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It's not about Adjustment Costs
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Abstract

Models of labor demand usually use cost or production functions to derive profit maximizing firm performance. These models often rely on the assumption of symmetric behavior, that is, the response to a positive or negative wage shock of the same relative size is identical to the shock, and the estimated labor demand elasticities are the same for increasing and decreasing employment. However, models like loss aversion and endowment effects question the assumption of symmetry in labor demand. In addition, the influence of a labor shortage should be reflected in the investigations. Estimations of Fractional Panel Probit models for three different skill levels are applied to evaluate these findings with a large panel of German establishments. The results indicate asymmetric structures for long-run own-wage elasticities and for some cross-wage elasticities, putting some doubt on the assumption of strict rationality in labor demand and indicating the influence of labor shortages.

Zusammenfassung

Modelle der Arbeitsnachfrage leiten das optimale Verhalten von Unternehmen häufig aus Kosten- bzw. Produktionsfunktionen ab. Die Analysen basieren häufig auf der Annahme eines symmetrischen Verhaltens bei Einstellungen oder Entlassungen, d.h. identische relative Lohnerhöhungen oder -senkungen führen zu denselben positiven bzw. negativen Beschäftigungseffekten in absoluter Höhe. Modelle der Verhaltensökonomik wie z.B. Verlustaversion und „Endowment-Effekte" stellen jedoch die Annahme der Symmetrie in Frage. Außerdem wird der mögliche Einfluss eines Fachkräftemangels auf symmetrische Veränderungen untersucht. Die Nachfrage nach drei Qualifikationsstufen wird mit Hilfe eines „Fractional Panel Probit"-Ansatzes geschätzt. Dazu wird ein großer Paneldatensatz auf Betriebsebene herangezogen. Die Ergebnisse deuten auf asymmetrische Lohnelastizitäten hin. Dies zeigt einerseits den Einfluss des Fachkräftemangels, weckt aber auch andererseits Zweifel an der Annahme von rational handelnden Betrieben.

I. Introduction

Labor demand analysis usually relies on the use of particular production or cost functions. Then, rational acting firms derive labor demand by maximizing their profits under the conditions of the actual markets. Optimal labor demand is therefore achieved when marginal labor costs equal marginal revenue from selling goods (cf. Hamermesh 1993). The results of the analysis allow identifying own- and cross-wage elasticities, indicating relative movements of labor demand from relative wage changes. Normally, it is assumed that the own-wages elasticities are negative, because higher wages increase the costs of production. Cross-wage elasticities show complementary and substitutional structures of labor demand between different qualifications. The assumption of rationality further implies that these elasticities are symmetrical; that is, positive or negative wage shocks of the same size should lead to identical quantitative long-run effects in absolute terms. Although adjustment processes might be different for increasing or decreasing employment for specific reasons, the new long-run equilibrium is independent from the velocity of adjustments.

However, there are a few situations that prevent symmetric behavior. In this paper, we will discuss three possible explanations for asymmetric elasticities: long-term adjustment processes that impede reaching the new equilibrium completely before a new shock arises, labor shortages that inhibit new personnel hiring, and, behavior that questions the assumption of strict rationality. Insights from behavioral economics suggest that individuals are not strictly rational in their actions. Therefore, we could also assume that this is true for firms' executives who decide about employment. In particular, the study at hand discusses two models of behavioral economics: loss aversion and the endowment effect.

The subsequent analysis uses the IAB Establishment Panel, a large panel data set from German establishments, to investigate the hypotheses of conventional labor demand theory. The survey is based on a stratified random sample and covers the period from 2004 to 2014. The unbalanced data contains about 16,000 observations each year. In particular, a fractional panel probit model (Wooldridge 2010a, 2010b) for three different skill levels is applied to estimate labor within a system of Seemingly Unrelated Regressions (SUR). Initial results support the assumption of asymmetric own- and cross wage elasticities. From the subsequent discussion and regression results, we will argue that this is at least partly due to the bounded rationality of the firms' decisions about hirings and firings. Especially, the long-run own-wage elasticities seem to be smaller in absolute terms for all skill levels when employment of the observed qualification increases. This means that the downward adjustment is larger (not necessarily faster) when wages increase versus an upward adjustment for a corresponding decrease of wages of the same absolute value. In addition, there is a substitutional relationship between medium- and high-skilled workers in the demand for the latter group, while there is no effect of changes in the remuneration of high-skilled workers on the demand for medium-skilled workers. Thus, employers are willing to change the number of skilled workers when labor costs of medium-skilled workers grow and fall, but the number of medium-skilled workers is not affected by the wages of high-skilled workers. In addition, it is possible to identify the influence of labor respective to skill shortages.

The research contributes to the rich literature on labor demand in two different ways. Firstly, it questions some assumptions that are usually used to derive labor demand from profit-maximizing respective cost-minimizing behavior of the firms. Especially, the application of insights from behavioral economics is a new aspect in the research. In addition, the paper introduces fractional panel probit estimations for different skill levels. These types of models efficiently estimate share regressions, even if the shares are zero or one, which is often the case when looking at different skills at the establishment level.

The remainder of the paper is organized as follows. The next section provides some information about labor demand theory and discusses the reasons for asymmetrical labor demand. In addition, we survey previous research. Section III introduces the fractional panel probit regression as the empirical model of the investigations and provides information about the used data, the IAB establishment panel. Section IV contains the results of the empirical estimations, while the final section summarizes the outcome of the research.

