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Employment Adjustment in German Firms

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Employment Adjustment in German Firms*

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Abstract: Using a representative establishment data set for Germany, we show that, in line with the existing literature for several countries, firms' adjustment costs for employment are characterized by a fixed and convex functional form. Furthermore, they are asymmetric with dismissal costs exceeding hiring costs. An analysis of firms' adjustment in the period 1996–2010 also indicates that adjustment behavior has changed over time. Comparing the employment adjustment in the two observed business cycles comprising the years 1996–2003 and 2004–2010, we find that the adjustment speed was higher in the second business cycle indicating that adjustment costs have fallen in recent years.

Zusammenfassung: Anhand von repräsentativen Daten des IAB-Betriebspanels wird gezeigt, dass die Kosten der betrieblichen Beschäftigungsanpassung in Deutschland eine funktionale Form mit fixer und konvexer Komponente aufweisen, wie es auch frühere Studien für andere Länder feststellen. Des Weiteren ist die Struktur der Anpassungskosten asymmetrisch, wobei die Entlassungskosten größer als die Einstellungskosten sind. Bei der Analyse des betrieblichen Anpassungsverhalten für den Zeitraum 1996–2010 wird zudem deutlich, dass sich das Verhalten über die Zeit geändert hat. Ein Vergleich der betrieblichen Beschäftigungsanpassung in den zwei beobachteten Konjunkturzyklen 1996–2003 und 2004–2010 zeigt eine schnellere Anpassung im zweiten Konjunkturzyklus, was auf gesunkene Anpassungskosten hinweist.

Keywords: adjustment costs, dynamic labor demand, employment adjustment, Germany

New JEL-Classifications: C24, D22, E24, J23

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1 Introduction

Following the 2008/2009 economic crisis, the adjustment of firms' labor volume has again moved into the focus of economic analysis. Across countries, firms have shown different reactions to this crisis, but also within countries firms' behavior has differed from previous reactions. For example, German firms predominantly adjusted working hours, while less adjustment of the number of employees was visible (see Burda and Hunt, 2011). This points to a fundamental change in firms' adjustment processes. Several studies for Germany indicate that firms' employment adjustment has indeed changed over time (see, e.g., Gartner and Klinger, 2010; Herzog-Stein and Seifert, 2010). However, these studies are mostly based on descriptive analyses of aggregated data. In contrast, the present study provides a more detailed econometric analysis based on data at the establishment level. Using a representative panel data set on German establishments, we estimate a dynamic labor demand model for the period 1996 to 2010. This allows us to compare employment adjustment in the two business cycles occurring between 1996 and 2010 and to investigate econometrically whether firms' adjustment behavior has changed over time. Moreover, we analyze labor demand separately for Western and Eastern Germany, thus extending the sparse empirical evidence on dynamic labor demand in Eastern Germany.

We also provide new insights concerning the functional form of firms' adjustment costs. Adjustment costs are an important component of dynamic labor demand theory. Firms' adjustment behavior depends on the functional form of the adjustment costs they face. Although empirical evidence so far indicates a fixed and convex specification (see Vermeulen, 2006, p. 11), this has not been established for Germany yet. In the only study for (Western) Germany which contains an intensive analysis of the functional form, Kölling (1998) prefers a convex functional form of adjustment costs. In contrast to Kölling, we will use a different switching regression approach and will show that for Germany in addition to the convex specification a fixed component of adjustment costs is also relevant.

The paper proceeds as follows: Section 2 sketches the main aspects of adjustment costs and presents the relevant empirical evidence on the functional form of adjustment costs. Section 3 provides a description of our data. Section 4 shows the empirical model, while Section 5 presents and discusses the results of a basic dynamic labor demand model. We investigate the change of firms' adjustment behavior over time in Section 6, and Section 7 concludes.

2 Adjustment Costs: Theoretical Considerations and Empirical Evidence

The underlying theory for our analysis is the dynamic labor demand theory. While the static labor demand theory focuses on firms' optimal employment level, the dynamic counterpart analyzes firms' adjustment toward the optimum and the time it takes to reach the optimal employment level which is not possible within the static theory (see Cahuc and Zylberberg, 2004, p. 212). Adjustment costs are an essential component of dynamic labor demand theory because they play an important role in firms' adjustment behavior. These costs are the reason that a plant does not dismiss all employees before the weekend and re-hire them on Monday (see Franz, 2009, p. 142; Nickell, 1986, p. 473). Labor is not a completely variable production factor because adjustment costs form a fixed component of total labor costs. Therefore Oi (1962) calls labor a 'quasi-fix' factor. Adjustment costs arise from an employment change and consist of hiring costs (e.g., search, selection, first training, administrative expenses of the Human Resources Department) and costs of dismissals (e.g., severance pay, consideration of dismissal protection, administrative expenses of the Human Resources Department). Ehrenberg and Smith (2012, p. 145) consider hiring costs as investments and so they point out the 'sunk' character of these costs.

Several criteria can be used for distinguishing adjustment costs (see, e.g., Hamermesh, 1993, p. 207; Kölling, 1998, p. 8; Nickell, 1986, p. 475). With regard to the place where the costs incur, one can differentiate between internal and external adjustment costs . If costs incur within the firm (e.g., costs for first training), they are internal. Expenses for job advertisements or external recruiting companies, which accrue outside the firm, are external. The internal costs can further be divided into an explicit and an implicit category. Explicit costs are expenses that are unambiguously quantifiable in monetary terms (e.g., expenses for job advertisements, severance pay) whereas the other expenses are implicit costs (e.g., temporary losses of productivity in the first days of the new employee at work).[1] Furthermore, one can distinguish between a gross and a net perspective in the analysis of adjustment costs. Net adjustment costs incur if the number of employees changes. In contrast, each hiring and dismissal decision affects gross adjustment costs, even if the employment level does not change. In this study, we use a net approach due to the data set used (see Section 3) und the underlying empirical model (see Section 4).

[1] Although there are some studies which quantify adjustment costs, measurement is not easy. Existing studies arrive at very different results that can be explained by different concepts and categories for the adjustment costs (see Freyens, 2010, p. 291; Hamermesh, 1993, p. 208). In particular, lack of a clear definition makes it very difficult to accurately measure adjustment costs.

The basic theory of dynamic labor demand assumes labor to be a homogeneous production factor, which is a restrictive assumption in the context of adjustment costs (see Kölling, 1998, p. 61). Different kinds of jobs and different qualification levels of employees can lead to different sizes of adjustment cost meaning that the firm would not adjust separate groups of employees in the same manner. Yet, following earlier studies, we assume labor to be homogeneous for the sake of analytical simplicity. Nevertheless, this allows us to draw some interesting conclusions about the adjustment procedures of labor demand (see Kölling, 1998, p. 61).

Another simplifying assumption concerns the two dimensions of labor demand. Firms can adjust their total labor volume by changing the number of employees and by changing working hours. Adjustment of working time gives more flexibility compared to an adjustment of just the number of employees. It can be done faster (see Sargent, 1978, p. 1015) and cheaper (see Shapiro, 1986, p. 516) than the adjustment of the number of employees. Therefore, in periods when the adjustment of the number of employees is no longer optimal, a firm can still get closer to the optimal labor volume by changing the number of hours worked (see, e.g., Nickell, 1978, p. 332–335; Santamäki, 1988, p. 101–102). Yet, the consideration of both dimensions leads to complex adjustment models. In order to simplify the model, working hours are ignored in the following analysis. The data set used (see Section 3), which does not provide clear information about working hours, is another reason for disregarding the working time. However, basic conclusions about adjustment procedures of labor demand are still possible (see Hamermesh, 1993, p. 209).

Furthermore, adjustment costs differ in functional form. One can classify fixed, linear, and convex adjustment costs. Fixed adjustment costs incur from firms' decision to adjust employment independently of the amount of employment adjustment.[2] An example is a job advertisement for two or four employees, which costs the same in both cases (see Hamermesh, 1989, p. 675; Kölling, 1998, p. 44). If the firm faces a new optimal employment level due to a shock or a changing economic situation, it must make a decision about an adjustment to the new optimum. Fixed adjustment costs and their relative magnitude to the profits resulting from an employment level closer to the optimal one are essential for this decision. If profits exceed costs, the firm will adjust employment. Because of the fixed specification, firms' adjustment is then done instantly and completely towards the new optimal employment level (see Hamermesh, 1993, p. 214).[3]

Linear adjustment costs, which increase proportionally in the amount of

[2] For details about fix adjustment costs we refer to Hamermesh (1989; 1990).

[3] The result of fixed adjustment costs are periods with adjustment and periods with no adjustment. Therefore Hamermesh (1990, pp. 96) calls this behavior 'bang-bang adjustment'.

adjustment, result in a different adjustment behavior. Again, firms adjust instantly while taking into account the costs-profits relation. But with a linear structure, the employment level is not adjusted completely towards the optimal level (see, e.g., Kölling, 1998, p. 30; Nickell, 1986, p. 491). Instead, firms keep employment constant near the optimum because of costs exceeding profits (see, e.g., Anderson, 1993, p. 1018; Kölling, 1998, p. 30; Nickell, 1978, p. 332; Nickell, 1986, p. 495). Examples for a linear cost structure, such as hiring from an agency (see Nickell, 1986, p. 477) or severance pay, show that linear adjustment costs are not unrealistic.

Convex adjustment costs, mostly used in a quadratic specification, are the third functional form. This specification was the one first used in the literature and goes back to Holt et al. (1960). Convex costs increase disproportionately with the amount of adjustment. Although a convex specification might be suitable for a specific part of adjustment (see Nickell, 1986, p. 477), it should not be considered as the only existing functional form (see, e.g., Bentolila and Bertola, 1990, p. 382; Hamermesh, 1989, p. 475; Nickell, 1986, p. 477; Rothschild, 1971, p. 605). A convex cost structure is a very restrictive assumption and difficult to justify. The reason for the common use of convex adjustment costs in the literature was the simple analytical handling in the models (see, e.g., Kölling, 1998, p. 9; Pfann and Verspagen, 1989, p. 365). But already Holt et al. (1960, p. 52) mentioned that the quadratic form is just a "...suitable first approximation." Adjustment costs can have different forms in reality (see Nickell, 1986, p. 519). Assuming convex adjustment costs rather than fixed or linear costs, firms spread adjustment of employment over several periods (see, e.g., Cahuc and Zylberberg, 2004, p. 218; Hamermesh, 1993, p. 211; Nickell, 1986, p. 483). Because of the convexity, marginal costs increase with the amount of employment adjustment. Therefore, it is optimal to spread the adjustment over several periods. Furthermore, the optimal employment level will not be reached in finite time (see, e.g., Kölling, 1998, p. 21; Nickell, 1986, p. 483), although there is long-run convergence to the optimum (see Kölling, 1998, p. 60).

