HdBA
Hochschule der
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University of Applied Labour Studies

Arbeitspapier
Working Paper

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# Firm Size and Employment Dynamics

## Estimations of Labor Demand Elasticities Using a Fractional Panel Probit Model and Establishment Data

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# Abstract*


**Firm Size and Employment Dynamics: Estimations of Labor Demand Elasticities Using a Fractional Panel Probit Model and Establishment Data**

This paper deals with the broad discussion on the relationship between job creation or destruction and firm size. To look if the argument that small and medium sized establishments (SME) show higher employment dynamics is confirmed or not, the following work uses elasticities from a standard labor demand model that are derived from the estimations of fractional probit models for panel data suggested by Papke and Wooldridge (2008). Elasticities are a useful measure of employment dynamics if it is assumed that small and large establishments act on the same markets. The results show that firm size does matter for the increase or decrease of employment. SME with less than 10 workers exhibit a higher employment dynamic compared to other entities at each respective percentile of the distribution of the wage share. Additionally, the outcome of the analysis weakly confirms the hypothesis that smaller firms are more restricted to the capital markets compared to large entities. But the results also show that firm size explains only one part of the size of job creation and destruction. As stated in the well-known Hicks-Marshall rules for elasticities of factor demand, the results feature that the reaction of labor demand on economic changes increases with the use of the factor labor itself. Firms with a high share of labor also have larger elasticities compared to firms with a strong use of capital. Both effects, the size effect and the effect of the use of labor, should mix up in reality and therefore possibly lead to controversial results for the relationship between firm size and employment dynamics. Also, it seems clear that a model of a negative relationship among both variables is too simple to explain the behavior of firms.



* The author thanks Claus Schnabel, Joachim Wagner, Lutz Bellmann and the participants of the workshop on the work with the IAB-Establishment Panel (Schwerin, June 22nd & 23rd 2009) for helpful comments on preliminary versions. This study uses the IAB Establishment Panel, Waves 2000 to 2007. Data access was provided via on-site use at the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) and/or remote data access.

## I. Introduction

This paper tries to give some new aspects on the established discussion about the influence of firm size on employment dynamics and labor demand. Firm size is an important factor in employment strategies. Often official economic policies are based on the assumption that small and medium sized establishments (SME's) show higher job creation rates and therefore are the best address for state subsidies. The long term EU Employment Strategy and the regulations of the economic stimulus packages of several industrial countries against the actual worldwide recession partly rely on this assumption[1]. In scientific research the picture is not as clear as in the political arguments. There has been an intensive and controversial discussion among economists on this topic but in most of the cases this discussion is based on a descriptive analysis with firm size as the only explanatory variable. The following work uses a multivariate approach to calculate labor demand elasticities with respect to factor prices and demand for goods and services. As it is assumed that firms act on the same markets independently of their size and thus experience equal economic shocks, these elasticities should give a good picture of employment dynamics and then also of differences according to the firm size.

The presented work is organized as follows: In the next section a short overview of the existing literature and the discussion about several methodological problems among economists are presented. The third section introduces a standard model of labor demand with two factors of production (labor and capital) and heterothetic production structures (cf. Hamermesh 1993, 31pp.). This model is the background of the subsequent estimations of a multivariate model. As the dependent variable is defined as a fraction between 0 and 1, the estimation strategy in section four follows the proposal of Papke and Wooldrigde (2008) to estimate fractional probit models for panel data.

## II. Previous Literature

Starting from the inaugural work of Gibrat in 1931 there has been a vast amount of studies on the relation between firm size and employment growth. The assumption of "Gibrat's Law" was strongly rejected by the very influential work of Birch (e.g. 1987). His findings that most of the newly created jobs stem from small and medium enterprises (SME) have dominated the discussion for several years and clearly influenced the employment strategies of admini-

[1] For more information about the economic goals of e.g. the German administration see: http://www.bmwi.de/English/Navigation/Ministry/structure-and-tasks, did=77128.html

stration and governments, e.g. the European Union.[2] But the results of Birch are doubtful and show some remarkable methodological problems. As Davis, Haltiwanger & Schuh (1996) state, the calculation of growth rates based on the employment in the base year is the source of at least two possible biases: a regression and a reclassification bias. The regression bias points out that the employment growth rates of firms which experience transitory or mean-reverting shocks depend on the size class they belong to. If a small firm initially increases employment and afterwards returns to its earlier size, it will experience a higher growth and a lower decrease of employment compared to larger establishments. Also, when a firm employs more people and is reclassified to a larger size class, the increase is calculated for the smaller size class. The firms in the larger size class show no positive growth rates, or if mean-reverting to the initial firm size, negative growth rates. A third source of a bias is maybe due to selectivity of the data. If failures are not reported in the data and calculation of growth rates are based on the observed establishments, the results are possibly biased to higher growth rates especially for SME, as smaller firms have a higher probability of failure.

To avoid these biases Davis, Haltiwanger & Schuh (1996) propose the calculation of growth rates based on the average employment of the two time periods used in the calculation. In the following work, this severe problem is treated in a different way because the focus here is on the relation of firm size and the effect of different sources of employment changes. The calculated elasticities show no or at least a very small regression bias because they are related to very small changes of employment. Also, the preferred estimation of the labor demand model sort the establishments to the size class of the first observation and does not allow reclassification of firms. Additionally, the estimation of a Heckman correction model proves selectivity in the data (Heckman 1979).

Newer studies that take into account the criticism of Davis, Haltiwanger & Schuh (1996) show a broad variety of results and mostly deteriorate the hypothesis of a strong relation between firm size and job creation. Nevertheless, Helfand, Sadeghi and Talan (2007) support the assumption of a negative relationship among size and growth. According to their dynamic-sizing reclassification approach, 64% of the newly created jobs between 1990 and 2005 in the U.S. belong to SME with less than 500 employees. Also, the share of growth of small firms is larger than its share of employment. Neumark, Wall and Zhang (2008) use the method of Davis, Haltiwanger and Schuh (1996) to calculate job creation for different size classes with another database for the U.S.. Their findings indicate a negative relationship of

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[2] European Employment Strategy: INTEGRATED GUIDELINES FOR GROWTH AND JOBS (2008-2010); http://ec.europa.eu/growthandjobs/pdf/european-dimension-200712-annual-progress-report/200712-annual-report-integrated-guidelines_en.pdf

firm size and growth rate but on a much lower level than suggested by Birch`s analysis. Additionally, this result is valid only for services but not for manufacturing. The work of Moscarini and Postel-Vinay (2009) rely on the assumption of Gertler and Gilchrist (1994) that small enterprises are more constrained in the demand for loans than larger firms. They estimate job creation and destruction for the U.S. and several other countries and find that large employers are more sensitive to business cycles than SME. Proportionally they destroy more jobs during and after recessions and create more jobs in the late period of expansions. This result holds within industries and countries but not between them.

Recent studies for Germany present also varying outcomes. Günterberg and Wallau (2008) state that between 2003 and 2008 job creation of SME in expansions is higher and job destruction in recessions is lower compared to larger firms. Elaborate studies with large official datasets put some doubt on this result (cf. Wagner 2007, Wagner, Koller & Schnabel 2008, Bauer, Schumacher & Vorell 2008). In these studies SME have a higher reallocation rate of jobs. Therefore, they play an important role for the efficiency of the labor market. But on the other side, small firms are not the "job engine" of the economy as they are also more than proportionally involved in job destruction.

In the next section a model is derived that show differences in the labor demand of small and large establishments.