II. Theoretical considerations and previous studies

Labor demand is often derived from a functional framework of cost or production functions. Next to Cobb-Douglas, generalized Leontief and CES production functions, the translog cost function is frequently applied in the literature (Berndt & Khaled 1979, Falk & Koebel 2004, Freier & Steiner 2010). The following analysis will rely on translog cost functions without restrictions of the results because of its very common structure containing the other functions as special cases. The outcome of the model implies symmetry in behavior, crucially because of its functional form. In the subsequent section, we will discuss several reasons why symmetric long-run labor demand elasticities possibly do not occur in the empirical results. As mentioned in the introduction, we will focus on three different causes: dynamic long-term adjustment processes, labor shortages, and bounded rationality.

The assumption of time-consuming dynamic adjustment processes proposes that it takes time to increase or decrease the firms' employment. This is in line with the use of a quadratic adjustment cost function, where the marginal costs of hiring and firing increase with the number of affected jobs (Hamermesh 1993). When adjustment costs increase, for example, because of strict employment protection rules (cf. Nickell 1986), the time to change employment will also increase. Therefore, adjustment costs are possibly asymmetric and lead to different adjustment processes when employment increases or decreases (cf. Hamermesh & Pfann 1996). If these costs are very high, then the velocity of adjustment will probably slow to finish the process before the next wage shock occurs. Then, the observed employment levels will reflect short-run elasticities but not long-run elasticities. The estimated values are possibly misleading and therefore, asymmetrical. However, even if many investigations use quadratic adjustment cost functions, the economic literature shows that other assumptions about the structure of adjustment costs are reliable (cf. Hamermesh 1989. Lumpy or linear cost functions with an immediate adjustment to the new equilibrium level, illustrate results with at least the same efficiency, especially when most cases show only a few workers were hired or fired (King & Thomas 2006). In addition, several studies with quadratic costs show that most of the adjustment processes take place within a short time period, usually less than year. Therefore, to estimate adjustment-appropriate processes, quarterly or monthly data is needed, and annual data, like the data used here, would be overaggregated (Hamermesh 1993, 253). Moreover, information about the hiring processes from other surveys suggest that in 2015 the average time to fill a vacancy in Germany was less than three months, and the time of unexpected vacancies was about four weeks. Even for highly skilled workers, the figures are rather small. Here, a successful hiring takes less than four months on average with four weeks of unexpected vacancies (Brenzel et al. 2016). Again, this supports the assumption that yearly data is marginally affected by adjustment costs. From the discussion, we therefore conclude that dynamic adjustment processes do not interfere the results presented below, as they are usually completed within a year and the data does not allow estimating shorter periods.

Rationing of (skilled) labor is another possible source for asymmetric wage elasticities. Skill shortages in the short run often appear through the business cycle and increase when the economy grows with a larger number of vacancies respective to lower unemployment (Elsby et al. 2010). In the long run, labor shortages probably occur because of negative demographic developments, technological organizational changes, and mismatches from the educational system. Even though the share of females participating in the labor markets and the share of graduates from the schooling system increased continuously over the past decades, skills-biased technological progress increased the demand for skilled workers. This resulted in a higher probability of skill shortages, especially if there is low mobility and other sources of mismatch preventing the hiring of new personnel (Ghayad & Dickens 2012). The restriction of labor demand due to a lack of skilled labor is controversially discussed in

Europe, especially in Germany since the early years of this millennium (cf. Bellmann & Hübler 2014). Although it is not clear if a common shortage of skilled labor exists, many firms have reported that they cannot hire as many workers as they want. The panel data used in the subsequent analysis, the IAB Establishment Panel, also surveys whether firms feel restricted in the hiring process. Table 1 contains the outcome of this question for the period from 2004 to 2014:

Table 1: Share of Firms Reporting Restricted Labor Demand

Year	Obs.	Share of Establishments (S. Dev.)
2004	7.596	0.104 (0.305)
2005	7.560	0.101 (0.301)
2006	7.490	0.139 (0.346)
2007	7.554	0.178 (0.383)
2008	7.649	0.201 (0.401)
2009	7.782	0.137 (0.344)
2010	7.380	0.181 (0.385)
2011	7.270	0.237 (0.425)
2012	7.675	0.236 (0.425)
2013	7.705	0.211 (0.408)
2014	7.599	0.246 (0.431)

Source: IAB Establishment Panel 2004 - 2014

As expected, Table 1 indicates that reported labor shortages depend on economic development, as the share of firms decreased during the Great Recession of 2008. Nevertheless, the problem establishments faced seems to increase in the surveyed period from a share of about 10% to almost a quarter of all establishments with at least 20 employees. If the firms are rationed in their labor demand, then hiring becomes more difficult compared to layoffs. Then, the own-wage elasticities for increasing employment should be smaller in absolute terms compared to the values of the decreasing number of workers, as the reaction to a reduction of wages is forced to be lower than desired. If the firms recognize an existing labor shortage, then rational agents would take into account the increased hiring efforts when they decide to lay off employees, which would result in larger labor hoarding activities during a business cycle (Oi 1962). Then, there is no rationale for asymmetric long-run elasticities. In some cases, if the firms overestimate the importance of their current decisions compared to actions in the future (cf. Kahneman & Tversky 1979), the elasticities become asymmetrical even if a rationing of (skilled) labor is detected. Thus, one should take into account these labor shortages in the subsequent regressions. As the IAB Establishment Panel includes reports from firms on whether they feel rationed in the hiring process, it is possible to control for this effect in the empirical analysis.