Considering the functional form also raises the question whether adjustment costs are symmetric or asymmetric, thus whether hiring costs and firing costs are equal. A symmetric cost structure simplifies the econometric model but there is no reason to expect an upward employment adjustment to generate the same costs as a downward employment adjustment (see Schiantarelli and Sembenelli, 1993, p. 149). Therefore, asymmetric adjustment costs are a much less restrictive assumption. The costs of hiring and firing result from different sources so that asymmetry is a reasonable assumption.

In case of a fixed specification, increasing adjustment costs lead to a longer period with no adjustment and a greater amount of employment change if an adjustment is optimal (see Gorter et al., 2003, p. 100). Assuming a linear structure instead, higher adjustment costs also cause a longer period of inaction. Furthermore, the difference between the optimal employment level and the actual level when the firm stops adjustment is larger (see, e.g., Anderson, 1993, p. 1018; Nickell, 1978, p. 337; Nickell, 1986, p. 495). Finally, the result of higher convex adjustment costs is a slower adjustment which is spread over many more periods (see, e.g., Cahuc and Zylberberg, 2004, p. 218; Sargent, 1978, p. 1018).

There is a large body of empirical evidence on the significant role of firms' adjustment costs (see, e.g., Burgess, 1988; Dolfin, 2006, p. 870; Gavosto and Sestito, 1993, p. 447; Nissim, 1984, p. 433; Oi, 1962; Rosen, 1968, p. 337; Rota, 2004, p. 43) showing that these costs actually have an effect on adjustment behavior. In contrast, Hall (2004) as well as Pindyck and Rotemberg (1983*a*; 1983*b*) find that adjustment costs are just marginal. Regarding the functional form, the studies by Holt et al. (1960) and Nickell (1984, p. 546) show that a convex structure is appropriate.[4] However, their evidence it not entirely persuasive as they assume pure convexity in their empirical models and make no comparison with other functional forms in these analyses. In addition, given the not convincing theoretical justification it is not surprising that there are many empirical objections to pure convex costs.

Hamermesh (1989, p. 687) presents first evidence against a pure convex structure. He shows that a fixed cost specification suits the data better than convex adjustment costs. The results of Anderson (1993), Caballero et al. (1997), Cooper and Willis (2009), Gavosto and Sestito (1993), Holtz-Eakin and Rosen (1991), Rota (2004), and Varejão and Portugal (2007) are also inconsistent with the assumption of pure convex adjustment costs. Instead, they find that firms' adjustment behavior is better represented by an assumption of a combination of various functional forms, for example, a fixed and convex specification (see, e.g., Abowd and Kramarz, 2003; Cooper et al., 2004; Hamermesh, 1992; Kramarz and Michaud, 2010; Lapatinas, 2009; Nilsen et al., 2007; Pfann and Verspagen, 1989).[5] For Germany, however, the study by Kölling (1998), which is the only work analyzing intensively the functional form of the adjustment costs we are aware of, shows that a model with combined fixed and convex adjustment costs components provides no further insights compared with a pure convex specification. Therefore, the predominance of the combination structure for adjustment cost has not been shown to extend to Germany yet.

Regarding the symmetry or rather asymmetry of adjustment costs the empirical evidence clearly favors asymmetry. However, there is no clarity concerning the relation of hiring costs to dismissal costs (see Hunt, 2000, p. 181). Based on data from the production sector in Italy, Jaramillo et al. (1993) find higher dismissal costs

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[4] Nickell (1984, p. 546) finds that the adjustment has a lag, which is just the case in the presence of convex adjustment costs.

[5] Vermeulen (2006, p. 11) confirms the dominance of a combination structure for adjustment costs in the existing literature.

compared to hiring costs. This relation also has been confirmed for Germany (see Burda, 1991, p. 73; Kölling, 1998, p. 151), for France (see Abowd and Kramarz, 2003; Goux et al., 2001; Kramarz and Michaud, 2010) as well as for Norway (see Nilsen et al., 2007, p. 597). In addition, based upon British and Dutch data, Pfann and Palm (1993) show higher dismissal costs for non-production workers, whereas they find higher hiring costs for production workers. Other evidence for hiring costs exceeding dismissal costs is described in Pfann and Verspagen (1989) for the Netherlands and in Chang and Stefanou (1988), Hamermesh (1993, p. 208) as well as in Hamermesh and Pfann (1996) for the US.

Our study investigates firms' adjustment behavior of labor in Germany. We assume a combined cost structure and asymmetry with dismissal costs exceeding hiring costs that we will test in the following analysis. Our hypothesis regarding the relation of hiring and dismissal costs is based on the labor market institutions in Germany. Germany, like other countries in continental Europe, has a more regulated labor market with higher dismissal protection than, for instance, the US (see, e.g., Abraham and Houseman, 1994, p. 59; Burda, 1991, p. 62; Emerson, 1988, p. 776). This in turn leads to less flexibility for firms and results in higher adjustment costs, especially higher dismissal costs in Europe compared to the US (see, e.g., Hunt, 2000, p. 177; Merkl and Wesselbaum, 2011, p. 805).

3 Data and Descriptive Evidence

The data used for the analysis come from the IAB Establishment Panel, which is a representative annual survey of German establishments.[6] The interviewed establishments are drawn from a stratified sample of plants, which are included in the German employment statistics. The strata are defined over plant sizes and industries; however, sampling within each cell is random. The panel oversamples large establishments, but weighting for representative results is possible. The panel started in 1993 with Western German plants and was extended to Eastern German plants in 1996. Nowadays, almost 16,000 establishments are interviewed each year. Information about, for example, plant characteristics, wages, profitability, management policy and especially about the workforce composition and its development over time is provided by the panel with the reference date June 30th.

We use the waves 1996 until 2010. Although the IAB Establishment Panel contains information about the agreed weekly working time and overtime, this information is not available for all years. An exact calculation of working hours based on the numbers of employees in full-time and part-time jobs is also not viable.

[6] For a detailed description of this data set see Bellmann et al. (2002), Fischer et al. (2009), and Kölling (2000).

Therefore, our empirical investigation can only analyze the adjustment of the number of employees and has to neglect the working time dimension. In particular, we consider the number of employees covered by social security.[7] The group of employees covered by social security is more homogenous regarding adjustment costs than the group of all employees. Therefore, the analysis of firms' adjustment behavior (e.g., adjustment speed) should be more accurate. Furthermore, we only analyze the private sector because of differences in the adjustment behavior between the public and private sector (shown descriptively by Ellguth and Kohaut (2011)). Another reason for this decision is the derivation of the empirical model, which is based on the assumption of profit maximization (see Section 4) that does not hold for the public sector.

Furthermore, we only consider firms' adjustment of the core workforce. In the last years, the use of temporary agency workers has increased, especially after the reform of the Temporary Employment Agencies Act (*Arbeitnehmerüberlassungsgesetz*) in 2003 (see, e.g., Antoni and Jahn, 2009; Spermann, 2011, pp. 5–11). The temporary agency workers can serve as an alternative instrument for employment adjustment. Therefore, one could also consider them in an analysis of firms' adjustment behavior. However, we ignore temporary workers for two reasons. First, the IAB Establishment Panel does not contain the number of temporary agency worker in all years of the sample. Second, we are interested in the adjustment of the core workforce that does not include temporary agency workers. As mentioned before, there are higher regulations in the German labor market than in the U.S. labor market. Dismissal protection plays an important role in Germany. Analyzing the core workforce, we focus on firms' adjustment behavior with regard to employees affected by labor market regulations (e.g., dismissal protection).

Figure 1 illustrates the average number of employees covered by social security per plant from 1996 until 2010. The fluctuation over time expresses changing employment levels and thus the employment adjustment of the plants. Furthermore, it shows the phases of the business cycle (except for the first years). The average number of employees per plant is lower during the economic downturn 2002/2003 and increases again in the economic upturn after 2004. Figure 2 provides more detailed information on adjustment behavior. Every year plants increase, decrease or do not change employment, regardless of the business cycle phase.[8] However, there is no clear pattern. Although a bigger share of plants reduced employment in the economic downturn 2002/2003, some plants also increased employment during

[7] Bellmann and Pahnke (2006) also use the number of employees covered by social security only. Nevertheless as a robustness check (not reported in the paper) we also carry out the analysis with all employees, which does not change our insights.

[8] Increase or decrease of the employment means a change of the number of employees covered by social security from the previous to the present year.