## III. Model

As the focus at this stage of analysis is the effect of establishment size on average labor demand, a model with homogenous employees is assumed. Therefore, a labor demand model with only two factors of production, capital and labor, is used. In the following it is also assumed that production is heterothetic, which is a more general case than a linear homogenous production function. In a heterothetic production function, output is related to factor prices and depends on the scale of output. In particular the model is based on a translog cost function (cf. Hamermesh 1993, 31pp.):

(1) $$\ln C = \ln Y + a_0 + a_1 \cdot \ln w + (1-a_1) \cdot \ln r + 0.5 \cdot b_1 \cdot \ln w^2 + b_2 \cdot \ln w \cdot \ln r + 0.5 \cdot b_3 \cdot \ln r^2 + d \cdot \ln Y \cdot \ln w + (1-d) \cdot \ln Y \cdot \ln r,$$

where $a_i$, $b_i$ and d are parameters. LnC, lnY, lnw and lnr are logarithms of total cost, output, wages and capital costs respectively. Applying Shephard's lemma to labor input and taking ratio to labor costs yields:

(2) $$s = a_1 + b_1 \cdot \ln w + b_2 \cdot \ln r + d \cdot \ln Y, \text{ with } s = \frac{w \cdot L}{Y}$$ (share of labor costs in total revenue).

This model is very useful for empirical analysis but oversimplifies some aspects of labor demand. The wage bill w·L does not only depend on the number of employees but also on the formation of a firm's labor force. Therefore, worker characteristics have to be included in the analysis. Also, it is well known that remuneration of employees differs between firms size, industries and union coverage (cf. Groshen 1991). For these reasons, some additional variables $Z_j$ should control for these aspects (see Section Four).

Ideally, it would be desirable to use interest rates of firm loans as an instrument for the costs of capital. Unfortunately, these informations are not available in the data used here. Normally, banks use a rating system with several explanatory variables to determine interest rates. On one side the cost of capital is influenced by the market price for money because the banks have to refinance most of their loans at market conditions for instance from central banks. On the other side establishment specific indicators are used to estimate the soundness and the risk of failure of the observed firm[3]. Market conditions are regularly expressed using interbank rates like the Euribor. At this rate, banks offer to lend unsecured funds to other banks. It is daily published for different time periods and used as a reference rate in the Euro wholesale money market based on the averaged interest rates. Firm specific indicators that influence credit worthiness are e.g. firm size, firm age, profitability, legal form and industry. This means, I assume a model where the costs of capital is explained as in the following equation:

(3) $\ln r = c_1 + c_2 \cdot \ln(\text{Euribor}) + c_i \cdot X_i,$

where $X_i$ are the additional firm specific explanatory variables for the interest rate. When the bank has the full market power to set the interest rates for company loans, then $c_2$ should be equal to one, because changes in the price of banks refinancing facilities will lead directly to identical changes in the interest rates for loans. Further on, I will assume that this is the case here. The third explanatory variable is output which is measured using the firm's turnover. According to our analysis so far, the following model occurs:

(4) $s = a_1 + b_1 \cdot \ln w + b_2 \cdot (c_1 + \ln(\text{Euribor}) + c_i \cdot X_i) + d \cdot \ln Y + e_j \cdot Z_j,$

(4a) $s = \alpha_1 + b_1 \cdot \ln w + b_2 \cdot \ln(\text{Euribor}) + d \cdot \ln Y + \beta_i \cdot X_i + e_j \cdot Z_j,$

with $\alpha_1 = (a_1 + b_2 \cdot c_1)$ and $\beta_i = b_2 \cdot c_i$. To estimate the effects of changes of wages, interest rates and output on labor demands, corresponding elasticities are derived from estimates of equation (4a). Elasticities of labor demand indicate relative changes of the amount of labor

[3] Cf. the regulations of promotional loans of the German federal development bank KfW (http://www.kfw-mittelstandsbank.de/EN_Home/Service/Pdfs_loan_sheets/RAIRS.pdf)

when wages, interests or demands alter with a specific rate (cf. Hamermesh 1993, 22). Taking into account that s is defined as share of labor costs in total revenue, the elasticities are easily calculated from the marginal effects of the relevant variables ($b_1$; $b_2$ and d) on s $\left( \partial s / \partial \ln w ; \; \partial s / \partial \ln Y \text{ and } \partial s / \partial \ln(\text{Euribor}) \right)$[4]:

(5) $$\eta_{Lw} = \frac{\partial L / L}{\partial w / w} = \frac{b_1}{s} - 1.$$

(6) $$\eta_{Lr} = \frac{\partial L / L}{\partial Eur / Eur.} = \frac{b_2}{s}.$$

(7) $$\eta_{LY} = \frac{\partial L / L}{\partial Y / Y} = \frac{d}{s} + 1.$$

$\eta_{Lw}$ is the elasticity of labor with respect to changes in the wage, $\eta_{Lr}$ is the elastictiy of labor with respect to changes in the interest rate of loans and $\eta_{LY}$ is the elastictiy of labor with respect to changes in the output. In theory, it is obvious that $\eta_{Lw}$ should be negative and $\eta_{LY}$ should be positive, because the demand for labor decreases with an increase in the price for labor but increases when production also grows. That means $b_1$ should be smaller than s and d should be larger than -s. Additionally, when capital is more or less a quasi-fixed asset in the short run, the value of $\eta_{Lr}$ and therefore $b_2$ should be close to zero.

Our goal in this investigation is to identify differences in labor demand linked to varying establishment sizes. Thus, to separate the altering influence of the three independent variables in equation (2), I introduce interaction variables of firm size dummies with lnw, ln(Euribor) and lnY to the model:

(4b) $$s = \alpha_1 + b_1 \cdot \ln w + b_2 \cdot \ln(\text{Euribor}) + d \cdot \ln Y + \beta_i \cdot X_i + e_j \cdot Z_j + f_l \cdot \ln w \cdot (\text{firm size})_l + g_l \cdot \ln(\text{Euribor}) \cdot (\text{firm size})_l + h_l \cdot \ln Y \cdot (\text{firm size})_l$$

This model that leads to firm size specific labor demand elasticities, e.g. $\eta_{Lw}$ for $(\text{firm size})_1$ now is:

(5a) $$ç_{Lw} = \frac{\partial L / L}{\partial w / w} = \frac{b_1 + f_1}{s} - 1.$$

Significant differences in the estimated values of $f_l$, $g_l$ or $h_l$ will indicate differences in the labor demand by establishment size. But before this model is tested empirically, I will give a picture of the data used here.

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[4] See Appendix for calculation.

## IV. Data

Our data are taken from eight waves (2000-2007) of the IAB Establishment Panel[5]. The data were initiated by the Institute for Employment Research of the Federal Labor Agency in 1993 (1996 for eastern Germany). It was created to meet the needs of the Federal Employment Agency for improved information on the demand side of the labor market. It is based on a stratified random sample – the strata are for 16 (currently 17) industries, 10 employment-size classes, and 16 regions (the Bundesländer) – from the population of all German establishments with at least one employee covered by social insurance. The establishment panel is characterized by very high response rates of more than 70% (80% for repeatedly participating establishments). To correct for panel mortality, exits, and newly founded units, the data are augmented regularly yielding an unbalanced panel. Overall, the IAB panel actually contains ca. 16,000 establishments each year. In 2007, for example, it contained information on 15,644 plants, employing some 2.46 million workers[6].

Descriptive statistics for the principal variables used in this paper are presented in the appendix (Table A.1 – A.3). The dependent variable is defined as the share of labor costs of total revenue. The Panel contains information about the firm's turnover in the year before the interview and also about the firm's monthly wage bill. Using these data the dependent variable is calculated by the ratio of the monthly wage bill and the turnover, where the turnover is divided by 12 to take into account that the figure is measured on a yearly basis. Because turnover is a part of the variable, establishments that do not report turnover like banks, insurances and public administrations are excluded from the data.