Bounded rationality could be another reason for asymmetric labor demand elasticities. Some authors consider the hypotheses of entrepreneurs as profit-maximizing rational agents with steady preferences as being visionary and unrealistic (Cartwright 2011), for example, people also follow economic narratives, which help to reduce complex problems and therefore support decision making by framing the individual view on actual occurrences (Shiller 2017). Decisions are, then, not necessarily rational in the sense that considerable information is processed independently from the individual point of view. In the following, we will focus on two models that try to explain decisions under risk without the assumption of strict rationality. Firstly, we introduce loss aversion as an alternative to the concept of risk aversion, and secondly, we use the endowment effect, which deals with the value of goods that are in the possession of the decision maker (Kahneman & Tversky 1979, Thaler 1980).

One usual assumption about rationality in economics is risk aversion. This means people accept a smaller but safer outcome instead of a higher expected result that carries uncertainty. In addition, they will act according to this rule when they expect either losses or gains. From psychological experiments, it seems that this expected utility hypothesis is only true for expected gains or profits (Kahneman & Tversky 1979). If the people are aware of losses, they are willing to take high risks to avoid large forfeitures. If this result is valid, then the decision makers' preferences alter depending on the state of their situation. In addition, this could be applied to labor demand at the establishment level. If wages decrease, production costs will fall and expected gains will increase. Then, firms will probably expect larger but uncertain gains and they should accept a safe but lower outcome compared to the expected value. In the sense of labor demand, a safe situation could be to employ only a few additional workers to avoid problems with hidden characteristics and possible large costs of dismissals in the future. In the opposite situation, if wages increase, then profits are likely to decrease. If the assumption of loss aversion is applied to this situation, the decision makers become prepared to take higher risks to avoid high losses. In such a situation, layoffs have the chance to decrease losses, as this reduces production costs, and the marginal productivity of workers increases. This is more risky, however, as the firms are unsure about future hiring when the economic situation becomes better. The costs of searching for new personnel and the hidden characteristics of the new workforce are possibly unknown at that moment. Loss aversion affects the size of labor demand elasticities. When firms are less willing to hire when wages decrease and more willing to lay off workers when wages increase, one should observe larger long-run negative elasticities when employment falls and smaller negative long-run elasticities when employment grows.

Another hypothesis about human behavior is the endowment effect (Thaler 1980). Here, the focus is on the value of goods. The owner seems to give a higher value to that particular good compared to a person who does not own that item. Therefore, it is possible that the price at which a person is willing to buy a good ("willingness to pay") is different from the price at which a person is willing to sell the same good ("willingness to accept"). While the employees are not "owned" by the entrepreneur, one could assume that labor is crucial for firms to produce goods or services. Therefore, if one tries to adopt the hypothesis of endowment effects to firm behavior, taking into account the qualification of the workers, employed labor possibly is of a higher value to the firms when compared to labor that is not employed in the company. This means that a kind of "willingness to hire" is larger than a kind of "willingness to fire" if wages increase or decrease, possibly because of firm-specific human capital and a smaller amount of hidden characteristics. Moreover, because of varying relative prices among the different types of labor, asymmetric cross wage elasticities occur in this case. From the arguments, it is obvious that loss aversion and endowment effects possibly have opposite effects for own-wage elasticities, whereas the latter is also indicated by asymmetric cross-wage elasticities, for example, it should be easier to substitute less-skilled workers with employees on a higher qualification level, just as in the opposite case.

Current literature on labor demand on the firm level does not often consider the effects described above. Bellmann and Hübler (2014) analyzed skill shortages in Germany during the time of the Great Recession. They found that skill shortages are affected by the economic cycle, but the outcomes are more or less short-term effects. Most of the firms overcome these problems over a longer period.

Successful strategies to fill vacancies are long-run personnel staff development, employing apprentices, and training for the firms' workforce.

Moreover, although many models of behavioral economics are applied to labor economics, almost none of them deal with labor demand at the microeconomic level (cf. Berg 2015, Dohmen 2014, Wang 2017). Usually, investigations about labor demand elasticities rely on the assumptions of the neoclassical standard model (cf. Addison, Portugal & Varejão 2014). An overview of the existing studies that are based on translog cost functions or other empirical types of cost or production functions like CES, Cobb-Douglas, or generalized Leontief functions is given in Hamermesh (1993) and Lichter, Peichl, and Siegloch (2015). The latter, in a meta-analysis of 942 elasticity estimates from 105 different international studies of labor demand, found an overall mean own-wage elasticity of labor demand of -0.508 (median: -0.386) with a standard deviation of 0.774. More than 80% of all estimates lie within the expected interval of zero to minus one. Moreover, a large number of these studies explore the demand for heterogeneous labor. The focus of these studies is on the own-wage elasticities of the demand for different skill levels and on the substitutional complementary relationships between the skill levels. Even though it is not always confirmed by empirical research, it is normally assumed that low-skilled workers show larger (i.e., more negative) own-wage elasticities compared to other skills (Addison et al. 2008). Changes in compensation for low-skilled workers should lead to larger reactions in relation to medium- or high-skilled workers. This is due to the assumption that the share of low-skilled workers that are marginally or peripherally employed is bigger as in other skill levels (Summers 1997). Moreover, size and signs of cross-wage elasticities change regularly depending on the used data and the classification of skills in the studies.

