionized in all periods are the comparison group; the last four columns use firms that are unionized throughout as a comparison group.

We first report results for firms that change from being nonunionized to unionized (row 1a, NU-U). The estimate indicates that unionization significantly increases the proportion of apprentices by 1.7 percentage points, although the point estimate is somewhat smaller than our OLS estimate of 2.8 percentage points (panel A). Adding (changes in) worker characteristics and the work council variable or using firms that are always unionized as a control group hardly changes the results. In the next row (1b, U-NU) we report results for firms that change from being unionized to not being unionized. Coefficient estimates are now smaller, and, although having the expected sign, not significantly different from 0. This is not surprising, for two reasons. First, the decline in apprenticeship program size should be gradual, as apprenticeship program usually last three years. Second, even after a firm has left the unionized sector, union agreements continue to be binding for at least another six months. Our findings are similar if we use an indicator variable that is equal to 1 if the firm trains as our dependent variable (rows 2a and 2b).

In order to take account of the possibly gradual adaptation of apprenticeship training, as has been suggested by figure 2, we next construct “long” differences, and exclude the year in which a change took place. Hence, we compare the year before a change with the year after a change. As our observation period is only five years, this reduces our sample of firms that change status. We report results for specifications I and II in panel C of table 3. For firms that switch from the nonunionized to the unionized sector (row 1a), point estimates tend to be somewhat larger. For firms that change from being unionized to nonunionized, results are similar to our baseline difference-in-difference estimates (row 1b).

We have conducted a number of robustness checks. Acemoglu and Pischke (1998) exclude firms in the construction sector from their empirical analysis, for two reasons. First, firms in this industry that do not train apprentices have to pay a fine that is then redistributed to firms in the industry that do train. Second, there is a minimum wage that applies to all firms in the construction industry. Our results are similar when we eliminate firms in the construction sector from our analysis. Acemoglu and Pischke (1998) also argue that training in small firms is likely to be worker-financed, and thus eliminate small firms from their

analysis. Excluding small firms (that is, firms with fewer than 30 employees) yields roughly similar results to those reported here. For instance, for firms that switch from being nonunionized to unionized, the point estimate equals 0.010, with a standard error of 0.004, for specification II.

These results are supportive of our hypothesis that unions increase training within the German apprenticeship program. According to our preferred estimate, unionization increases the proportion of apprentices by 1.7 percentage points (table 3, panel B, row 1a). As the average fraction of apprentices in firms is only 4.89% (see table 1, panel A), this effect is sizable. We acknowledge that a causal interpretation of this estimate hinges on our identification assumption that changes in training intensity between firms result entirely from changes in union status, not some other change. Remember, however, that we condition on (changes in) a large set of characteristics of the firm and the firm’s workforce. For instance, controlling for (changes in) the proportion of qualified workers should eliminate a possible bias due to changes in the selection of workers into firms that change union status. Further important covariates include the (change in) firm size, wages, revenue, and investment—all of which describe the economic situation of the firm.

D. Wage Cuts and Layoffs

Our results suggest that, because of wage compression, unionized firms are more likely to train workers in apprenticeship schemes than nonunionized firms. While these findings are clearly in line with our model, they are also consistent with existing models of unions and training, such as Acemoglu and Pischke (1999b). However, our richer model allows us to derive two additional implications that are unique to our model, and thus help to distinguish our model from the existing models.

According to our model, wages are more compressed in unionized firms because of wage floors that are binding in unionized firms, but not in nonunionized firms. The two implications we test in this section are a direct consequence of wage floors.

First, wage floors should prevent firms from cutting wages as a response to a negative productivity shock. We therefore expect wage cuts to occur more frequently in nonunionized than in unionized firms. Table 4, panel A, provides empirical support for this hypothesis. The table reports the estimate for the marginal effect of the firm’s union status on the probability of a wage cut from a probit regression, where we control for potential labor market experience and its square, gender, log firm size, year and industry dummies, and a dummy for metropolitan area. 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 cut in real wages of at least 5% or at least 10%, respectively. In our sample, 22.7% of spells experience a cut in real wages of at least

¹⁹ The number of observations is lower in this specification because we are able to match worker information only for the years 1996 to 1999.

TABLE 4.—UNIONIZATION AND WAGE FLOORS: WAGE CUTS AND LAYOFFS

Panel A: Unionization and Real Wage Cuts							
	Low-Skilled		Medium-Skilled		Difference Low-Medium		
	Coef	StdE	Coef	StdE	Coef	StdE	
<i>N</i>		21,429		237,316			
a: 1 %	-0.058	(0.014)**	-0.022	(0.004)**	-0.036	(0.015)*	
b: 5 %	-0.042	(0.010)**	-0.018	(0.003)**	-0.024	(0.011)*	
c: 10 %	-0.015	(0.007)**	-0.006	(0.002)**	-0.009	(0.007)	

Panel B: Unionization and Layoffs						
	Job to Unemployment			Job to Job		
	(1) Year Only	(2) Plus Controls	(3) Fixed Firm Effect	(4) Year Only	(5) Plus Controls	(6) Fixed Firm Effect
Training Firm Unionized	-0.049 (0.005)**	-0.020 (0.005)**	0.018 (0.008)*	-0.015 (0.006)*	0.019 (0.006)**	-0.021 (0.011)*
<i>N</i>	93,678	89,056	89,056	93,678	89,056	89,056

Panel A reports the marginal impact of unionization on the probability of a real wage cut of at least 1%, 5%, or 10% between two successive periods, obtained from probit regressions. Results are based on sample B where workers who switch firms between two periods are excluded. Regressions are separately estimated for the low- and medium-skilled, and control for year dummies, potential labor market experience and its square, gender, foreign status, log firm size, metropolitan area, and thirteen industries. Panel B reports the impact of unionization on the probability of becoming unemployed and moving from job to job after apprenticeship training. Columns 1 and 4 only control for year effects. Columns 2 and 5 additionally condition on firm size (in logs), thirteen industries, age and age squared, apprenticeship duration (in logs), high school degree (*Abitur*), and gender. Columns 3 and 6 include fixed firm effects. Results are based on sample C.