The main explanatory variables from the theoretical model are the logs of turnover, wages and costs of capital. The monthly wage bill is divided by the number of employees before taking the logarithm to reflect the average remuneration. Part-time workers are included in this calculation with a factor of 0.5. In addition, the nominal values of turnover and wages are discounted by the producer price index[7]. The yearly mean of the 12-month Euribor is used as an instrument for the costs of capital[8]. The Euribor (Euro Interbank Offered Rate) is the rate at which euro interbank term deposits within the euro zone are offered by one prime bank to

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[5] Data access was provided via remote data access from the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB).

[6] For more information on the structure of the IAB Establishment Panel see Fischer, Janik et al. (2008, 2009).

[7] The producer price index is published by the German Federal Statistical Office (2000 = 100; www. destatis.de/ jetspeed/portal/cms/Sites/destatis/Internet/EN/Navigation/Statistics/Preise/Preise.psml )

[8] See www.euribor.org

another prime bank. This rate is often used as the reference for the refinancing of commercial banks at the money market and therefore basis for the base rates of company loans. To analyze the effects of the establishment size on labor demand, I use eight dummies for different size classes. The following table contains the definition of the size classes and the total number of observations in the respective class:

### Table 1: Establishment Size Classes

| No. of employees | Obs. |
|---|---|
| 1 – 4 | 23,286 |
| 5 – 9 | 17,408 |
| 10 – 19 | 15,017 |
| 20 – 49 | 18,672 |
| 50 – 99 | 11,744 |
| 100 – 199 | 9,761 |
| 200 – 499 | 10,418 |
| 500 and more | 7,518 |
| **Total** | **113,824** |

Source: IAB Establishment Panel 2000-2007.

According to the theoretical considerations additional variables are also used in the estimations. These are the share of female employees, of part-timers, of temporary workers and of low skilled workers. We also used dummy variables for the legal form of the establishment, the firm's profitability, whether the establishment is covered by a collective agreement and finally, 41 dummies for several industries are included.

Because of the estimation strategy balanced panel is needed, i.e. the information about establishments should cover the whole period of observation between 2000 and 2007 without any missing data. Although, the IAB-establishment panel show high response rates with only a few missing values, the sample would reduce dramatically if only complete observations are used. Therefore, a multiple imputation procedure is used to construct a balanced panel for all establishments in the data. The method applied here uses MICE ("Multiple Imputation by Chained Equations") introduced by van Buuren et al. (1999)[9]. MICE assumes that the missing data is at least MAR (Missing at Random), i.e. the probability of missingness does not depend on unobserved information. Unlike simple and univariate imputation methods,

[9] MICE is implemented in the „ice" procedure of STATA V10.

MICE uses repeated and chained multivariate estimations to replace missing information. The imputation model includes all variables of the analysis model. In the work at hand 5 complete data sets are created through multiple imputations and jointly used for estimation. The statistical interference of the imputed data is reflected by applying Rubin's Rules to the combined data[10].

## V. Estimates

The estimated procedure for the estimation of the share equations (4a) and (4b) follow the work of Papke and Wooldridge (2008). They propose a fractional panel probit model that allows the estimation of average partial effects for fractional response data. The methodology equals the "general estimation equation"-models that are provided by several statistical software packages[11]. Unlike their earlier work (Papke & Wooldridge 1996,) they use a normal distribution (e.g. a probit model) that leads to simple estimators in the presence of unobserved heterogeneity. Papke and Wooldridge (2008) also include the averages of the time variant explanatory variables to allow for correlation between the unobserved heterogeneity $c_i$ and the exogenous variables of the empirical model $x_i$. In particular they assume the following model:

$$(8) \qquad E(y_{it}|x_{it}, c_i) = \Phi(x_{it}\beta + \overline{x}_i\xi + c_i),$$

with $y_{it}$ as response variable, $0 \le y_{it} \le 1$; $t = 1, \ldots, T$; $c_i$ as unobserved establishment effects and $\Phi$ as the standard normal cumulative distribution function (cdf). The partial effects not only depent on the estimated $\beta$'s but also on the density function $\phi$:

$$(9) \qquad \frac{\partial E(y_{it}|x_{it}, c_i)}{\partial x_{itj}} = \beta_j \phi(x_{it}\beta + \overline{x}_i\xi + c_i).$$

Unfortunately, because of the unobserved nature of the $c_i$ it is not possible to calculate the partial effects from equation (9). Papke and Wooldridge propose the derivation of average partial effects (APE) that base on the average of equation (8), i.e. the expected mean of the wage share:

$$(10) \qquad E(\Phi(x_{it}\beta + \overline{x}_i\xi + c_i)) = \sum_{t=1}^{T}\sum_{i=1}^{N} \frac{\Phi(x_{it}\hat{\beta} + \overline{x}_i\hat{\xi})}{TN}$$

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10 The variances of the imputed data are calculated with the "micombine" procedure of STATA V10. Detailed information is available from the author by request.

11 E.g. the "xtgee" procedure of STATA V10, details of computation are available from the author by request.

The APE's are then given by the derivative of equation (10) with respect to $x_i$:

$$(11) \qquad APE(x_i) = \hat{\beta}_i \sum_{t=1}^{T} \sum_{i=1}^{N} \frac{\phi\left(x_{it}\beta + \bar{x}_i\xi\right)}{TN}$$

In the paper here, the focus is not not the calculation of APE's but on the determination of factor and output elasticities. Therefore, average elasticities are derived from the APE's by using the expected mean of the cdf in equation (10). According to equations (5), (6) and (7) the average elasticities for estimated parameters of lnw, lny and ln(Euribor):

$$(12) \qquad \eta_{Lw} = \frac{\hat{\beta}_{\ln w} \sum_{t=1}^{T} \sum_{i=1}^{N} \phi\left(x_{it}\beta + \bar{x}_i\xi\right)}{\sum_{t=1}^{T} \sum_{i=1}^{N} \Phi\left(x_{it}\beta + \bar{x}_i\xi\right)} - 1$$

$$(13) \qquad \eta_{Lr} = \frac{\hat{\beta}_{\ln(Eurib.)} \sum_{t=1}^{T} \sum_{i=1}^{N} \phi\left(x_{it}\beta + \bar{x}_i\xi\right)}{\sum_{t=1}^{T} \sum_{i=1}^{N} \Phi\left(x_{it}\beta + \bar{x}_i\xi\right)}$$

$$(14) \qquad \eta_{LY} = \frac{\hat{\beta}_{\ln Y} \sum_{t=1}^{T} \sum_{i=1}^{N} \phi\left(x_{it}\beta + \bar{x}_i\xi\right)}{\sum_{t=1}^{T} \sum_{i=1}^{N} \Phi\left(x_{it}\beta + \bar{x}_i\xi\right)} + 1$$

From equations (12) to (14) it is clear that elasticities vary across the firms, but because the propensity density function (pdf) $\phi(.)$ and the cdf $\Phi(.)$ also contain the unobserved $c_i$, it is not possible to calculate them from the empirical results. The expected wage share is used as denominator to derive the elasticities. Therefore, it is possible to assume, that the firms wage share influence the particular size of the elasticities. If the absolute value of the elasticities increases with the wage share and thus the use of labor, the results would confirm the well known Marshall-Hicks rules for derived factor demand. To proof whether this is the case here, results are presented for elasticities at different points of the distribution of wages, other factors holding constant. According to the definition of the wage share (wL/Y), the distributions of wages and the wage share are c.p. equal.