The studies that deal with asymmetries analyze dynamic adjustment models and estimate differences in the velocity of the adjustment process (e.g., Azetsu & Fukushige 2009; Ilut, Kehrig, & Schneider 2014; Dhyne, Fuss, & Mathieu 2015). It is important to stress the point that the goal of the work here is to look at the size of the long-run elasticities and not at the velocity of employment changes. However, we will exclude the assumption of long-run adjustment processes in the subsequent analysis, as previous research does not support this hypothesis and the data used is probably overaggregated (cf. Hamermesh 1993, 253). In the following section, we introduce the empirical model of fractional panel probit regressions and the data used in this analysis.

III. Empirical Model and Data

The empirical model used in the study at hand is based on labor demand equations and is derived from a translog cost function (Berndt & Khaled 1979). Initially, the following form is assumed:

$$(1) \qquad C = C(w_i, r, Y),$$

where C is the cost, r is the interest rate, w_i is the wages for different qualifications, and Y is the firm's output. As such, the translog cost function derived from (1) is given by (Hamermesh 1993, 40):

$$(2) \qquad \ln C = \ln Y + a_0 + \sum_i a_i \cdot \ln w_i + b \cdot \ln r + 0.5 \cdot \sum_i \sum_j c_{ij} \cdot \ln w_i \cdot \ln w_j + 0.5 \cdot \sum_i d_i \cdot \ln w_i \cdot \ln r,$$

where a_0, a_i, b, c_{ij} and d_i are parameters and lnC, lnY, lnw, and lnr are the logarithms of C, Y, w, and r, respectively. In addition, the following conditions should hold (Hamermesh 1993, 40):

$$(3) \qquad \sum_i a_i + b = 1$$

(4) $\sum_i \sum_j c_{ij} + \sum_i d_i \cdot = 0$

(5) $c_{ij} = c_{ji}$

Equations (3) and (4) stem from the underlying assumption of translog cost functions that C is homogenous of degree 1 in w_i and r, and equation (5) reflects the requirement on the cost function, that the function is twice the differential and the second cross derivatives are symmetric. Applying Shephard's lemma to labor input and taking the ratio to labor costs into account yields:

(6) $s_i = a_i + c_{ii} \cdot \ln w_i + \sum_j c_{ij} \cdot \ln w_j + d_i \cdot \ln r,$

where s_i is the share of labor costs for each skill level in total revenue $\left(\frac{w_i L_i}{Y_i}\right)$. Therefore, we estimate a system of three different share equations, as we observe the same number of different qualifications. Moreover, we use the production function in its heterothetic form. This is a more general case than a linear homogenous production function, in which output is related to factor prices and depends on the scale of the output Y. This is normally the case when there are several existing technologies to produce identical goods. Significant estimations of the additional parameter Y would support the assumption of heterotheticity.

The fractional panel probit estimation has some advantages over alternative strategies like the logs-odds transformation of the dependent variable to estimate a linear model with the data. Even though it is then possible to estimate a rather simple regression model, two severe problems can occur when this procedure is used. First, shares of zero and one are not defined when a log-odds transformation is conducted. Second, a linear functional form does not reflect the possible important non-linearities. Especially, the former of both arguments is important here, as we observe a number of firms in the data that does not employ all kinds of workers. Using a fractional panel probit model makes it possible to include these observations in the analysis. The model is based on the fractional nature of the wage share. Assuming a normal distribution of the dependent share s (e.g., a probit model), Papke and Wooldridge (2008) and Wooldridge (2010b) proposed the following model:

(7) $E(s_{it}|X_{it}, c_i) = \Phi(X_{it}\beta_i + c_i),$

where s_{it} is the share variable from equation (6), $0 \le s_{it} \le 1$; t = 1, …, T, X_{it} are the covariates of the model like $\ln w_i$, $\ln w_j$, and other variables discussed in the subsequent data section. β_i are the parameters, c_i are the firm-specific heterogeneities, and Φ is the standard normal cumulative distribution function (cdf). From equation (7), the partial effects not only depend on the estimated β's, but also on the density function ϕ:

(8) $$\frac{\partial(s_{it}|X_{it},\ c_i)}{\partial X_{it}} = \beta_i \phi(X_{it}\beta_i + c_i)$$

As the cdf is a monotonic function, the value of β identifies the direction of the partial effect. Unfortunately, because of the unobserved nature of c_i, it is not possible to calculate the partial effects from equation (8). One possibility applied to calculate the partial effects in this model is to average the individual partial effects and model the distribution of c_i, given strictly exogenous covariates X_i, so that the selection becomes ignorable (Papke & Wooldrigde 2008, Wooldrigde 2010b). Applying assumptions to the random nature and distribution of ci, Wooldridge (2010a, 2010b) identified the average structural function (ASF) of the model, which allows for consistent estimation of the expected value of equation (7):

(9) $$ASF(X_i)= N^{-1}\sum_{i=1}^{N}\Phi\left(\frac{X_{it}\widehat{\beta}_i+\sum_{r=2}^{T}(\widehat{\psi}_r+\overline{X}_i\widehat{\zeta}_r)}{\exp(\sum_{r=2}^{T-1}\widehat{\omega}_r)}\right),$$

where r is the number of observations of an establishment in the panel, $\overline{x}_i$ is the average of X_i over time, ψ and ξ are the parameters of the model that identifies c_i, ω_r indicates the deviation of each subgroup from the variance in each establishment, and ^ define the estimated values. The average partial effects (APE) are then given by the derivative of equation (9) with respect to X_i:

(10) $$APE(X_i)= \widehat{\beta}_i N^{-1}\sum_{i=1}^{N}\phi\left(\frac{X_{it}\widehat{\beta}_i+\sum_{r=2}^{T}(\widehat{\psi}_r+\overline{X}_i\widehat{\zeta}_r)}{\exp(\sum_{r=2}^{T-1}\widehat{\omega}_r)}\right),$$

In the current paper, the focus is not on the calculation of the APEs, but on the determination of own- and cross-wage elasticities. Therefore, the average elasticities are derived from the APEs by using the ASF as the expected means of the cdf. The average elasticities η for the estimated parameters are then given as follows (cf. Kölling 2012):

(11) $$\eta_{L_i w_i} = \frac{APE(\ln w_i)}{ASF(X_i)}-1$$ (own-wage elasticities),

(12) $$\eta_{L_i w_j} = \frac{APE(\ln w_j)}{ASF(X_i)}$$ (cross-wage elasticities),

with L_i as the number of workers of skill level i.