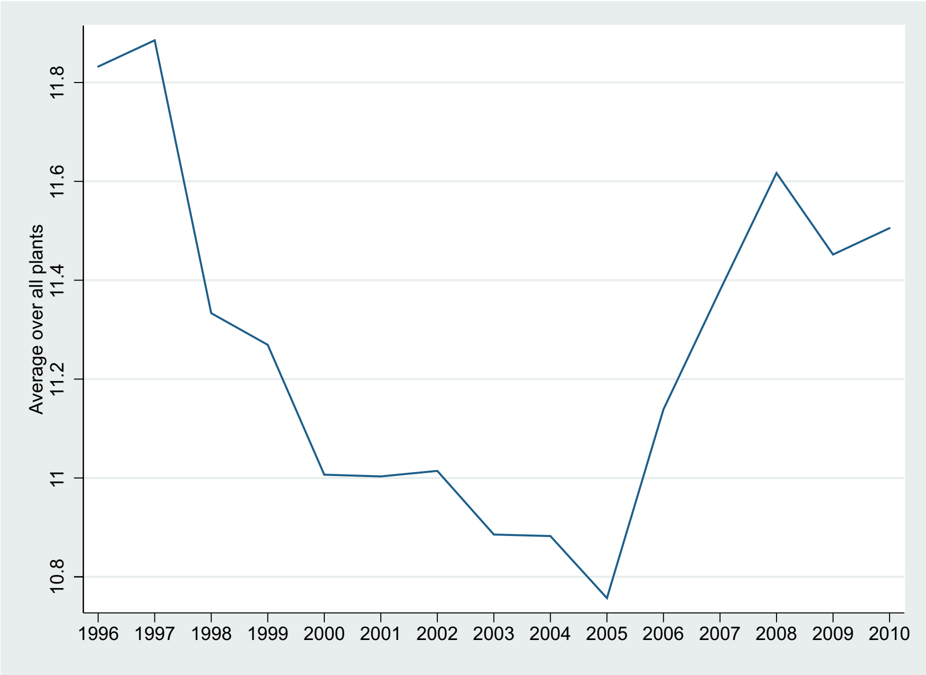

Figure 1: Average number of employees per plant
Notes: Weighted data, private sector only
Source: IAB Establishment Panel, waves 1996–2010, own calculations

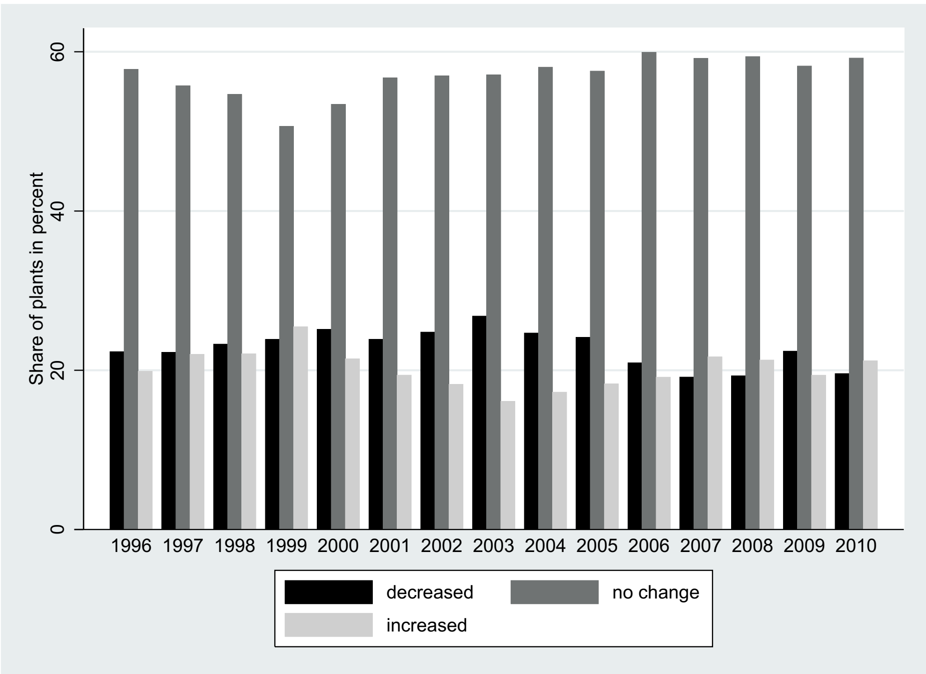

Figure 2: Share of the plants which decrease, do not change or increase employment (in percent)
Notes: Weighted data, private sector only
Source: IAB Establishment Panel, waves 1996–2010, own calculations

that time. Another striking result is that more than 50 percent of the plants do not change their employment level over the year. This is a first evidence in favor of non-convex adjustment costs: no employment adjustment is only optimal for a plant in the presence of fixed or linear adjustment costs.[9] Figures 3 and 4 show a slight difference between Western and Eastern Germany. In nearly every year, the share of plants that do not adjust employment is bigger in Western Germany compared with Eastern Germany. Because of this difference and the existing general differences between the labor markets in Western and Eastern Germany we will conduct the econometric analysis separately for the two German regions.

Table 1, which illustrates the varying adjustment decision of the plants from one year to another, further underlines the relevance of non-convexity. With convex adjustment costs plants should optimally spread employment adjustment over several time periods so that adjustment takes place in every period. But Table 1 indicates that many plants which adjust (increase or decrease) employment in one year do not further adjust it in the following year.[10] Of course, we need econometric analysis to identify the functional form of adjustment costs more clearly.

4 Econometric Model

As no direct data on firms' adjustment costs is available for Germany, the analysis of the firms' adjustment costs structure is based on a theoretical model of dynamic labor demand. We will compare a pure convex specification for adjustment costs with a combination of a fixed and a convex structure.[11] First we derive the empirical model with convex adjustment costs which we will then compare to the empirical model with fixed and convex adjustment costs. For the model with pure convex costs, we follow the work of Kölling (1998, pp. 10–22), Nickell (1986), as well as Sargent (1978; 2010) and assume labor L_t, which is the only existing production factor, to be homogeneous.

[9] This evidence may be not completely convincing. One could think that no employment adjustment can also be optimal in the presence of convex adjustment costs if the optimum does not change. However, the optimum will not be reached in finite time. Furthermore, it is plausible that the optimal employment level changes at least within two years. Therefore, no employment adjustment two years in a row should not be observed in the presence of pure convex adjustment costs. Yet, Table 1 shows the opposite.

[10] One could argue that results coming from annual data do not show permanent adjustment and thus cannot serve as evidence for pure convex costs because employment adjustment towards the optimum is already achieved within a year. However, the economic environment and thus the optimal employment level changes at least annually. Therefore, a plant might switch from increasing employment to decreasing, but should not stop adjustment.

[11] A separate analysis of a linear form is not required because its effect on adjustment behavior is nested in the fixed and convex form (see Gavosto and Sestito, 1993, p. 437).

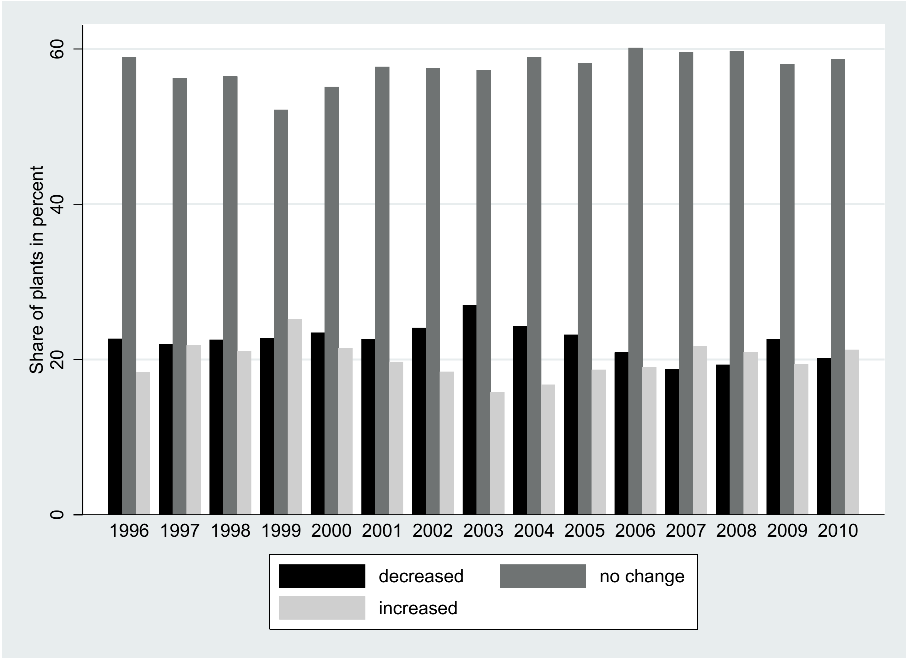

Figure 3: Share of the plants in Western Germany which decrease, do not change or increase employment (in percent)
Notes: Weighted data, private sector only
Source: IAB Establishment Panel, waves 1996–2010, own calculations

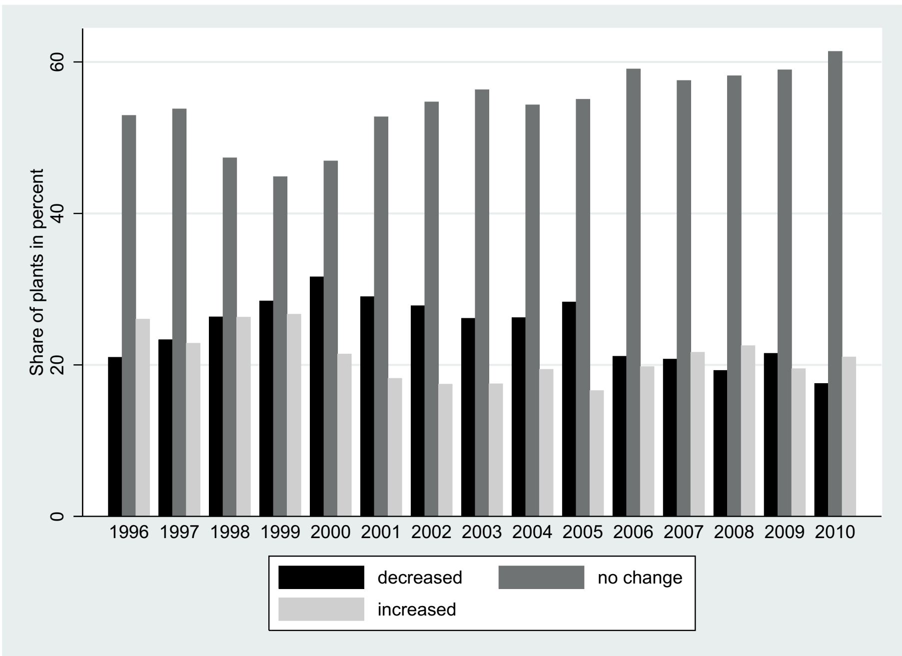

Figure 4: Share of the plants in Eastern Germany which decrease, do not change or increase employment (in percent)
Notes: Weighted data, private sector only
Source: IAB Establishment Panel, waves 1996–2010, own calculations