To look whether there is selectivity in the model, additional Heckmann Correction Models have been estimated (Heckman 1979). In the first stage, probit regressions of the probability of a failure are carried out for each year. From that stage inverse Mills ratios are calculated and included into the regressions (Results are available from the author.). The result of the added variable is insignificant and therefore the assumption of selectivity is not supported.

Thus, the further analysis does not include the inverse mills ratio in the estimations. In Table 2 the results of the original model with and without selectivity are presented.

**Table 2: Fractional Panel Probit Estimation of the Labor Demand Model**

| | (a) w/o sample selection | (b) w. sample selection | (c) w. est. size interaction var. w/o sample selection | (d) w. est. size interaction var. w. sample selection |
|---|---|---|---|---|
| | Coef. (S. E.) | Coef. (S. E.) | Coef. (S. E.) | Coef. (S. E.) |
| Log. wage p. cap. | 0.718** (0.007) | 0.753** (0.014) | 0.728** (0.022) | 0.748** (0.032) |
| Log. average 12-month Euribor | -0.001 (0.007) | 0.001 (0.008) | 0.009 (0.018) | 0.026 (0.015) |
| Log. turnover | -0.655** (0.005) | -0.688** (0.014) | -0.651** (0.010) | -0.658** (0.021) |
| Share of part-time workers | -0.309** (0.014) | -0.285** (0.022) | -0.310** (0.014) | -0.284** (0.022) |
| Share of temp. employed | 0.015 (0.011) | 0.009 (0.016) | 0.014 (0.011) | 0.008 (0.016) |
| Share of employed subject to social insurance scheme | 0.041* (0.021) | 0.202** (0.038) | 0.049* (0.021) | 0.202** (0.038) |
| Share of female workers | -0.015 (0.022) | -0.030 (0.032) | -0.016 (0.022) | -0.031 (0.032) |
| Share of low skilled workers | 0.040** (0.009) | 0.021 (0.013) | 0.040** (0.009) | 0.022 (0.012) |
| Est. covered by a Coll. Agreement (dummy. yes=1) | 0.008 (0.006) | 0.009 (0.007) | 0.008 (0.006) | 0.009 (0.006) |
| Establishment size dummies (ref. N ≤ 4): | | | | |
| 5 ≤ N ≤ 9 | 0.376** (0.010) | 0.296** (0.015) | 0.453** (0.153) | 0.838** (0.223) |
| 10 ≤ N ≤ 19 | 0.712** (0.017) | 0.548** (0.023) | 0.577** (0.158) | 0.366 (0.244) |
| 20 ≤ N ≤ 49 | 1.066** (0.022) | 0.828** (0.035) | 0.887** (0.202) | 0.479 (0.289) |
| 50 ≤ N ≤ 99 | 1.449** (0.033) | 1.115** (0.05) | 1.547** (0.222) | 1.391** (0.510) |
| 100 ≤ N ≤ 199 | 1.790** (0.038) | 1.367** (0.067) | 1.872** (0.225) | 1.554** (0.541) |
| 200 ≤ N ≤ 499 | 2.171** (0.046) | 1.609** (0.076) | 2.699** (0.306) | 2.21** (0.711) |
| N ≥ 500 | 2.617** (0.057) | 1.901** (0.133) | 1.642** (0.394) | 4.401** (0.739) |

continued

| | | | | |
|---|---|---|---|---|
| Interaction: (est. Size) x (Log. Wage p. Cap.) / (ref.: 20 ≤ N ≤ 49) | | | | |
| (Log. Wage p. Cap.) x (N ≤ 4) | | | -0.029<br>(0.024) | -0.002<br>(0.039) |
| (Log. Wage p. Cap.) x (5 ≤ N ≤ 9) | | | 0.029<br>(0.026) | 0.028<br>(0.038) |
| (Log. Wage p. Cap.) x (10 ≤ N ≤ 19) | | | 0.019<br>(0.031) | 0.005<br>(0.039) |
| (Log. Wage p. Cap.) x (50 ≤ N ≤ 99) | | | -0.002<br>(0.028) | -0.030<br>(0.048) |
| (Log. Wage p. Cap.) x (100 ≤ N ≤ 199) | | | -0.031<br>(0.029) | -0.048<br>(0.048) |
| (Log. Wage p. Cap.) x (200 ≤ N ≤ 499) | | | -0.052<br>(0.037) | -0.054<br>(0.074) |
| (Log. Wage p. Cap.) x (N ≥ 500) | | | -0.059<br>(0.049) | 0.082<br>(0.128) |
| Interaction: (est. Size) x (Log. Av. Euribor) / (ref.: 20 ≤ N ≤ 49) | | | | |
| (Log. Av. Euribor) x (N ≤ 4) | | | -0.037<br>(0.021) | -0.065**<br>(0.025) |
| (Log. Av. Euribor) x (5 ≤ N ≤ 9) | | | -0.009<br>(0.024) | -0.033<br>(0.022) |
| (Log. Av. Euribor) x (10 ≤ N ≤ 19) | | | -0.007<br>(0.020) | -0.014<br>(0.021) |
| (Log. Av. Euribor) x (50 ≤ N ≤ 99) | | | -0.023<br>(0.039) | -0.022<br>(0.027) |
| (Log. Av. Euribor) x (100 ≤ N ≤ 199) | | | 0.005<br>(0.034) | -0.028<br>(0.028) |
| (Log. Av. Euribor) x (200 ≤ N ≤ 499) | | | 0.015<br>(0.031) | 0.072<br>(0.057) |
| (Log. Av. Euribor) x (N ≥ 500) | | | 0.053<br>(0.045) | 0.010<br>(0.142) |
| Interaction: (est. Size) x (Log. Turnover) / (ref.: 20 ≤ N ≤ 49) | | | | |
| (Log. Turnover) x (N ≤ 4) | | | 0.007<br>(0.013) | -0.015<br>(0.027) |
| (Log. Turnover) x (5 ≤ N ≤ 9) | | | -0.035*<br>(0.014) | -0.079**<br>(0.025) |
| (Log. Turnover) x (10 ≤ N ≤ 19) | | | -0.012<br>(0.016) | -0.012<br>(0.023) |
| (Log. Turnover) x (50 ≤ N ≤ 99) | | | -0.016<br>(0.014) | -0.026<br>(0.029) |
| (Log. Turnover) x (100 ≤ N ≤ 199) | | | -0.003<br>(0.016) | -0.012<br>(0.038) |
| (Log. Turnover) x (200 ≤ N ≤ 499) | | | -0.020<br>(0.017) | -0.041<br>(0.053) |
| (Log. Turnover) x (N ≥ 500) | | | 0.065**<br>(0.022) | -0.218**<br>(0.061) |

continued

| | | | | |
|---|---|---|---|---|
| 8 dummies for profitability (ref.: very profitable) | yes | yes | yes | yes |
| 5 dummies for legal form (ref.: single enterprise) | yes | yes | yes | yes |
| 7 dummies for each year (ref.: 2000) | yes | yes | yes | yes |
| 40 dummies for industries (ref.: Farm.) | yes | yes | yes | yes |
| Mean of time variant explanatory variables | yes | yes | yes | yes |
| Inv. Mills-Ratio | | 0.030<br>(0.044) | | 0.038<br>(0.044) |
| Constant | 2.212**<br>(0.096) | 2.576**<br>(0.172) | 2.254**<br>(0.119) | 2.512**<br>(0.220) |
| Obs.<br>(Establ.) | 25,376<br>(3,172) | 6,811<br>(973) | 25,376<br>(3,172) | 6,811<br>(973) |

Source: IAB Establishment Panel 2000-2007 (5 imputations of missing data). Note: Semi-robust standard errors adjusted for clustering on establishments and years in parentheses. ** and * denote significance at the .01. and .05 levels, respectively.