German establishment data from the IAB Establishment Panel is now used to estimate the fractional panel probit model of labor demand. The Institute for Employment Research of the German Federal Labor Agency has surveyed establishments in the panel since 1993 in Western Germany and since 1996 in the former eastern part of Germany. The data is a stratified random sample of all German establishments with at least one employee covered by social insurance contributions. In particular, the survey uses 17 industries, 10 employment size classes, and 16 regions (the Bundesländer) as particular strata of the total population (Fischer et al. 2008, 2009). In the work at hand, the data is restricted to the period from 2004 to 2014, as the variable that indicates labor shortage respectively skill shortage has been collected since then. The IAB Establishment Panel shows a very high response rate of over 70% to 80% for establishments that have participated more than once. The data is unbalanced, however, as new establishments replace panel mortality through exits and non-response. In total, there are about 16,000 observations each year available for our investigation (Fischer et al. 2008, 2009).

Additional data stems from the Establishment Historical Panel, which provides detailed information from official labor statistics about the particular qualifications of the workers in the observed establishments and their respective daily remuneration (Eberle & Schmucker 2017). In detail, the Establishment Historical Panel contains the number of low-, medium-, and high-skilled employees with full- or part-time contracts. Low-skilled employees are defined as individuals with a lower secondary, intermediate secondary or upper secondary school completion certificate but no vocational qualifications. Medium-skilled employees are individuals with a lower secondary, intermediate secondary or upper secondary school completion certificate and a vocational qualification. The group of high-skilled employees of an establishment are those who have a degree from a university (including universities of applied sciences "*Fachhochschule*"). In order to calculate the number of employees for the respective qualifications, part-time workers are assigned with the value of 0.5. This assumption is probably heroic, but unfortunately there is no other data available that provides information of the working time of part-time workers e.g. on the industry structure used in the sample. As wage shares are defined as the proportion of labor costs in total revenue $\left(\frac{w_i L_i}{Y_i}\right)$, we also use average remuneration of the particular skills and the firms' turnover, Y, to calculate s_i for each skill level as the dependent variable. Therefore, we end up with regressions for three different wage shares that are estimated simultaneously with a seemingly unrelated regression approach. Moreover, the regressions exclude establishments with less than 20 employees in total to ensure a higher variability of the dependent variables.

Moreover, the official data offers additional information about the mean and the median daily remuneration of full-time employees for each particular skill group. The variable includes special payments, such as holiday pay or 13th monthly salary, but only contains values up to the upper earnings limit for statutory pension insurance contributions. This means that about 10% of the data is censored and the earnings means are biased. To remedy this censoring problem, the data provider regularly imputed the information on daily wages according to the procedure of Card, Heining, and Kline (2015) before the medians were calculated. For subsequent analysis in the paper, the mean of wages is used to calculate the wage shares and the median of wages is used to derive the logarithms of wages, as it is less affected by coincidental inferences and censoring. Furthermore, from equation (6), the logarithms of daily wages are used in the regressions. The calculation of the elasticities in equations (11) and (12) are based on the parameter estimates of these covariates. The values are not discounted to a price index because I assume that, at least in the short run, small changes in the price levels are not perceived as changes of the (real) remuneration. Additional time effects should be caught by time dummies. To control whether there are differing elasticities for increasing or decreasing employment, additional dummy variables are created that become one if the establishment experienced a growing workforce for each qualification level. Out of this, we calculate interaction variables with the wage variables, indicating possible differences in the parameter estimates for increasing or decreasing employment.

According to the theoretical considerations, the estimations should take care of the probable influence of labor shortage or skill shortage on the estimated labor demand elasticities. The IAB Establishment Panel contains information about firms that report labor shortages. From the information, it is possible to create a dummy variable indicating labor shortage. This is used as a further covariate. Moreover, we used interaction variables of the particular dummy and the wage variables to control for the influence of labor shortage on the estimated own- and cross-wage elasticities. The model derived previously is very useful for an empirical analysis, but has to be expanded with additional variables to overcome oversimplifying aspects. Therefore, characteristics of the workforce were included in the analysis along with structural parameters (Groshen 1991). As we assumed a heterothetic cost function, the regressions should contain some information about the production level. The IAB Establishment Panel contains information about firms' value added where intermediate materials were excluded from turnover in the year prior to the interview. Because we used this variable in our investigation, establishments that did not report turnover, including banks, insurance companies, and public administrations, were excluded from the database. From equation (6), the logarithm of value added is used.