Table 1: Share of the plants which decrease, do not change or increase their employment, if their employment decreased, did not change or increased in the previous year (in percent)

	Plants whose employment decreased in the previous year			Plants whose employment did not change in the previous year			Plants whose employment increased in the previous year		
Year	thereof plants, whose employment decreased	thereof plants, whose employment not chang.	thereof plants, whose employment increased	thereof plants, whose employment decreased	thereof plants, whose employment not chang.	thereof plants, whose employment increased	thereof plants, whose employment decreased	thereof plants, whose employment not chang.	thereof plants, whose employment increased
1996	33.37	47.22	19.41	18.28	68.40	13.32	27.07	48.24	24.69
1997	31.26	40.93	27.81	17.40	66.67	15.93	29.70	41.83	28.47
1998	26.78	44.38	28.84	19.67	65.26	15.07	30.71	37.85	31.44
1999	32.27	39.66	28.07	20.06	58.27	21.67	29.80	39.86	30.33
2000	29.98	44.94	25.08	19.85	63.13	17.01	37.03	38.11	24.86
2001	30.93	45.81	23.26	20.46	64.55	14.99	31.16	43.05	25.80
2002	31.88	44.43	23.69	21.57	66.10	12.33	34.14	41.43	24.42
2003	31.08	46.75	22.17	21.41	66.48	12.11	38.52	40.69	20.79
2004	31.14	47.40	21.46	19.37	68.60	12.03	34.16	41.98	23.86
2005	31.64	43.34	25.03	19.47	66.64	13.89	33.99	42.25	23.77
2006	25.24	48.66	26.10	17.55	68.05	14.40	26.32	49.41	24.28
2007	25.30	46.26	28.44	15.23	69.26	15.51	25.58	42.37	32.05
2008	25.55	48.15	26.30	15.48	69.28	15.24	26.27	39.96	33.77
2009	30.11	41.87	28.02	17.83	67.70	14.48	30.60	44.90	24.50
2010	26.95	41.36	31.68	15.52	68.77	15.71	27.91	44.85	27.25

Notes: Weighted data, private sector only
Source: IAB Establishment Panel, waves 1996–2010, own calculations

The starting point of the model is the following profit equation:

$$\Pi = \sum_{t=0}^{\infty} \rho^t (a_1 L_t - \frac{1}{2} a_2 L_t^2 - L_t w_t - \frac{c}{2} (L_t - L_{t-1})^2) \ . \tag{1}$$

Π is the present value of future differences between revenues (with output following from a quadratic production function with the positive and constant parameters a_1 und a_2 and prices normalized to unity) and the sum of labor costs and convex adjustment costs (with a constant parameter c).[12] ρ $(0 < \rho < 1)$ denotes the firm's discount factor. Assuming rational expectations profit maximization leads to the following law of motion for the firm's employment:

$$L_t = \gamma_1 L_{t-1} + \gamma_2 L_t^* + \nu_t \ . \tag{2}$$

According to equation (2) the number of employees in period t is a function of the optimal employment level L^* in period t and the employment level in the previous period L_{t-1}. γ_1 represents a measure of the adjustment speed as γ_1 indicates how strongly L_t depends on L_{t-1} and thus how sluggishly L_t is adjusted towards L_t^* (see Kölling, 1998, p. 21). Low adjustment costs cause a high adjustment speed and result in a low value for γ_1. Finally, ν_t is the residual term when estimating equation (2).

Following the traditional approach in the literature, equation (2) will be expressed with employment levels in logarithmic form.[13]

$$l_t = \lambda_1 l_{t-1} + \lambda_2 l_t^* + \nu_t \ , \tag{3}$$

where lower-case letters represents logarithms. Yet, we still cannot estimate equation (3) in its current form since the data does not contain information about the optimal employment level. To solve this problem, we follow Kölling (1998, p. 132) (see also Breitung, 1992, p. 144) and express l_t^* as a linear function of the logarithm of the turnover and the logarithm of the nominal wage bill per employee.[14] In addition,

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12 The factor $\frac{1}{2}$ in the formulas for production and adjustment costs simplifies optimization.

13 Clearly, equation (3) does not follow directly from equation (2). We use the logarithmic expression in the tradition of the previous studies, e.g., Arellano and Bond (1991), Bellmann and Pahnke (2006), Bohachova et al. (2011), Breitung (1992; 1994), Buch and Lipponer (2010), Cooper and Willis (2009), FitzRoy and Funke (1998), Funke et al. (1998), Kölling (1998), Lapatinas (2009) and Rottmann and Ruschinski (1998).

14 That this is true can be shown with a Cobb-Douglas production function and using the fact that in the long-run optimum the real wage equals marginal product of labor (see Breitung, 1992, p. 144). Furthermore, the turnover and nominal wage bill per employee is used instead of the output and the real wage because the IAB Establishment Panel only contains this information (see Breitung, 1992, p. 170).

further controls are included in the empirical model which is given by:

$$l_t = \alpha_1 l_{t-1} + \beta_1 \text{log.turnover} + \beta_2 \text{log.wage} + \boldsymbol{\beta x_t} + \nu_t \ . \tag{4}$$

The vector of controls $\boldsymbol{x_t}$ includes several variables for employment structure like: the share of female employees in the workforce, the share of qualified employees, the share of part-time employees, the share of fixed-term employees and the share of employees covered by social security in the regression (see Bellmann and Pahnke, 2006, p. 207; Kölling, 1998, p. 134). Additionally, we consider a dummy variable whether the managers regarded the profit situation in the previous year as very good or good, a dummy reflecting modern production technology, a dummy reflecting the existence of a works council (lagged by one year to avoid endogeneity problems), a dummy reflecting the existence of a collective agreement (lagged by one year to avoid endogeneity problems), two dummies indicating whether the managers expect an increasing or decreasing turnover and a set of dummy variables for the industry and the year.

Regarding the share of female employees, two effects in the labor demand equation are possible. On the one hand, women in stereotyped occupations (e.g., secretary) are overrepresented in small plants, which would lead to a negative coefficient. On the other hand, women are rather concentrated in the production of bulk commodities or in simple services which are carried out in bigger plants. This in turn implies a positive coefficient. There are also ambiguous expectations regarding the sign of the share of qualified employees. As they are more productive than other employees, the plant is able to produce the same output with less workers (negative coefficient). However, the higher productivity can result in higher economic success and so in more labor demand (positive coefficient). The sign of the share of part-time employees is expected to be positive, as a plant needs more employees to produce same output. The share of fixed-term employees should also has a positive effect because for fixed-term employees adjustment costs are lower, especially dismissal costs (see Goux et al., 2001, p. 548; Varejão and Portugal, 2007, p. 159). Thus, labor demand can be higher without adjustment costs increasing too much. Both signs are possible for the share of employees covered by social security. On the one hand, these employees show higher adjustment costs compared to marginal employees. If adjustment is mainly achieved by changing the number of employees covered by social security, a higher labor demand increases costs in case of adjustment (negative coefficient). On the other hand, the employees covered by social security could have higher productivity compared to other employees and so the same effects occur as with qualified employees (positive/negative coefficient).

The dummy variable whether the managers regarded the profit situation in the previous year as very good or good is expected to have a positive sign, as plants in a good economic situation are likely to show a higher labor demand (see Bellmann and Kölling, 1997, p. 98). The same should hold for the dummy variable reflecting modern production technology. Modern technology leads to higher productivity and thus to more labor demand. But it is ambiguous as with modern, more productive technology a plant is able to produce the same output with less workers (negative coefficient). No clear effect can also be predicted for the dummy variable reflecting the existence of a works council. Following the exit-voice-approach, a works council results in a better economic situation for the plant with less fluctuation and, hence, less adjustment (see, e.g., Freeman and Medoff, 1984; Hirsch et al., 2010; Jirjahn, 2010). Thus, more labor demand and a positive coefficient can be expected. However, the works council with its codetermination rights (e.g., in case of dismissal or social plans) and rent-seeking activities may increases labor costs, especially adjustment costs (see, e.g., Addison and Teixeira, 2006; Hirsch et al., 2010; Jirjahn, 2010; Müller-Jentsch, 1997, pp. 265–272). The result would be a lower labor demand and a negative coefficient. The dummy variable reflecting the existence of a collective agreement should have similar effects. The regulations in the collective agreement, especially regarding the dismissals (e.g., severance pay, social plans), raise adjustment costs. Further, as a collective agreement indicates higher union power, it may also lead to higher adjustment costs (see Jaramillo et al., 1993).

If the plant expects a higher turnover in the future connected with a higher labor demand, it will start the upward employment adjustment in the present period because of the convex cost structure (see Bellmann and Pahnke, 2006, p. 207). The result is a positive coefficient for the dummy variable indicating whether the managers expect increasing turnover and a negative coefficient in the decreasing case.

For the analysis of the asymmetry we estimate the following model including interaction terms[15] based on Jaramillo et al. (1993) as well as Schiantarelli and Sembenelli (1993):

$$\begin{aligned} l_t = {} & \alpha_1 l_{t-1} + \Delta\alpha_1 \delta l_{t-1} + \beta_1 \text{log.turnover} + \Delta\beta_1 \delta \text{log.turnover} \\ & + \beta_2 \text{log.wage} + \Delta\beta_2 \delta \text{log.wage} + \boldsymbol{\beta x_t} + \Delta\boldsymbol{\beta}\delta\boldsymbol{x_t} + \nu_t \end{aligned} \tag{5}$$

[15] In the empirical analysis and interpretation of the results it is important to note that the interaction terms might be affected by endogeneity since the dummy variable depends on firms' employment adjustment, which determines also l_t. Therefore, a new employment level l_t after adjustment might also affects the dummy variable. But Jaramillo et al. (1993, p. 642) consider this with reference to Heckman (1978) not as a problem due to the use of a dynamic panel estimation according to Arellano and Bond (1991). We use a dynamic panel as well with a similar approach.

with

$$\delta = \begin{cases} 1, & \text{if } L_t > L_{t-1} \\ 0, & \text{else.} \end{cases}$$

Different costs for upward and downward adjustment and thus different adjustment speeds are reflected in different values for α_1. A negative $\Delta\alpha_1$ indicates a faster adjustment in the case of upward adjustment and so higher dismissal costs compared to the costs of hiring.