The parameters for the variables of lnw and lnY in the base model are significant on a 1%-level and have a reasonable size, whereas the parameter of ln(Euribor) is insignificant in all estimations. Also, the share of low skilled and part-time workers and share of employees subject to the social insurance scheme are significant and show the expected signs whereas the other explanatory variables are insignificant. Table 3 contains the average partial effects (APE) and the average labor demand Elasticities derived from the variables from column (a) of Table 2 (without interaction variables):

**Table 3: Average Partial Effects and Average Labor Demand Elasticities**

| | w | Y | r |
|---|---|---|---|
| **Average Partial Effect APE** | 0.208**<br>(0.002) | -0.190**<br>(0.001) | -0.000<br>(0.001) |
| **Average Labor Demand Elasticity η** | -0.245**<br>(0.006) | 0.311**<br>(0.004) | -0.001<br>(0.005) |

Note: Standard errors of the average labor demand elasticities are obtained by bootstrapping using 200 replications. ** and * denote significance at the .01. and .05 levels, respectively.

Columns (c) and (d) contain estimations of the model including the interaction variables of lnw, lnY and lnr. Compared to the base model, the results of most of the explanatory variables are quite similar. Several $\chi^2$-tests of joint significance show a significant outcome of the interaction variables of lnw and lnY with the firm size classes.[12] But on the other side except one all the parameter estimates for the variables are insignificant on the usual levels. The interaction variables of lnr with firm size in column (c) are conjointly insignificant.[13] According to these results it is hardly possible to assume size specific differences in the firms reaction to economic changes.

However, these results do not take into account that the firm specific elasticities also depend on the firms wage share (cf. equations 12 to 14). Also, estimations of a model with interaction variables do not consider the reclassification problems as described in Section II. Therefore, distinct regressions for each size class are carried out where the establishments stay in the size class of their initial observation. The results of the estimations are presented in table 4:

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12 Joint significance of lnw·(firm size) in column (c): $\chi^2(7)$ = 23.86**
Joint significance of lnY·(firm size) in column (c): $\chi^2(7)$ = 20.11**

13 Joint significance of ln(Euribor)·(firm size): $\chi^2(7)$ = 10.75

**Table 4: Fractional Panel Probit Estimation of the Labor Demand Model at Initial Establishment Size Class**

| | 4 ≥ n | 5 ≤ n ≤ 9 | 10 ≤ n ≤ 19 | 20 ≤ n ≤ 49 | 50 ≤ n ≤ 99 | 100 ≤ n ≤ 199 | 200 ≤ n ≤ 499 | n ≥ 500 |
|---|---|---|---|---|---|---|---|---|
| | Coef. (S. E.) | Coef. (S. E.) | Coef. (S. E.) | Coef. (S. E.) | Coef. (S. E.) | Coef. (S. E.) | Coef. (S. E.) | Coef. (S. E.) |
| Log. wage p. cap. | 0.700** (0.013) | 0.747** (0.016) | 0.754** (0.024) | 0.723** (0.020) | 0.737** (0.038) | 0.710** (0.031) | 0.731** (0.038) | 0.695** (0.071) |
| Log. average 12-month Euribor | -0.026 (0.014) | -0.003 (0.016) | 0.005 (0.015) | 0.005 (0.016) | -0.002 (0.036) | 0.008 (0.020) | -0.005 (0.031) | 0.064 (0.036) |
| Log. turnover | -0.661** (0.010) | -0.680** (0.011) | -0.669** (0.014) | -0.650** (0.012) | -0.663** (0.018) | -0.651** (0.015) | -0.653** (0.016) | -0.635** (0.019) |
| Share of part-time workers | -0.308** (0.032) | -0.282** (0.038) | -0.285** (0.036) | -0.303** (0.040) | -0.422** (0.083) | -0.435** (0.077) | -0.363** (0.118) | -0.289** (0.103) |
| Share of temp. empl. | 0.011 (0.022) | 0.007 (0.022) | 0.005 (0.026) | -0.002 (0.038) | 0.041 (0.073) | 0.046 (0.074) | 0.086 (0.088) | 0.084 (0.128) |
| Share of empl.subj. to soc. Ins. | 0.025 (0.033) | 0.110* (0.053) | 0.110 (0.063) | 0.071 (0.075) | -0.101 (0.128) | -0.208 (0.248) | -0.063 (0.316) | 0.094 (1.051) |
| Share of female workers | -0.007 (0.052) | -0.028 (0.027) | -0.017 (0.037) | -0.056 (0.062) | 0.055 (0.102) | -0.073 (0.124) | 0.027 (0.200) | -0.173 (0.298) |
| Share of low skilled | 0.045 (0.023) | 0.019 (0.025) | 0.029 (0.021) | 0.029 (0.019) | 0.038 (0.034) | 0.065 (0.036) | 0.049 (0.052) | 0.137 (0.102) |
| Coll. Agr. (yes=1) | -0.002 (0.010) | 0.025* (0.011) | -0.001 (0.013) | 0.020 (0.017) | -0.010 (0.026) | -0.018 (0.025) | 0.017 (0.039) | -0.021 (0.124) |
| Est. Size dummies | yes | yes | Yes | yes | yes | yes | yes | yes |
| Dummies for profitability | yes | yes | Yes | yes | yes | yes | yes | yes |
| Dummies for legal form | yes | yes | Yes | yes | yes | yes | yes | yes |
| Dummies for each year | yes | yes | yes | yes | yes | yes | yes | yes |
| Dummies for industries | yes | yes | yes | yes | yes | yes | yes | yes |
| M. of time variant expl. variables | yes | yes | yes | yes | yes | yes | yes | yes |
| Constant | 2.268** (0.210) | 2.392** (0.199) | 2.342** (0.231) | 2.155** (0.235) | 2.629** (0.335) | 2.700** (0.291) | 3.943** (1.325) | 1.004 (1.081) |
| Obs. (establ.) | 5,816 (727) | 4,512 (564) | 3,784 (473) | 4,528 (566) | 2,256 (282) | 1,784 (223) | 1,704 (213) | 992 (124) |

Source: IAB Establishment Panel 2000-2007. Note: Semi-robust standard errors adjusted for clustering on establishments and years in parentheses. ** and * denote significance at the .01. and .05 levels, respectively.

The figures of Table 4 confirm mostly the results of the previous estimations. The parameters for the logarithm of wages and turnover are significant on a 1%-level in every column, whereas the results for the logarithm of the Euribor are still insignificant. Starting from the parameter estimates the average labor demand elasticties for each firm size are derived according to the equations (12) to (14):

**Table 5: Average Labor Demand Elasticities of $\eta_{Lw}$, $\eta_{Lr}$ and $\eta_{LY}$ for Different Firm Sizes**

| Firm Size | $\eta_{Lw}$ | $\eta_{Lr}$ | $\eta_{LY}$ |
|---|---|---|---|
| N ≤ 4 | -0.214** (0.011) | -0.029* (0.013) | 0.258** (0.009) |
| 5 ≤ N ≤ 9 | -0.202** (0.012) | -0.003 (0.013) | 0.274** (0.009) |
| 10 ≤ N ≤ 19 | -0.209** (0.014) | 0.005 (0.012) | 0.298** (0.010) |
| 20 ≤ N ≤ 49 | -0.244** (0.016) | 0.005 (0.011) | 0.320** (0.008) |
| 50 ≤ N ≤ 99 | -0.253** (0.025) | -0.002 (0.016) | 0.329** (0.012) |
| 100 ≤ N ≤ 199 | -0.267** (0.027) | 0.008 (0.018) | 0.328** (0.012) |
| 200 ≤ N ≤ 499 | -0.192** (0.031) | -0.005 (0.024) | 0.278** (0.013) |
| N ≥ 500 | -0.290** (0.042) | 0.065* (0.027) | 0.352** (0.016) |

Note: Standard errors of the average labor demand elasticities are obtained by bootstrapping using 200 replications. ** and * denote significance at the .01. and .05 levels, respectively.