Other variables used were the logarithms of the Euribor interest rates, shares of part-time workers, female workers, temporary employees, and employees subject to the social insurance scheme; dummies for coverage by a collective agreement, Eastern Germany, and the firms' profitability; the state of machinery; firm size; industries; and years. The Euribor interest rates were used as an instrument for capital costs, allowing capital to be variable over time. Profitability and state of machinery base on a self-rating of the establishments on a range from 1 (low or outdated) to 3 (high respectively up-to-date). Moreover, the nominal values of these variables were discounted by the producer price index. Table A.1 in the appendix contains the descriptive statistics of the main variable used in this investigation.

The labor demand model used here is a static model and does not contain lagged variables, as a dynamic model does, to calculate the adjustment processes. As discussed in Section II, most of the adjustment process takes place within a year, and annual data is overaggregated; additionally, the use of lagged dependent variables to model labor demand dynamics is caused by a quadratic adjustment of the cost function. This is very restrictive, and questionable, as empirical studies with other cost functions, like lumpy or linear costs, illustrate results with at least the same efficiency (Hamermesh 1993). After this deeper look at the data, the next section presents the outcome of the fractional pane probit regressions.

IV. Results of the empirical analysis

This section contains the results of estimations of the empirical model in equation (6). We used three dependent variables indicating the wage share of different kinds of labor. Each equation was estimated as a fractional panel probit model. We applied a system of seemingly unrelated regressions (SUR) to estimate the outcome of all equations simultaneously. Subsequently, we present the complete model with all interaction variables to detect differences in the labor demand elasticities. The results of an SUR without interaction variables are shown in the appendix. Table 2 contains the parameter estimates of the complete model:

Tab. 2: Seemingly Unrelated Estimations of Labor Demand with a Fractional Panel Probit model

	(a) Low skilled	(b) Medium skilled	(c) High skilled
Log. of wages for low skilled per capita	0.052** (0.008)	-0.001 (0.007)	0.004 (0.007)
Log. of wages for medium skilled per capita	0.021 (0.028)	0.071* (0.028)	0.072** (0.026)
Log. of wages for high skilled per capita	0.007 (0.009)	0.012 (0.008)	0.053** (0.011)

Table 2 cont.

Interaction variables: Dummy for larger employment of particular skill level•			
Log. of wages for low skilled per capita	0.036** (0.009)	-0.001 (0.005)	0.001 (0.008)
Log. of wages for medium skilled per capita	-0.011 (0.011)	0.013 (0.007)	-0.018 (0.012)
Log. of wages for high skilled per capita	-0.014 (0.007)	-0.008* (0.004)	0.025** (0.009)
Interaction variables: Dummy for reported rationing in labor demand •			
Log. of wages for low skilled per capita	-0.005 (0.011)	0.004 (0.008)	0.025** (0.007)
Log. of wages for medium skilled per capita	-0.002 (0.016)	-0.026** (0.010)	-0.015 (0.015)
Log. of wages for high skilled per capita	-0.031** (0.010)	-0.006 (0.006)	-0.001 (0.011)
Dummy for reported labor shortage	0.175** (0.048)	0.129** (0.048)	-0.032 (0.073)
Log. average 12-month Euribor	0.013 (0.019)	-0.003 (0.008)	-0.019 (0.022)
Log. of value added	-0.043** (0.008)	-0.043** (0.007)	-0.056** (0.010)
Share of part-time workers	0.019 (0.016)	0.009 (0.018)	0.007 (0.025)
Share of temp. Employed	0.006 (0.017)	-0.004 (0.009)	-0.012 (0.017)
Share of employed persons subjected to the social insurance scheme	0.037 (0.027)	0.030 (0.022)	0.070 (0.041)
Share of female workers	-0.009 (0.024)	0.016 (0.021)	-0.001 (0.028)
Coverage by a collective agreement	0.004 (0.005)	0.002 (0.004)	-0.003 (0.006)
Dummy for Eastern Germany	0.123** (0.009)	0.004 (0.005)	-0.081** (0.009)
Log Pseudolikelihood	-14.842	-93.735	-25.370
Wald-Test χ^2 (df.)	9,999** (261)	9,582** (261)	9,654** (261)
Obs. (Establ.)	19,687 (6,412)	19,687 (6,412)	19,687 (6,412)

Source: IAB Establishment Panel 2004 - 2014.

Note: The model also includes the following dichotomous and auxiliary variables: establishment size (seven dummies), firm profitability (two), state of technical equipment (two), industry (fourty), year (ten), the means of the time variant covariates and a constant. Robust standard errors adjusted for clustering on establishments in parentheses. ** and * denote significance at the .01 and .05 levels, respectively.

All parameters for own-wages are statistically significant and show the expected size between zero and one. As the values are close to zero, the calculated elasticities will be near to minus one (see Table 3). The only significant cross-wage parameter is the remuneration of medium-skilled workers in the demand for high-skilled employees. The wages for high-skilled workers do not affect the labor demand for medium-skilled workers on a statistically relevant level, and the difference between both parameters is significant on a 5% level. Therefore, this is probably an indicator for asymmetries in the cross-wage elasticities among medium- and high-skilled workers. This could support the assumption of a kind of endowment effect discussed in Section II, as higher wages for medium-skilled workers increase labor demand for high-skilled workers, but not the other way around.

The estimations of the interaction variables for firms with growing employment of respective skill levels for own-wages are positive and statistically significant for low- and high-skilled workers. The outcome for medium-skilled workers is also positive, but it is only significant on a rather weak 10% level.