* and ** indicate statistical significance at the 5% and 1% level, respectively.

1%, 9.4% of at least 5%, and 3.9% of at least 10%. We base our analysis on sample B, but restrict our sample to workers who stay with the same employer between two successive periods. Due to wage censoring, we delete university graduates from our sample.

The incidence of a wage cut is significantly higher in nonunionized than in unionized firms for both low- and medium-skilled workers, for all three definitions. Interestingly, the impact of the firm's union status on the probability of a wage cut tends to be stronger for the low-skilled workers than for the medium-skilled. This suggests that the union wage is more binding for low-skilled workers, as expected.

A second consequence of wage floors is that layoffs should occur more frequently in unionized than in nonunionized firms: since unionized firms are not allowed to pay wages below the union wage, they lay off workers who turn out to be less productive than the union wage. At the same time, voluntary turnover should be lower in unionized than in nonunionized firms since workers who are paid the union wage in unionized firms earn a higher wage than they would in a nonunionized firm. 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 C). 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 our results below are based on this distinction. We were able to show that, if we observe a higher job-to-unemployment and a lower job-to-job quit rate in unionized firms, then it must be the case that workers in unionized firms are more likely to be laid off and less

likely to quit.²⁰ In our sample, 9.4% of workers become unemployed after apprenticeship training, and 17.8% move to another firm without an intervening unemployment spell.

Panel B of table 4 reports coefficients from linear probability models of the impact of the firm's union status on the probability that a trainee becomes unemployed after completing training (columns 1–3), and on the probability that she moves from one job to another (columns 4–6). Results in column 1 and 4 condition on time dummies only. In line with our hypothesis, apprentices from unionized firms are less likely to move from job to job. However, contrary to our hypothesis, they are also less likely to move into unemployment. These coefficients may simply reflect that, as implied by our model, unionized firms employ more able workers than nonunionized firms, and more able workers are less likely to switch firms, and in particular less likely to become unemployed after apprenticeship training.²¹ Furthermore, unionized firms may be of higher quality than nonunionized firms and thus lay off fewer workers after apprenticeship training.

To account for differences in firm and worker quality, we next control for the size and industry of the training firm, as well as for the following worker characteristics: age and age squared, gender, the log of the apprenticeship duration, and

²⁰ 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 unionized and nonunionized firms have the same probability of becoming unemployed. Both assumptions are reasonable; for example, see Nagypal (2008) for empirical evidence of the former.

²¹ There are several theoretical models that predict a lower ability of job-to-unemployment movers, including the asymmetric information models by Gibbons and Katz (1991), Acemoglu and Pischke (1998), and Schönberg (2007). Von Wachter and Bender (2006) provide convincing evidence that apprentices who leave the training firm are of lower ability than workers who stay with the training firm.

a dummy for whether the worker has a high school degree (*Abitur*, columns 2 and 5). This reduces the size of both coefficients.

However, observed characteristics may only partly take account of unobserved worker and firm characteristics. Our panel structure allows us to condition on fixed training firm effects, exploiting variation in the firm's union status over time. We report results in columns 3 and 6. Estimates now indicate that unionization significantly increases the probability of becoming unemployed after apprenticeship training by 1.8 percentage points, or 19.1%, and significantly reduces the probability of a job-to-job transition by 2.1 percentage points, or 11.8%. This suggests that workers in unionized firms are more likely to be laid off, and less likely to quit voluntarily, just as predicted by our model, but not by existing models of unions and training.

V. Conclusion

This paper addresses the question of whether unions, by imposing wage floors that lead to wage compression, increase training in the economy. Our focus is on Germany, which provides an interesting context in which to test this hypothesis, due to its large-scale apprenticeship program and its collective bargaining system based on voluntary union recognition. This effectively creates a unionized and nonunionized sector, defined by the firm's union recognition.

We develop a theoretical framework that provides a set of testable implications. In the first step of the empirical analysis, we document that wages are more compressed in unionized than in nonunionized firms, just as our model predicts. We then show that unionized firms are more likely to train workers in apprenticeship training than nonunionized firms. In a third step, we test and empirically confirm two novel implications that are unique to our model, and do not follow from existing models of unions and training: wage cuts occur less frequently and layoffs more frequently in unionized than in nonunionized firms. Overall, these findings are consistent with our hypothesis 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 wage 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. One implication of this finding is that the decline in unionization rates—as witnessed by Germany over the last decade—may have undesired consequences for the apprenticeship system.

Contrary to the prediction of our model, we also find that nonunionized firms train apprentices. This suggests that wage compression due to unions are an important, but not the only, reason for firm-financed apprenticeship training in Germany. Our analysis is thus compatible with earlier work by Acemoglu and Pischke (1998) that proposes asymmetric

information as an important reason for why firms sponsor training in Germany.

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