The calculated wage and demand elasticities are always significant on a 1%-level. Additionally, the value of $\eta_{Lr}$ for the smallest and the largest firm size becomes significant on the 5%-level. It seems that the labor demand elasticities slightly increase with firm size. The largest firms always show the highest elasticities. This pattern would indicate that employment dynamics also increases with firm size. The results for $\eta_{Lr}$ indicate that capital is a complement good for labor in small firms and a substitute for labor in large firms. This seems to confirm the assumption of Gertler and Gilchrist (1994) that large firms are less restricted to the capital markets and therefore use capital as a substitute for labor.

To prove whether these differences in table 5 are significant in a statistical sense, a Welch-test is used. This test is an approximate solution to the Behrends-Fischer problem and an alternative to a t-test when the variances of two independent samples are possibly different (cf. Sawilowsky 2002). The test value is defined as follows:

(10) $$T = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$ with $\bar{x}_i$: estimates, $s_i^2$: variance, $n_i$: number of observations.

In this test, the degrees of freedom have to be estimated according to equation (9):

(11) $$\hat{\upsilon} = \frac{(q_1 + q_2)^2}{\frac{q_1^2}{(n_1 - 1)} + \frac{q_2^2}{(n_2 - 1)}}$$ with $q_i = \frac{s_i ?}{n_i}$

Once both values have been calculated, these can be used with the t-distribution to test the null hypothesis that the two parameters are equal. In Table 6, the estimates of Table 5 and the results of a correspondent Welch-test compared to a reference group are displayed:

**Table 6: Welch-Test of Average Labor Demand Elasticities**

| | n ≤ 4 | 5 ≤ n ≤ 9 | 10 ≤ n ≤ 19 | 20 ≤ n ≤ 49 | 50 ≤ n ≤ 99 | 100 ≤ n ≤ 199 | 200 ≤ n ≤ 499 | n ≥ 500 |
|---|---|---|---|---|---|---|---|---|
| $\eta_{Lw}$ | -0.214 | -0.202** | -0.209* | -0.244 | -0.253 | -0.267 | -0.192 | -0.290 |
| $(T, \hat{\upsilon})$ | (1.560; 9,491.41) | (2.162; 8,887.29) | (1.680; 8,295.97) | Reference group | (0.319; 5,014.30) | (0.743; 3,926.00) | (1,505; 3,508.89) | (1.034; 1,808.12) |
| $\eta_{Lr}$ | -0.029* | -0.003 | 0.005 | 0.005 | -0.002 | 0.008 | -0.005 | 0.065** |
| $(T, \hat{\upsilon})$ | (1.909; 10,297.98) | (0.447; 9,010.89) | (0.005; 8,208.22) | Reference group | (0.348; 5,316.06) | (0.139; 4,187.64) | (0.369; 3,431.22) | (2.045; 1,949.55) |
| $\eta_{LY}$ | 0.258*** | 0.274*** | 0.298* | 0.320 | 0.329 | 0.328 | 0.278*** | 0.352* |
| $(T, \hat{\upsilon})$ | (5.196; 10,285.19) | (3.724; 8,983.25) | (1.756; 8,010.51) | Reference group | (0.569; 5,147.75) | (0.535; 4,151.74) | (2.800; 3,961.13) | (1.752; 2,119.46) |

Note: $^{xxx}$, $^{xx}$ and $^{x}$ denote significant differences from the reference group (20 ≤ n ≤ 49) at the .01, .05 and .10 levels, respectively. All estimates of the resp. parameters in the reference group are significantly different from zero on a .01 level.

Table 6 contains some significant differences of the average labor demand elasticities compared to establishments with 20 to 49 employees. The average wage elasticity in the reference group is significantly larger than in smaller firms with 5 to 19 workers. The result for the smallest entities with less than 5 employees does not differ significantly from firms 20 to 49 workers. In contrast to the smaller firm sizes, all larger establishment sizes show insignificant differences compared to the reference group.

As before in Table 5, only the results for the smallest and the largest firm sizes identify significant differences for the capital price elasticities. Again, this possibly pictures that larger firms are less restricted to the capital markets. The demand elasticities also show significantly lower elasticities for smaller establishments, but also significant larger demand elasticities for the largest firm size. Unlike the largest firms, entities with 200 to 499 employees show a significant lower outcome.

These results so far only reflect the effects of the firm size on the average labor demand elasticities, but do not take into account the influence of the use of labor in the establishments. From the theoretical analysis in equation (2) it is obvious that the use of labor ist illustrated with the share of labor costs in total revenue, i.e. the exogenous variable. Unfortunately, it is not possible to derive elasticities for different wage shares directly from the results of the regressions in table 3 and 4. Thus, an explanatory variable, the logarithm of wage per capita, is used as an instrument for the use of labor. Looking at the definition of the wage share (s = wL/Y), it is clear that wage per capita (w) ceteris paribus (c.p.) follows the distribution of the wage share. Additionally, the regressions control for the logarithms of L and Y and thus back the c.p. assumption. In the following average partial elasticities are calculated at the 10th, 25th, 50th, 75th and 90th percentile of the wage distribution. This approach is consistent with the analysis of Papke and Wooldridge (2008). Figure 1 to Figure 3 present the distribution of elasticities across different wage shares (Tables A.4 to A.5 contain the respective values of the elasticities):