According to the calculation in equation (11), this indicates labor demand elasticities that are smaller in absolute terms for firms with increasing employment of the observed skill level. Independently of the time that it takes to adjust employment, this means that a 10% increase or decrease of specific wages leads to different corresponding changes in employment. A downward adjustment is always larger than an upward adjustment of employment for a wage shock of the same size in absolute terms. This is in line with the model of loss aversion presented in Section II, and probably supports the proposal of bounded rationality in labor demand, as we controlled for the effects of labor shortages.

In addition, Table 2 shows some estimates for the indicator of labor shortage and its interaction with the wage variables. The parameters for the dummy variable specifying reported labor shortage of the surveyed firms are significantly positive for low- and medium-skilled employees, whereas the outcome for high-skilled workers is, as expected, negative but statistically insignificant. The corresponding elasticities point to a 12.2% and 9.4% increase of employment for low- and medium-skilled workers in firms that have problems with hiring of new personnel. In combination with the negative sign of the parameter for high-skilled workers, this could be a sign of substituting unfilled vacancies for highly skilled workers with employees on a lower qualification level. There are also some statistically significant parameter estimates for the interaction variable between reported labor shortage and wage levels for particular skills. The outcome presents additional asymmetries, as the relationships between high- and low-skilled labor becomes more complementary in the equation for low-skilled labor and more substitutional in the demand for high-skilled labor. However, the influence on labor demand is rather low and the particular total elasticities for firms with reported labor shortages stays insignificant. In addition, the expected muting effect of skill shortages on the demand for high-skilled labor is insignificant, whereas the elasticity of the demand for medium-skilled labor becomes more negative. This could be in line with the larger employment of this qualification level according to a substitution of vacancies for highly skilled workers. Table 3 contains the corresponding elasticities for the estimated wage parameters.

Tab. 3: Calculated Average Partial Elasticities of Estimates form Table 2

	(a) Low skilled	(b) Med. skilled	(c) High skilled
Constant respectively decreasing employment of particular skill level			
Log. of wages for low skilled per capita	-0.964**	-0.001	0.003
Log. of wages for medium skilled per capita	0.015	-0.948*	0.051**
Log. of wages for high skilled per capita	0.005	0.009	-0.963**
Increasing employment of particular skill level			
Log. of wages for low skilled per capita	-0.939**	-0.001	0.004
Log. of wages for medium skilled per capita	0.007	-0.939**	0.038*
Log. of wages for high skilled per capita	-0.005	0.003	-0.945**
Dummy for reported labor shortage	0.122**	0.094**	-0.023

Source: IAB Establishment Panel 2004 - 2014. ** and * denote significance of the underlying parameter estimates at the .01 and .05 levels, respectively

The calculated own-wage elasticities are close to minus one but still in the expected interval (cf. Lichter, Peichl & Siegloch 2015). As we control for the muting effects of a labor shortage, the outcome is not unlikely. In addition, there are only marginal differences between the different skill levels, indicating that a 10% increase in remuneration leads to about a 9.5% reduction of labor demand. The only significant cross-wage elasticity is the influence of wages of medium-skilled workers on the demand of high-skilled workers. The positive parameter supports a substitutional relationship with a drop of 0.5% for highly skilled labor if the remuneration for medium-skilled labor increases by 10%. The interaction variables for growing employment of the particular group and its wage level are always positive and at least significant on a 10% level. Therefore, respective elasticities are smaller in absolute terms, showing a smaller reaction to shrinking wages than to a corresponding rise of the particular wages of the same absolute size. On average, the relative response to a 10% fall of wages is about 0.1 and 0.25% points lower than for a 10% increase in wages. The differences are rather little but in line with the assumption of loss aversion behavior of the firms' executives. As loss aversion and endowment effects could have opposite effects on labor demand, the outcome possibly represents the balance of both effects with a stronger impact of loss aversion. The only significant cross-wage interaction variable is the remuneration of highly skilled labor on the demand for medium-skilled labor. The negative parameter indicates a larger complementary structure of labor demand between medium- and high-skilled. This is the opposite effect of that in the demand for high-skilled workers and could be interpreted as support for some kind of "endowment effect" for the employment of highly skilled workers. Nevertheless, the parameter estimate is small and the calculated cross-wage elasticity for growing employment stays insignificant. From the empirical outcome, we can conclude that there are some asymmetries in labor demand for different skill levels, even controlling probable labor shortage. In addition, we found some support for the assumption that the source of these asymmetries is some kind of bounded rationality of the decision makers within the observed establishments. Hence, the results of the study are now summarized in the subsequent conclusion.

V. Summary

The study at hand discusses different reasons for asymmetries of firms' labor demand for the calculated elasticities. We identified three possible sources for theses asymmetries: long-term adjustment processes that prevent labor demand from reaching an optimal level, labor shortage that reduces the number of wanted hirings, and bounded rationality where the behavior of the firms' executives is not independent from the establishment's actual situation. Especially, the effects of the so-called loss aversion and endowment effects are analyzed in detail.

To investigate whether there are asymmetric labor demand elasticities and, in addition, to identify possible reasons for this behavior, we applied a fractional panel probit model that takes into account unobserved heterogeneity. We used a large survey of German establishments over the period from 2004–2014 to estimate the model. As the data contain yearly observations and the available literature for Germany suggests that the average time to adjust to a new optimal labor demand is much faster, it is not possible to detect the effects of long-term dynamic adjustment processes with the current survey. However, the data contains information about labor shortages at the establishment level, which is used to control for the effect of this involuntary lower employment. We argue that the remaining asymmetries are due to bounded rationality.