As equation (4) is a dynamic panel model, we use an system GMM estimator (GMM-SYS / Arellano-Bover estimator) (see Arellano and Bover, 1995).[16] This estimator is an extension of the difference GMM estimator (GMM-DIFF / Arellano-Bond estimator) (see Arellano and Bond, 1991). The GMM-SYS estimator uses previous levels $l_{t-2}, ..., l_1$ as instruments for the first differences Δl_{t-1} like the GMM-DIFF estimator and additionally lagged first differences $\Delta l_{t-1}, ..., \Delta l_2$ as instruments for the levels. Comparing the two estimators, the GMM-SYS estimator is more efficient and yields better results (see, e.g., Bond and van Reenen, 2007, p. 4452; Blundell and Bond, 1998, p. 116; Blundell and Bond, 2000, p. 339; Blundell et al., 2000). Additionally, we use the more robust two-step version of the estimator, which leads to an additional efficiency increase if the standard errors are Windmeijer-corrected (see, e.g., Bond, 2002, p. 147; Roodman, 2009, p. 97; Windmeijer, 2005, pp. 44–46).

Every plant adjusts employment according to equation (4) or (5) if pure convex adjustment costs are assumed. But if a fixed and convex structure is assumed, these equations are just relevant for those plants which actually decide to adjust. Depending on fixed adjustment costs, the plant will only adjust employment if the profit gained from adjustment exceeds costs or, put differently, if the difference to the optimal level L^* is big enough. Hence, adjustment only occurs if

$$k < |L_{t-1} - L_t^*| \tag{6}$$

with a threshold value k. Otherwise the plant will keep the employment level of the previous period ($L_t = L_{t-1} + \nu_t$). For fixed and convex adjustment costs, we thus arrive at a switching-regression where the inequality (6) determines whether the employment level L_t is changed according to equations (4) or (5), respectively, or whether the employment level L_t stays constant ($L_t = L_{t-1} + \nu_t$).[17] There are different approaches estimating a switching-regression (e.g., D-method). In our

[16] For details about the analysis of dynamic panel models we refer to Baltagi (2008, ch. 8).

[17] For details on switching-regressions see, e.g., Cameron and Trivedi (2005, p. 555ff.), Goldfeld and Quandt (1976) as well as Maddala (1986).

analysis we use a two-step procedure according to Maddala (1994, pp. 223–228). In a first step a probit model is estimated for the selection or switching. Afterwards, in a second step the current equation – in our case equation (4) or (5) – is estimated with a selection term à la Heckman estimated from the probit model.[18] To obtain correct standard errors, the bootstrap is used.

The basis for the probit model is inequality (6), which determines the latent variable. The firm's decision about employment adjustment depends on the following inequality and thus $L_t \neq L_{t-1}$ if:

$$
\begin{aligned}
& |L_{t-1} - L_t^*| - k > 0 \\
\Leftrightarrow \quad & |L_{t-1} - \sum_i X_i| - k > 0
\end{aligned}
$$

in which $\sum_i X_i$ are the determinants of L_t^*. The relation described by equation (2) is also given for L_{t-1} and so labor demand in $t-1$ depends on L_{t-2} as well as L_{t-1}^*. This leads to the following condition for $L_t \neq L_{t-1}$:

$$
\begin{aligned}
\Leftrightarrow \quad & |L_{t-2} + L_{t-1}^* - L_t^*| - k > 0 \\
\Leftrightarrow \quad & |L_{t-2} + \sum_i \Delta X_i| - k > 0 \,.
\end{aligned}
$$

Besides L_{t-2}, the decision for adjustment depends on the change of L^* or its determinants from the previous to the current period. In the analysis the model for the latent variable in the probit model is given by:

$$
y_t^* = \rho l_{t-2} + \boldsymbol{\sigma} |\triangle \boldsymbol{x_t}| + \boldsymbol{\theta} \boldsymbol{z_t} + u_t \,. \tag{7}
$$

In addition to l_{t-2}, the vector $|\triangle \boldsymbol{x_t}|$ in equation (7) contains the absolute value of the percentage change of turnover and wage bill per employee as well as the absolute values of changes in percentage points of the various employment shares. Furthermore, $|\triangle \boldsymbol{x_t}|$ contains two dummy variables indicating whether managers' valuation of the profit situation has increased or decreased and two dummy variables indicating whether the production technology has been upgraded or downgraded. We also include two dummy variables indicating whether managers are expecting a change of turnover in the current period after expecting no change in the previous period and whether managers are expecting no change of turnover in the current period after expecting a change in the previous period. Finally, the vector $\boldsymbol{z_t}$ includes some of the variables from equation (4), which we expect to show an impact on fixed

[18] For details on sample selection and dynamic panel data models and applications see, e.g., Garcia et al. (2007), Jiménez-Martín (2006), Jiménez-Martín and Garcia (2010) as well as Lodigiani and Salomone (2012).

adjustment costs, too.[19]

5 Empirical Results

First, we estimate the model with pure convex adjustment costs. In doing so, we also investigate a potential asymmetry in adjustment costs. Second, we estimate the model with fixed and convex costs in a switching-regression approach. This estimation is only done for plants which actually adjust employment. Afterwards, we compare the results of both models and decide which better suits the data.

Table 2 reports the estimation results of the model with convex, symmetric adjustment costs (specification (4)).[20] The coefficient α_1 for the lagged logarithmic number of employees covered by social security has the value 0.6746 in Western Germany. It represents a median adjustment of approximately 1.8 years, implying a lower adjustment speed compared to the result of Kölling (1998, p. 143), who, analyzing West German plants during 1993–1996, finds a median adjustment of around 0.7 years.[21] However, our result is in line with results from other studies for Germany. The bulk of these studies show a median adjustment between 0.7 and 7.7 years.[22] Furthermore, Table 5 contains the elasticities of labor demand regarding nominal wage rate and turnover, respectively: The long-run value for the wage rate is –0.27 and for turnover 0.10. These results are also in line with other studies for Germany. The share of qualified employees has a negative sign and so their higher productivity enables the plant to produce the same output with fewer people. As expected, the coefficient of the share of part-time employees is greater than zero. The plant needs more employees for the same output. Furthermore, we find a positive effect for the share of fixed-term employees as well as for the share of employees covered by social security. Moreover, a good profit situation leads to higher labor demand which is also reflected by the signs of the dummy variables for the expected turnover. In contrast, the existence of a works council reduces labor demand.

Table 2 also contains various summary statistics to assess the quality of the models estimated. The value of the Hansen test indicates a misspecification.

[19] These are the dummy variables indicating whether the managers regarded the profit situation in the previous year as very good or good, reflecting a modern production technology, the existence of a works council, the existence of a collective agreement, indicating whether managers expect an increasing or decreasing turnover and sets of industry and year dummies.

[20] Summary statistics are reported in Table A.1 in the Appendix.

[21] The median adjustment is the time span the plant needs to do half of the adjustment towards the optimum. It is based on the equation $\alpha_1^t = 0.5$, which is solved for t (see Hamermesh, 1993, p. 248) and which has the dimension 'years'. For an alternative interpretation of α_1 see Funke et al. (1998, p. 231). $(1 - \alpha_1)$ is the share of the adjustment towards the optimum, occurring between the previous and the current period.

[22] The reasons for the wide range of results might be, among other things, a different observation period or a different estimation method.

However, one has to consider that the Hansen test provides no unambiguous and strong statements (see Roodman, 2009, p. 98) and that even with a positive result it is possible that the model is biased (see Wooldridge, 2010, p. 135). We continue to rely on our model because an Arellano-Bond-Test does not indicate a second-order serial correlation in the first-differenced residuals.[23] The table also shows the value of the Theil U statistic as a measure for the predictive power (see Greene, 2012, p. 128). The basis for the calculation is an estimation for the period 1996–2007 which is then used to predict the years 2008–2010. A higher value indicates a lower predictive power, but a single value is not meaningful. We use the Theil U statistic to compare the predictive power of different models.

For Eastern German plants the coefficient α_1 has the value 0.6600 which implies a median adjustment after approx. 1.7 years. Apparently, the adjustment process is faster and so adjustment costs are lower in Eastern Germany compared to Western Germany, which has also been found by Bellmann and Pahnke (2006, pp. 212–213) as well as Fuchs (2010, pp. 168–169). However, the difference to Western Germany is not statistically significant as the confidence intervals overlap. The long-run elasticities in Eastern Germany are 0.07 for turnover and –0.23 for wage rate. The other coefficients are not qualitatively different to Western Germany. Only the effect for the existence of a works council is statistically insignificant for Eastern German plants, and modern production technology has a statistically significant positive sign. Apparently, plants with modern technology have higher productivity and demand more employees. Since an Arellano-Bond-Test indicates no second-order serial correlation in the first-differenced residuals, we use the model although the Hansen test indicates a misspecification.

Next, we analyze a potential asymmetry of the adjustment costs by estimating model (5) including the interaction terms for the direction of adjustment (see Table 3).[24] For Western and Eastern Germany the coefficient $\Delta\alpha_1$ is less than zero, suggesting that employment adjustment proceeds faster in case of an employment increase. Besides, all the interaction terms together are statistically significant, indicating asymmetric adjustment costs with dismissal costs exceeding hiring costs.[25]

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[23] Fuchs (2010, p. 123) uses the same argument for a further analysis of her (seemingly misspecified) model. All Arellano-Bond-Tests in our study indicate no second-order serial correlation in the first-differenced residuals unless otherwise mentioned.

[24] The model for Eastern Germany is estimated with l_{t-1} and additional l_{t-2} such that the Arellano-Bond-Test does not indicate a second-order serial correlation in the first-differenced residuals.

[25] Note that the analysis is not a clear comparison of plants increasing employment with plants decreasing employment because the reference category for the dummy variable are plants that decrease or do not change employment. Therefore as a robustness check, we also estimate the model with a dummy variable indicating whether the plant decreases employment (not reported in the paper). This also results in estimates indicating that dismissal costs exceeds hiring costs.