**Figure 1: Distribution of Wage Elasticities for Different Firm Sizes**

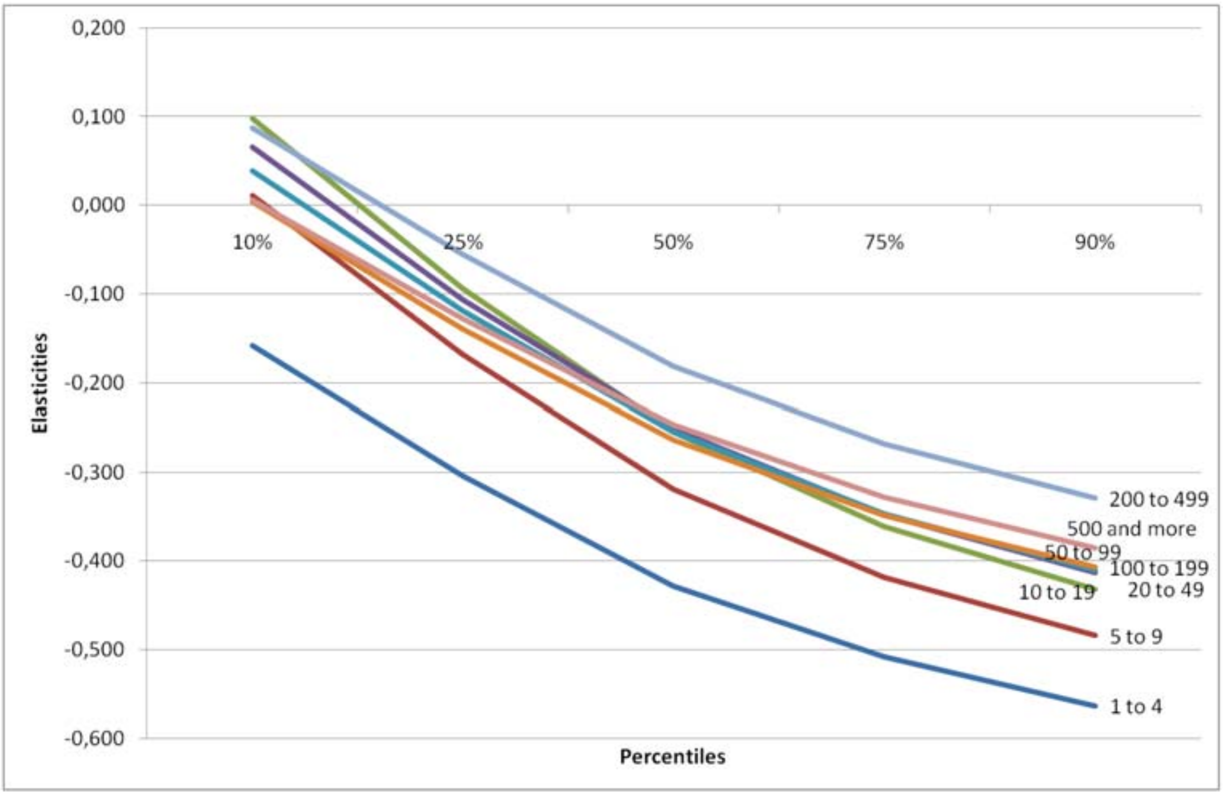


**Figure 2: Distribution of Demand Elasticities for Different Firm Sizes**

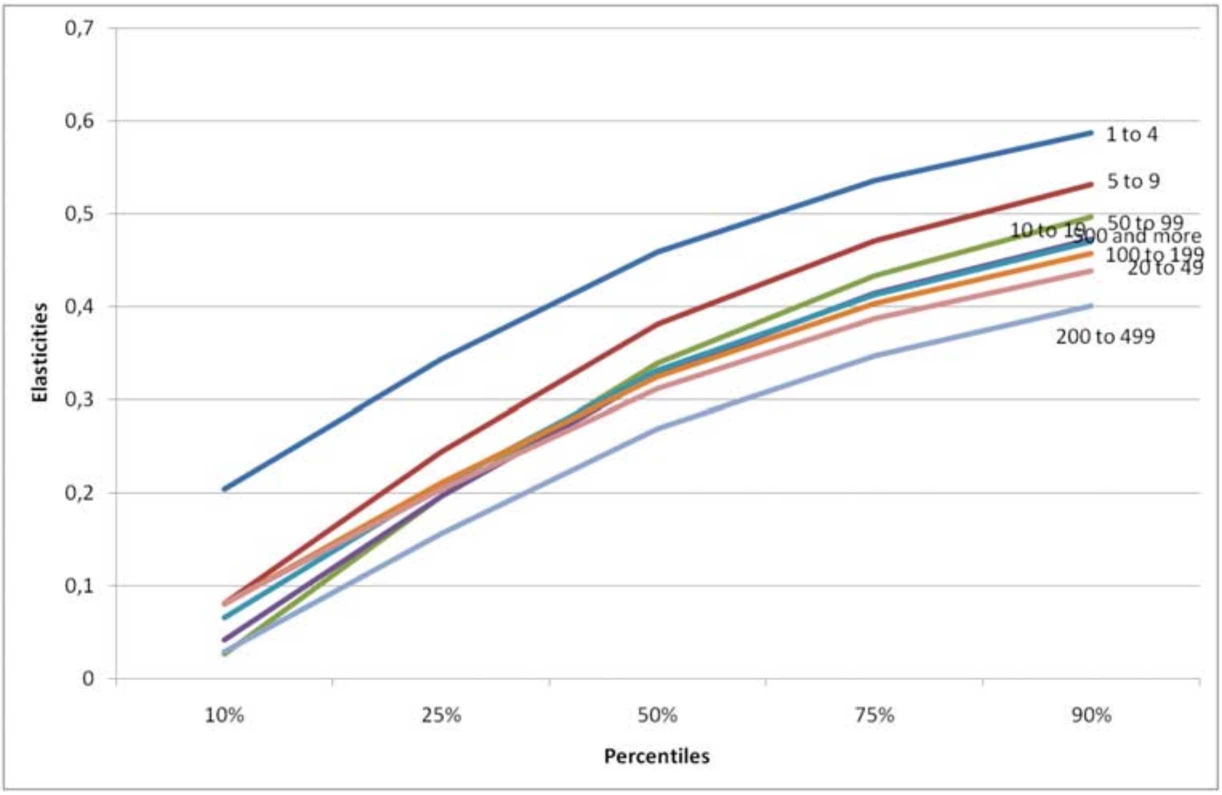
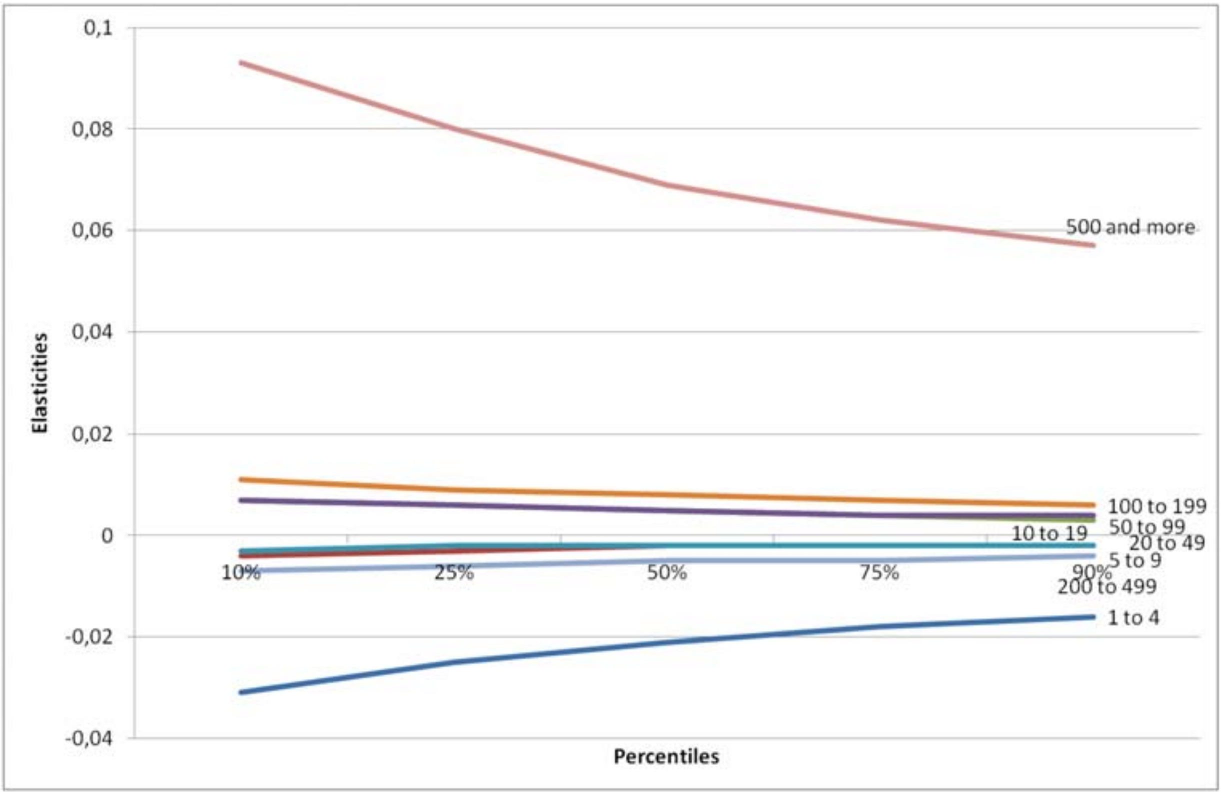