From the outcome of the regressions, we find support for both the influence of labor shortage and indications for loss aversion and the endowment effect. The employment of low- and medium-skilled workers is significantly larger in firms that report labor shortage, whereas the number of high-skilled workers is lower. Nevertheless, the latter estimate is not significantly different from zero. In addition, there are some statistically relevant parameters from the interaction variables between a dummy indicating labor shortage and the respective wage levels. Moreover, the results suggest that, controlling for labor shortage, calculated labor demand elasticities for all skill levels are more negative in firms that reduce employment of the particular qualification level. This probably supports the assumption of loss aversion in the behavior of firms' decision makers, as this outcome indicates that downward adjustment according to an increase in wages is larger than an upward adjustment according to a comparable fall in remuneration of the respective skill level. However, the differences in the levels are rather small but statistically significant, at least for low- and high-skilled workers. The results are robust when controlled for reported labor market restrictions and other important structural parameters that influence labor markets. The conclusion is that analyses of the labor market should allow for long-run asymmetric behavior. It seems that additional aspects of behavioral economics are useful to finding more insights of firms' labor demand. However, although statistically significant, the estimated effects are quite small, and further research is needed to confirm the results of the study.

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Appendix

Table A.1: Descriptive Statistics of the Treatment Variable

Variable	Obs.	Mean	St. Dev.	Min.	Max.
Total Employment	86,867	238.098	986.694	20	59207
No. of low skilled	86,867	23.067	85.626	0	4406
No. of medium skilled	86,867	157.996	675.166	0	40070.5
No. of high skilled	86,867	38.686	221.906	0	16969
Share of est. with increasing employment of low skilled	58,927	0.332	0.471	0	1
Share of est. with increasing employment of medium skilled	58,927	0.453	0.498	0	1
Share of est. with increasing employment of high skilled	58,927	0.392	0.488	0	1
Median daily remuneration of low-skilled	58,155	73.274	28.088	.179	394.848
Median daily remuneration of medium-skilled	86,385	83.157	26.740	.627	378.589
Median daily remuneration of high-skilled	73,722	124.383	49.341	.844	586.187
Share of est. reporting labor shortage	83,260	0.179	0.383	0	1
Share of part-time workers	105,243	0.194	0.240	0	1
Share of temp. Employed	105,765	0.071	0.151	0	1
Share of employed persons subjected to the social insurance scheme	106,477	0.829	0.272	0	1
Share of female workers	106,349	0.404	0.296	0	1
Coverage by a collective agreement	105,666	0.777	0.416	0	1
Log. average 12-month Euribor	106,478	0.791	0.654	-.600	1.573
Log. of value added	61,900	14.566	2.140	3.792	22.709
Reported state of machinery (1=new)	105,148	2.155	0.686	1	3
Reported profitability (1=very profitable)	84,861	1.867	0.811	1	3
Dummy for Eastern Germany	106,478	0.633	0.482	0	1

Source: IAB Establishment Panel 2004 – 2014

Tab. A.2: Seemingly Unrelated Estimations of Labor Demand with a Fractional Panel Probit model

	(a) Low skilled	(b) Medium skilled	(c) High skilled
Log. of wages for low skilled per capita	0.123** (0.021)	-0.005 (0.014)	0.017 (0.012)
Log. of wages for medium skilled per capita	-0.026 (0.058)	0.153* (0.064)	0.159** (0.051)
Log. of wages for high skilled per capita	-0.014 (0.015)	0.010 (0.014)	0.097** (0.017)
Log. average 12-month Euribor	-0.034 (0.045)	-0.031 (0.024)	-0.017 (0.051)
Log. of value added	-0.090** (0.021)	-0.116** (0.022)	-0.128** (0.020)
Share of part-time workers	-0.006 (0.032)	-0.013 (0.038)	-0.034 (0.052)
Share of temp. Employed	0.036 (0.032)	0.025 (0.021)	0.007 (0.033)
Share of employed persons subjected to the social insurance scheme	0.004 (0.047)	0.029 (0.045)	0.132 (0.079)
Share of female workers	-0.037 (0.046)	0.007 (0.044)	0.038 (0.059)
Coverage by a collective agreement	0.009 (0.012)	0.008 (0.011)	-0.006 (0.014)
Dummy for reported labor shortage	0.011 (0.006)	0.005 (0.006)	0.005 (0.007)
Dummy for Eastern Germany	0.262** (0.034)	0.008 (0.014)	-0.180** (0.021)
Log Pseudolikelihood	-19.981	-123.9458	-33.981
Wald-Test χ^2 (df.)	7,746** (269)	7,741** (269)	7,930** (269)
Obs. (Establ.)	25,534 (8,684)	25,534 (8,684)	25,534 (8,684)

Source: IAB Establishment Panel 2004 - 2014.
Note: The model also includes the following dichotomous and auxiliary variables: establishment size (seven dummies), firm profitability (two), state of technical equipment (two), industry (fourty), year (ten), the means of the time variant covariates and a constant. Robust standard errors adjusted for clustering on establishments in parentheses. ** and * denote significance at the .01 and .05 levels, respectively.

Tab. A.3: Calculated Average Partial Elasticities of Estimates form Table A.2

	(a) Low skilled	(b) Med. skilled	(c) High skilled
Log. of wages for low skilled per capita	-0.911**	-0.003	0.001
Log. of wages for medium skilled per capita	-0.019	-0.886*	0.111**
Log. of wages for high skilled per capita	-0.010	0.007	-0.932**

Source: IAB Establishment Panel 2004 - 2014. ** and * denote significance of the underlying parameter estimates at the .01 and .05 levels, respectively

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