Table 2: Estimation of the basic model of dynamic labor demand with convex adjustment costs[1] (only private sector; 1996–2010; two-step GMM-SYS estimator; dependent variable is log number of employees covered by social security)

	Western Germany		Eastern Germany	
Explanatory variables	coeff.	std.error	coeff.	std.error
Lagged employment l_{t-1}	0.6746***	0.0252	0.6600***	0.0232
Turnover (*log*)	0.0310***	0.0099	0.0238**	0.0110
Nom. wage bill per employee (*log*)	–0.0867***	0.0082	–0.0783***	0.0101
Share of female employees (*in percent*)	0.0002	0.0003	–0.0003	0.0003
Share of qualified employees (*in percent*)	–0.0013***	0.0001	–0.0014***	0.0002
Share of part-time employees (*in percent*)	0.0006***	0.0002	0.0011***	0.0002
Share of fixed-term employees (*in percent*)	0.0020***	0.0004	0.0024***	0.0004
Share of employees covered by social security (*in percent*)	0.0164***	0.0005	0.0202***	0.0006
Profit situation ‡(*dummy: very good/good=1*)	0.0258***	0.0031	0.0259***	0.0038
Modern production technology (*dummy: 1 or 2 on 5-point scale=1*)	0.0055	0.0038	0.0122**	0.0048
Works council ‡(*dummy: yes=1*)	–0.0299***	0.0100	–0.0105	0.0124
Covered by collective agreement ‡(*dummy: yes=1*)	0.0035	0.0054	0.0021	0.0053
Firm expects turnover increase (*dummy: yes=1*)	0.0233***	0.0029	0.0399***	0.0041
Firm expects turnover reduction (*dummy: yes=1*)	–0.0366***	0.0033	–0.0586***	0.0040
Constant	–0.0838	0.1505	–0.5030***	0.1590
Industry dummies	yes		yes	
Year dummies	yes***		yes***	
Number of observations (plant-years)	49577		38141	
Wald (37)	4248.20***		5602.03***	
Hansen (103)	122.5397*		184.8406***	
Arellano-Bond (m1 | m2)	–12.52***	–1.47	–14,66***	1.57
Theil U	0.1180		0.1367	

[1] The table presents coefficients and Windmeijer-corrected standard errors. Reference categories of the dummy variable groups: no turnover change expected, agriculture and forestry, 1996 and 1997. Significance levels: * p<0.1; ** p<0.05; *** p<0.01. Arellano-Bond (m1 | m2) are tests for first- and second-order serial correlation in the first differenced residuals. For the Theil U statistics the years 2008 to 2010 are predicted based on an estimation of the years 1996 to 2007. ‡Indicates that the information refers to the previous year.
Source: IAB Establishment Panel, waves 1996–2010

Table 3: Estimation of the basic model of dynamic labor demand with convex adjustment costs and an asymmetric cost structure[1] (only private sector; 1996–2010; two-step GMM-SYS estimator; dependent variable is log number of employees covered by social security)

	Western Germany		Eastern Germany	
Explanatory variables	coeff.	std.error	coeff.	std.error
Lagged employment l_{t-1}	0.7280***	0.0225	0.7535***	0.0197
l_{t-1} ×dummy(1=L increased between t-1 and t)	–0.0747***	0.0054	–0.0793***	0.0075
Turnover (*log*)	0.0108	0.0090	0.0059	0.0116
Nom. wage bill per employee (*log*)	–0.0535***	0.0071	–0.0606***	0.0098
Share of female employees (*in percent*)	0.0001	0.0002	–0.0001	0.0003
Share of qualified employees (*in percent*)	–0.0009***	0.0001	–0.0010***	0.0002
Share of part-time employees (*in percent*)	0.0005***	0.0001	0.0008***	0.0002
Share of fixed-term employees (*in percent*)	0.0001	0.0004	0.0001	0.0004
Share of employees covered by social security (*in percent*)	0.0125***	0.0004	0.0155***	0.0006
Profit situation ‡(*dummy: very good/good=1*)	0.0200***	0.0030	0.0252***	0.0042
Modern production technology (*dummy: 1 or 2 on 5-point scale=1*)	0.0069*	0.0036	0.0147***	0.0053
Works council ‡(*dummy: yes=1*)	–0.0131	0.0102	–0.0145	0.0131
Covered by collective agreement ‡(*dummy: yes=1*)	–0.0011	0.0050	–0.0003	0.0058
Firm expects turnover increase (*dummy: yes=1*)	–0.0006	0.0030	0.0020	0.0047
Firm expects turnover reduction (*dummy: yes=1*)	–0.0377***	0.0032	–0.0539***	0.0043
Constant	0.0850	0.1337	–0.4445***	0.1592
Industry dummies	yes		yes	
Year dummies	yes***		yes***	
Other interactions with dummy(1=L increased between t-1 and t)	yes***		yes***	
Number of observations (plant-years)	49423		30317	
Wald (74/73)	8571.57***		10220.42***	
Hansen (103/101)	109.3018		162.172***	
Arellano-Bond (m1 | m2)	–10.94***	–0.03	–10.35***	0.76
Theil U	0.1080		0.0873	

[1] The table presents coefficients and Windmeijer-corrected standard errors. Reference categories of the dummy variable groups: no turnover change expected, agriculture and forestry, 1996 and 1997 (Eastern Germany: additional 1998). Significance levels: * p<0.1; ** p<0.05; *** p<0.01. In order to avoid a correlation with the error term, we use l_{t-2} instead of l_{t-1} for the interaction. The model for Eastern Germany is estimated with two lags to get an Arellano/Bond-Test which does not indicate second-order serial correlation in the first-differenced residuals. Arellano-Bond (m1 | m2) are tests for first- and second-order serial correlation in the first differenced residuals. For the Theil U statistics the years 2008 to 2010 are predicted based on an estimation of the years 1996 to 2007. ‡Indicates that the information refers to the previous year.
Source: IAB Establishment Panel, waves 1996–2010

Table 4: Estimation of the basic model of dynamic labor demand with fix and convex adjustment costs and an asymmetric cost structure[1] (only private plants which adjust their level of employment; 1996–2010; two-step GMM-SYS estimator; dependent variable is log number of employees covered by social security)

	Western Germany		Eastern Germany	
Explanatory variables	coeff.	std.error	coeff.	std.error
Lagged employment l_{t-1}	0.7877***	0.0457	0.7493***	0.0582
l_{t-1} ×dummy(1=L increased between t-1 and t)	–0.0629***	0.0090	–0.0744***	0.0158
Turnover (*log*)	–0.0052	0.0190	0.0186	0.0393
Nom. wage bill per employee (*log*)	–0.0912***	0.0172	–0.1032***	0.0250
Share of female employees (*in percent*)	0.0002	0.0006	–0.0003	0.0010
Share of qualified employees (*in percent*)	–0.0016***	0.0003	–0.0015***	0.0005
Share of part-time employees (*in percent*)	0.0008*	0.0004	0.0013**	0.0006
Share of fixed-term employees (*in percent*)	0.0001	0.0008	0.0007	0.0008
Share of employees covered by social security (*in percent*)	0.0162***	0.0010	0.0194***	0.0021
Profit situation ‡(*dummy: very good/good=1*)	0.0195***	0.0053	0.0411***	0.0098
Modern production technology (*dummy: 1 or 2 on 5-point scale=1*)	0.0116**	0.0057	0.0276**	0.0140
Works council ‡(*dummy: yes=1*)	–0.0155	0.0174	–0.0153	0.0280
Covered by collective agreement ‡(*dummy: yes=1*)	–0.0053	0.0110	–0.0070	0.0129
Firm expects turnover increase (*dummy: yes=1*)	0.0042	0.0051	0.0195*	0.0107
Firm expects turnover reduction (*dummy: yes=1*)	–0.0341***	0.0049	–0.0494***	0.0098
Constant	0.2033	0.4267	–0.9315*	0.4873
Industry dummies	yes		yes	
Year dummies	yes***		yes	
Selection term	yes***		yes**	
Other interactions with dummy(1=L increased between t-1 and t)	yes***		yes***	
Number of observations (plant-years)	28824		17577	
Wald (73/70)	4280.76***		9928.60***	
Hansen (103/100)	380.1639***		422.321***	
Arellano-Bond (m1 | m2)	–5.91***	0.45	–6.80***	1.13
Theil U	0.0795		0.0838	

[1] The table presents coefficients and standard errors that are calculated from a bootstrapping with 150 replications. Reference categories of the dummy variable groups: no turnover change expected, agriculture and forestry, 1996 and 1997 (Eastern Germany: additional 1998 and 1999). Significance levels: * p<0.1; ** p<0.05; *** p<0.01. In order to avoid a correlation with the error term, we use l_{t-2} instead of l_{t-1} for the interaction. The model for Eastern Germany is estimated with two lags to get an Arellano/Bond-Test which does not indicate second-order serial correlation in the first-differenced residuals. Arellano-Bond (m1 | m2) are tests for first- and second-order serial correlation in the first differenced residuals. For the Theil U statistics the years 2008 to 2010 are predicted based on an estimation of the years 1996 to 2007. ‡Indicates that the information refers to the previous year.
Source: IAB Establishment Panel, waves 1996–2010

Furthermore, the Theil U statistics indicate that the model with asymmetric adjustment costs has a higher predictive power.

So far, the results indicate that adjustment costs are asymmetric with dismissal costs exceeding hiring costs. In a next step, Table 4 presents the results for the model with fixed and convex as well as asymmetric adjustment costs. The results of the probit model which is estimated in the first step to calculate the selection terms are given in Table A.2 in the Appendix.[26] In Western Germany the coefficient α_1 has the value 0.7877, which results in a median adjustment of approximately 2.9 years. As in the pure convex case, we have evidence for asymmetric adjustment costs in Western and Eastern Germany. Thus, the 2.9 years are the median adjustment for employment decrease in Western Germany. If employment increases, the plant adjusts approximately 0.7 years faster. The corresponding values are 2.4 years (employment decrease) and 1.8 years (employment increase) for Eastern German plants and hence the difference is 0.6 years. The long-run elasticity for the wage rate is –0.19/–0.43 (employment increase/decrease) in Western Germany and –0.12/–0.76 in Eastern Germany. As the effect of turnover is statistically insignificant, we report no long-run elasticities for turnover. The other coefficients are qualitatively similar to the previous models, as long as they are statistically significant. Along with turnover, the share of fixed-term employees, the existence of a works council and an expected turnover increase are statistically insignificant in Western Germany. With fixed and convex, asymmetric adjustment costs, the effect of modern technology is statistically significant for Western German plants. Apart from turnover, also the statistical significance of the share of fixed-term employees (now insignificant) and an expected turnover increase (now statistically significant) also change compared to the model with symmetric convex or asymmetric convex in Eastern Germany.

Coming back to the question whether the adjustment costs are purely convex or fixed and convex, we have no straightforward test to answer this question. Yet, our analysis gives us some important hints in favor of a fixed and convex specification. First of all, the selection terms are statistically significant in Western and Eastern Germany meaning that selection in the status of employment adjustment plays a role. Furthermore, a model with fixed and convex costs has a higher predictive power (Theil U statistic). We also find a higher predictive power assuming pure convex costs if the model is estimated just for plants which actually adjust employment. However, if only these plants are considered, the selection term has to be included, resulting in our model with fixed and convex adjustment costs. Based on all this evidence we

[26] As a robustness check, we estimate the probit model also with l_{t-1} instead of l_{t-2} as well as with the change of the employment shares from the pre-previous to the previous period instead of the change from the previous to the current one. But these variations lead to a lower predictive power in the probit model and do not really result in a different outcome for the second step.

Table 5: Overview of the main results of several models

Model	**Data**	**Specification of the adjustment costs**	**Adjustment coefficient (α_1)**	**Wage elasticity (short-/long-term)**	**Turnover elasticity (short-/long-term)[1]**
Table 2	Western Germany; 1996–2010	convex and symmetric	0.675	–0.09/–0.27	0.03/0.10
	Eastern Germany; 1996–2010	convex and symmetric	0.660	–0.08/–0.23	0.02/0.07
Table 3	Western Germany; 1996–2010	convex and asymmetric	0.653[2] 0.728[3]	–0.05/–0.15[2] –0.05/–0.20[3]	(0.04/0.12)[2] (0.01/0.04)[3]
	Eastern Germany; 1996–2010	convex and asymmetric	0.674[2] 0.754[3]	–0.01/–0.04[2] –0.06/–0.34[3]	(0.03/0.11)[2] (0.01/0.03)[3]
Table 4	Western Germany; 1996–2010	fix, convex and asymmetric	0.725[2] 0.787[3]	–0.05/–0.19[2] –0.09/–0.43[3]	(0.02/0.06)[2] (-0.01/-0.02)[3]
	Eastern Germany; 1996–2010	fix, convex and asymmetric	0.675[2] 0.749[3]	–0.03/–0.12[2] –0.10/–0.76[3]	(0.02/0.09)[2] (0.02/0.14)[3]

[1] Statistically insignificant elasticities are in parenthesis.
[2] Plants with an employment increase.
[3] Plants with an employment decrease.
Source: IAB Establishment Panel, waves 1996–2010; own calculations

prefer a fixed and convex specification instead of a pure convex one. The result of asymmetric adjustment costs does not depend on the assumption of purely convex or fixed and convex cost structure.[27]

Table 5 summarizes the main results for the adjustment coefficient and elasticities of the several models in this study. As mentioned already, the values are in line with previous studies for Germany such as Addison and Teixeira (2005), Bellmann and Pahnke (2006), Bohachova et al. (2011), Breitung (1992), Buch and Lipponer (2010), Flaig and Rottmann (2001), Flaig and Steiner (1989), Franz and König (1986), Fuchs (2010), Koellreuter (1980), Kölling (1998), Pfeiffer (1999) as well as Rottmann and Ruschinski (1998). These studies differ in database, observation period, observed regions, analyzed sectors, estimation approaches and the specification of adjustment costs. While Flaig and Rottmann (2001), Flaig and Steiner (1989), Koellreuter (1980), as well as Pfeiffer (1999) use a static estimation approach, other studies employ a dynamic approach. Our study is the only existing one apart from Kölling (1998) that allows for asymmetric adjustment costs. In addition, it extends the sparse literature analyzing dynamic labor demand models for eastern Germany by Fuchs (2010) and by Pfeiffer (1999).

6 Changing Adjustment Behavior over Time

Our observation period from 1996 to 2010 contains two business cycles and thus several economic up- and downturns.[28] The first cycle comprises the years 1996 to 2003 and the second one starts in 2004. With these two cycles it is possible to investigate whether firms' adjustment behavior has changed over time. For such an analysis we need to compare entire business cycles instead of single years. If two single years are compared, these two years could originate from different economic phases of the business cycle. This may lead to a comparison of employment adjustment in economic upturn (predominantly hirings) with that in economic downturns (predominantly firings). This could result in a difference in the estimated effects caused by asymmetry and not just because of a changing over time.

We find evidence for a change in adjustment behavior of German plants in several studies. The German Council of Economic Experts compares firms' adjustment

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27 We also estimate the models separately for the production and the service sector (results not reported in the paper). Both estimations indicate fixed and convex, asymmetric adjustment costs. Furthermore, the elasticities for turnover and wage in the production sector are in line with Flaig and Rottmann (2001) as well as Pfeiffer (1999).

28 In Germany, no clear definition and scheduling of economic phases exists. For that reason there is no comprehensive classification of the years 1996 to 2010. Based on the development of the GDP, the Ifo Business Climate Index and findings of the German Council of Economic Experts as well as the Federal Statistical Office we apply the following classification: 1996–2000, 2004–2007 and 2010 upturns; 2001–2003 and 2008–2009 downturns.

behavior and the labor market reaction of three different economic upturns (1993II–1995II; 1999II–2001I; 2004IV–2007II). Their results indicate a change in the adjustment of employment. Especially in the last upturn the economic recovery was employment-intensive and many full-time jobs covered by social security were created (see GCEE, 2007, items 482–492). The flexibility and the dynamic of the labor market increased, which was – among other things – the result of labor market reforms in the years 2003 to 2005. This is also found by Gartner and Klinger (2010), who compare the economic upturns 1998II–2001I and 2004IV–2008I as well as the economic downturns 2001II–2004III and 2008II–2010II. Furthermore, they find a lower turnover rate of employment in the second business cycle (see Gartner and Klinger, 2010, p. 729). A change towards a lower fluctuation in the number of employees is also found by Burda and Hunt (2011) who compare the recession 2008–2009 with previous ones, Herzog-Stein and Seifert (2010) who compare the recession 2008–2009 with the recession 1973–1975, as well as Rothe (2009) who compares the upturns 1998I–2002IV, 2006I–2008II and the downturns in between. Apart from less adjustment activity with respect to the number of employees, a greater adjustment of working hours can be discovered due to better flexibility (see Burda and Hunt, 2011), although the instrument of working time adjustment was also used in previous recessions (see Herzog-Stein and Seifert, 2010, pp. 553–555).

All in all, there is clear evidence of changing adjustment behavior. But except for Burda and Hunt (2011) who also compare current employment levels with predicted ones, all the studies mentioned above use descriptive analyses of aggregated data. In contrast, we apply an econometric approach with establishment data. Using the dynamic labor demand model from Section 5 with fixed, convex, and asymmetric adjustment costs, we analyze a possible change in adjustment behavior. We do so by interacting the lagged logarithmic number of employees covered by social security with a dummy variable indicating whether the observation is from the first business cycle from 1996 to 2003.

Table 6 reports the results of this estimation. The interaction term is significantly positive in both Western and Eastern Germany. Based on the coefficients, the median adjustment of Western German plants is approximately 0.14/0.22 years (employment increase/employment decrease) larger in the first business cycle compared with the second business cycle. The corresponding values are 0.22/0.34 years for Eastern Germany. Compared with the analysis without interaction term (see table 4), a few differences can be found. The coefficients for adjustment, α_1, are lower if the interaction term is included. Furthermore, the short-run elasticity of labor demand with regard to wage rate has decreased in Western Germany. The statistical significance level for the coefficients has changed only marginally, except for the dummy variable for the modern production technology in Eastern Germany that is

Table 6: Estimation of the basic model of dynamic labor demand with fix, convex and asymmetric adjustment costs allowing for different adjustment behavior in different business cycles[1] (only private plants which adjust their level of employment; 1996–2010; two-step GMM-SYS estimator; dependent variable is log number of employees covered by social security)

	Western Germany		Eastern Germany	
Explanatory variables	coeff.	std.error	coeff.	std.error
Lagged employment l_{t-1}	0.7210***	0.0454	0.6831***	0.0585
l_{t-1} ×dummy(1=L increased between t-1 and t)	–0.0626***	0.0092	–0.0771***	0.0161
l_{t-1} ×dummy(1=obs. from 1996–2003)	0.0221***	0.0035	0.0424***	0.0090
Turnover (*log*)	0.0170	0.0190	0.0505	0.0402
Nom. wage bill per employee (*log*)	–0.0685***	0.0172	–0.1021***	0.0257
Share of female employees (*in percent*)	0.0003	0.0006	–0.0001	0.0011
Share of qualified employees (*in percent*)	–0.0014***	0.0003	–0.0013***	0.0005
Share of part-time employees (*in percent*)	0.0010**	0.0004	0.0015**	0.0006
Share of fixed-term employees (*in percent*)	0.0004	0.0008	0.0007	0.0008
Share of employees covered by social security (*in percent*)	0.0159***	0.0010	0.0182***	0.0021
Profit situation ‡(*dummy: very good/good=1*)	0.0173***	0.0052	0.0380***	0.0095
Modern production technology (*dummy: 1 or 2 on 5-point scale=1*)	0.0136**	0.0057	0.0201	0.0130
Works council ‡(*dummy: yes=1*)	–0.0133	0.0172	–0.0242	0.0282
Covered by collective agreement ‡(*dummy: yes=1*)	–0.0062	0.0113	–0.0005	0.0127
Firm expects turnover increase (*dummy: yes=1*)	0.0050	0.0051	0.0200*	0.0106
Firm expects turnover reduction (*dummy: yes=1*)	–0.0315***	0.0049	–0.0464***	0.0097
Constant	–0.0809	0.4241	–1.0865**	0.4894
Industry dummies	yes		yes	
Year dummies	yes***		yes***	
Selection term	yes***		yes**	
Other interactions with dummy(1=L increased between t-1 and t)	yes***		yes***	
Number of observations (plant-years)	28824		17577	
Wald (74/71)	4568.55***		11215.95***	
Hansen (103/100)	265.3168***		250.9633***	
Arellano-Bond (m1 | m2)	–5.63***	0.43	–6.67***	1.22

[1] The table presents coefficients and standard errors that are calculated from a bootstrapping with 150 replications. Reference categories of the dummy variable groups: no turnover change expected, agriculture and forestry, 1996 and 1997 (Eastern Germany: additional 1998 and 1999). Significance levels: * p<0.1; ** p<0.05; *** p<0.01. In order to avoid a correlation with the error term, we use l_{t-2} instead of l_{t-1} for the interaction. The model for Eastern Germany is estimated with two lags to get an Arellano/Bond-Test which does not indicate second-order serial correlation in the first-differenced residuals. Arellano-Bond (m1 | m2) are tests for first- and second-order serial correlation in the first differenced residuals. ‡Indicates that the information refers to the previous year.
Source: IAB Establishment Panel, waves 1996–2010

now insignificant.

These differences in firms' adjustment behavior between the business cycles can also be found in an analysis with pure convex, asymmetric adjustment costs (not reported in the paper). Thus, the assumption on the functional form does not drive this result. The employment adjustment in the second business cycle proceeds at a higher speed.[29] The plants spread the adjustment over a shorter period of time as it is indicated by the lower median adjustment. This might be evidence of lower adjustment costs. A higher flexibility in the adjustment of employment can be a reason for that. However, our results contrast with studies mentioned above based on a descriptive analysis of aggregated data. These studies find a lower fluctuation in recent years. An explanation might be that some plants adjust with a higher speed and at the same time fewer plants decide to adjust at all. But this explanation is not tenable in light of the analysis with assumed pure convex and asymmetric adjustment costs because all plants, adjusting or not, are included. Fewer plants with employment adjustment in the second cycle would lead to a negative interaction term which we do not observe. Still, there is an explanation for the differences between the results of our study and the results of the studies mentioned above. Because of the improved opportunity of working time adjustment, less adjustment of the number of employees is needed. Nevertheless, if plants do have to adjust employment, they adjust in a faster way because the possibility of employment adjustment has also improved (see Herzog-Stein and Seifert, 2010, p. 552).

7 Conclusions

Using a large and representative establishment data set for Germany, we investigate firms' labor adjustment behavior in terms of the number of employees covered by social security. The results of our empirical analysis indicate that adjustment costs are characterized by a convex structure including a fixed component. Thus firms do not adjust employment permanently, and there are periods with no employment adjustment. Furthermore, the cost structure is found to be asymmetric: In case of an employment increase, the adjustment runs faster compared with a decrease suggesting that dismissal costs exceed the costs of hiring. These results are in line with the existing literature. Based on our preferred baseline model the long-term wage elasticity is –0.19 in case of an employment increase and –0.43 in case of an employment decrease in Western Germany. The corresponding values are –0.12 and –0.76 for Eastern Germany. Thus the elasticities are higher (in absolute terms) in

[29] Strictly speaking a third business cycle starts with the year 2010. Therefore, the analysis is repeated excluding the year 2010 (results not reported in the paper). The results do not change. An analysis without the year 2010 also indicates a faster adjustment in the second business cycle.

case of a reduction in employment.

Moreover, we identify a change in firms' employment adjustment over time. The adjustment was spread over a longer period of time in the business cycle from 1996 to 2003 and thus the adjustment speed was lower compared to the following business cycle from 2004 to 2010. This indicates lower adjustment costs in the business cycle after 2003, which might be related to recent reforms and more flexibility in the labor market. Nowadays, the plants seem to be able to adjust their employment covered by social security more quickly.

For a further investigation of labor adjustment, we would need information on working time to include this adjustment dimension in the analysis, thus providing a more complete picture of firms' labor adjustment. Several studies have shown an intensified use of working time adjustment in the recent past, which may also affect the change in the adjustment of the number of employees. Because of recent reforms of temporary agency employment in Germany, this type of employment may have become more important for firms' employment adjustment. The faster adjustment of the employment covered by social security in the second business cycle found in this study may reflect this, among other things. Future research should thus take temporary agency employment explicitly into account and analyze its role as an alternative adjustment instrument.

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Appendix

Table A.1: Summary Statistics

	Western Germany		Eastern Germany	
Variables	mean	std.dev.	mean	std.dev.
Turnover (*log*)	15.0067	2.3580	14.1643	1.9656
Nom. wage bill per employee (*log*)	7.4273	0.6565	7.1740	0.5757
Share of female employees (*in percent*)	37.5478	28.7271	36.0627	29.8497
Share of qualified employees (*in percent*)	71.3128	26.2142	82.9504	22.0685
Share of part-time employees (*in percent*)	19.2782	22.7839	12.8306	20.6617
Share of fixed-term employees (*in percent*)	3.5216	9.3177	4.5019	12.3852
Share of employees covered by social security (*in percent*)	79.9109	22.3018	83.7581	19.2358
Profit situation ‡(*dummy: very good/good=1*)	0.3381	0.4731	0.3596	0.4799
Modern production technology (*dummy: 1 or 2 on 5-point scale=1*)	0.6689	0.4706	0.6730	0.4691
Works council ‡(*dummy: yes=1*)	0.3349	0.4720	0.2199	0.4142
Covered by collective agreement ‡(*dummy: yes=1*)	0.5863	0.4926	0.3863	0.4869
Firm expects turnover increase (*dummy: yes=1*)	0.2809	0.4494	0.2218	0.4154
Firm expects turnover reduction (*dummy: yes=1*)	0.2527	0.4346	0.2736	0.4458
Employment adjustment (*dummy: yes=1*)	0.6632	0.4726	0.6389	0.4803

Notes: Unweighted data, private sector only. ‡Indicates that the information refers to the previous year.
Source: IAB Establishment Panel, waves 1996–2010

Table A.2: Estimation of the selection model (only private plants; 1996–2010; probit estimator; dependent variable is a dummy variable whether the plant adjusts the number employees covered by social security from period t-1 to period t)

	Western Germany		Eastern Germany	
Explanatory variables	coeff.	std.error	coeff.	std.error
l_{t-2}	0.5464***	0.0075	0.5627***	0.0086
|ΔTurnover| (*absolute percentage change*)	0.0000	0.0000	0.0003*	0.0001
|ΔNom. wage bill per employee| (*absolute percentage change*)	0.0004**	0.0002	0.0001	0.0002
|ΔShare of female employees| (*absolute change in percentage points*)	0.0047***	0.0010	–0.0092***	0.0012
|ΔShare of qualified employees| (*absolute change in percentage points*)	0.0008	0.0005	0.0013**	0.0006
|ΔShare of part-time employees| (*absolute change in percentage points*)	–0.0019***	0.0006	–0.0031***	0.0009
|ΔShare of fixed-term employees| (*absolute change in percentage points*)	0.0066***	0.0012	0.0060***	0.0013
|ΔShare of employees covered by social security| (*absolute change in percentage points*)	0.0805***	0.0027	0.0776***	0.0039
Profit situation ‡(*dummy: very good/good=1*)	0.0356*	0.0185	0.0740***	0.0207
Improvement of the profit situation (*dummy: yes=1*)	0.0024	0.0185	–0.0557***	0.0208
Deterioration of the profit situation (*dummy: yes=1*)	0.0539***	0.0184	0.0139	0.0203
Modern production technology (*dummy: 1 or 2 on 5-point scale=1*)	–0.0153	0.0180	–0.0051	0.0200
Improvement of the production technology (*dummy: yes=1*)	–0.0050	0.0205	–0.0233	0.0226
Deterioration of the production technology (*dummy: yes=1*)	0.0309	0.0214	0.0080	0.0236
Works council ‡(*dummy: yes=1*)	–0.0245	0.0255	–0.0496	0.0322
Covered by collective agreement ‡(*dummy: yes=1*)	–0.0386**	0.0179	–0.0038	0.0208
Firm expects turnover increase (*dummy: yes=1*)	0.2761***	0.0229	0.3063***	0.0271
Firm expects turnover reduction (*dummy: yes=1*)	0.2320***	0.0231	0.2394***	0.0249
Change1 expects turnover (*dummy: yes=1*)[3]	–0.1047***	0.0215	–0.0588**	0.0239
Change2 expects turnover (*dummy: yes=1*)[4]	0.0775***	0.0213	0.0799***	0.0230
Constant	–1.6676***	0.0813	–1.6786***	0.0713
Industry dummies	yes***		yes***	
Year dummies	yes		yes***	
Number of observations (plant-years)	45470		34692	
Wald (44)	9115.50***			
Pseudo R-squared	0.3398			

[1] The table presents coefficients and standard errors clustered at the establishment level. Reference categories of the dummy variable groups: no turnover change expected, agriculture and forestry, no change of the profit situation, no change of the production technology, no change of the turnover expectations and 1996. Significance levels: * p<0.1; ** p<0.05; *** p<0.01. ‡indicates that the information refers to the previous year.

[2] For a converging probit model in Eastern Germany we use an IRLS-Algorithm instead of the default Newton-Raphson-Algorithm. Thus a Wald statistic and the pseudo R-squared are not generated.

[3] The dummy variable reflects a plant expecting a change of the turnover, while expecting no change in the previous period.

[4] The dummy variable reflects a plant expecting no change of the turnover, while expecting a change in the previous period.

Quelle: IAB Establishment Panel, waves 1996–2010

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