**Figure 3: Distribution of Capital Elasticities for Different Firm Sizes**

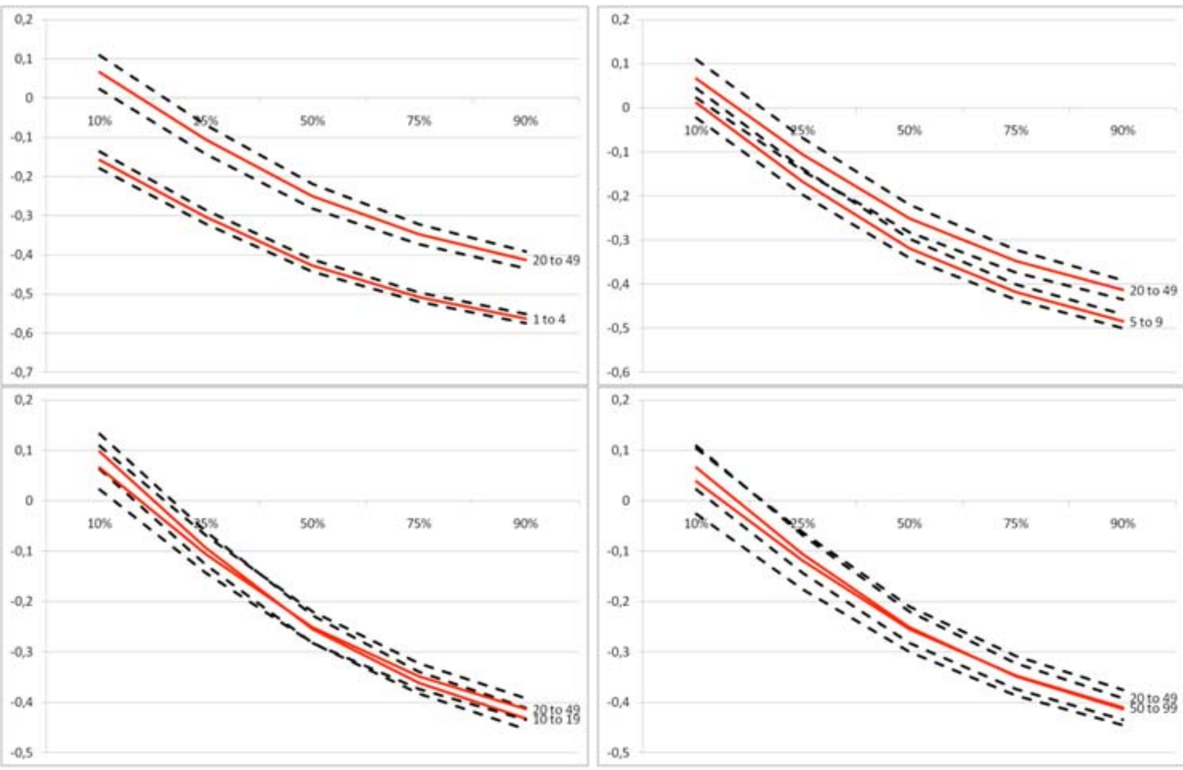


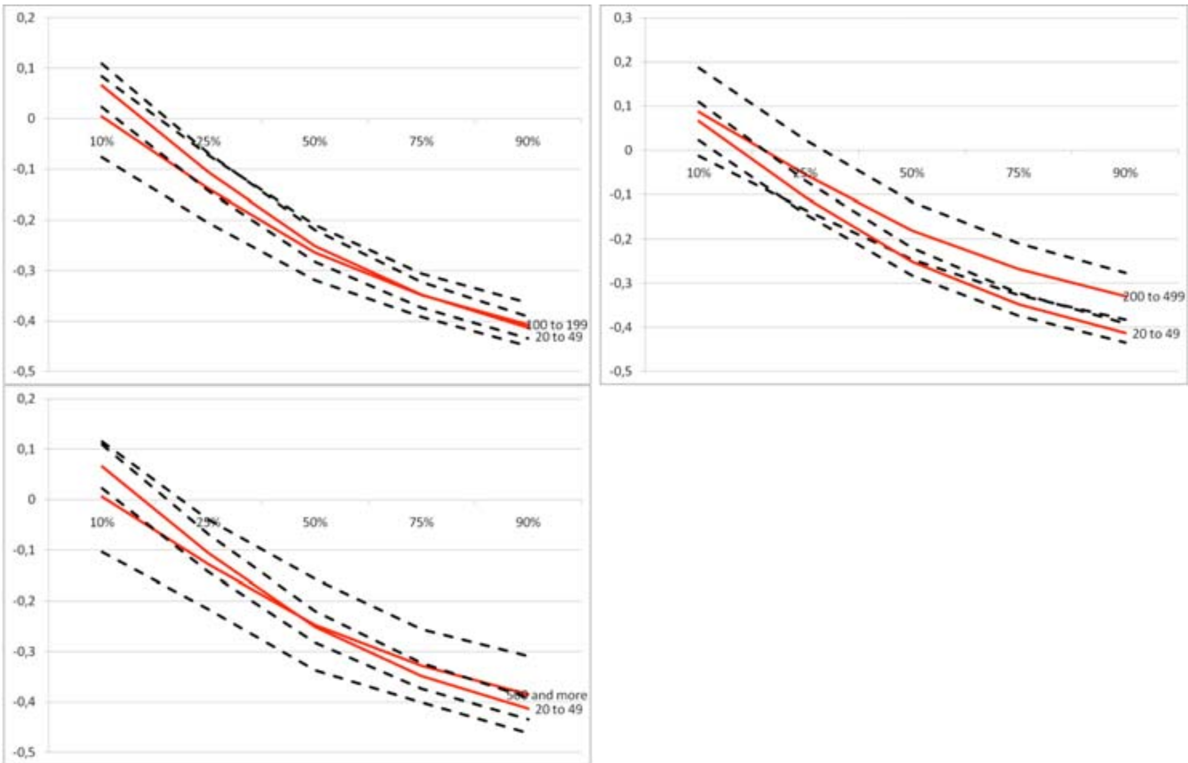
If the distribution of the wage share is introduced to the analysis, the pattern becomes a little bit unclear. Unlike in the calculation of elasticity at the mean of the wage distribution, firms with less than 5 respective 5 to 9 employees show the highest absolute values for the wage and the demand elasticity, whereas firms with 200 to 499 employees have the lowest absolute values. This result maybe shows that it is important to include the distribution of wages into the analysis to receive reliable results. The other functions are very close to each other and cross the other graphs in some cases. Also, it becomes obvious that not only the firm size but also the use of labor matters for the size of the elasticities. The average elasticity of a firm with less than 5 workers at the 25th percentile is always lower in absolute terms compared to other firm sizes, but the elasticity of an entity with 200 to 499 employees at the 90th percentile is still smaller.

In Figure 3, the elasticity of labor demand on changes of the costs of capital is carried out. The pattern shows that the elasticities of the firms with more than 500 employees are the largest, while the elasticities for the establishments with less than 5 workers are clearly negative. This order is independently from distribution of labor costs.

To prove whether there are significant differences between the firms sizes, confidence intervals on the 95%-level are calculated from the estimated standard errors in Table 5. In the following figures, the results for each firm size are compared to the reference group of establishments with 20 to 49 employees:

**Figure 4: Confidence Intervals of Wage Elasticities**

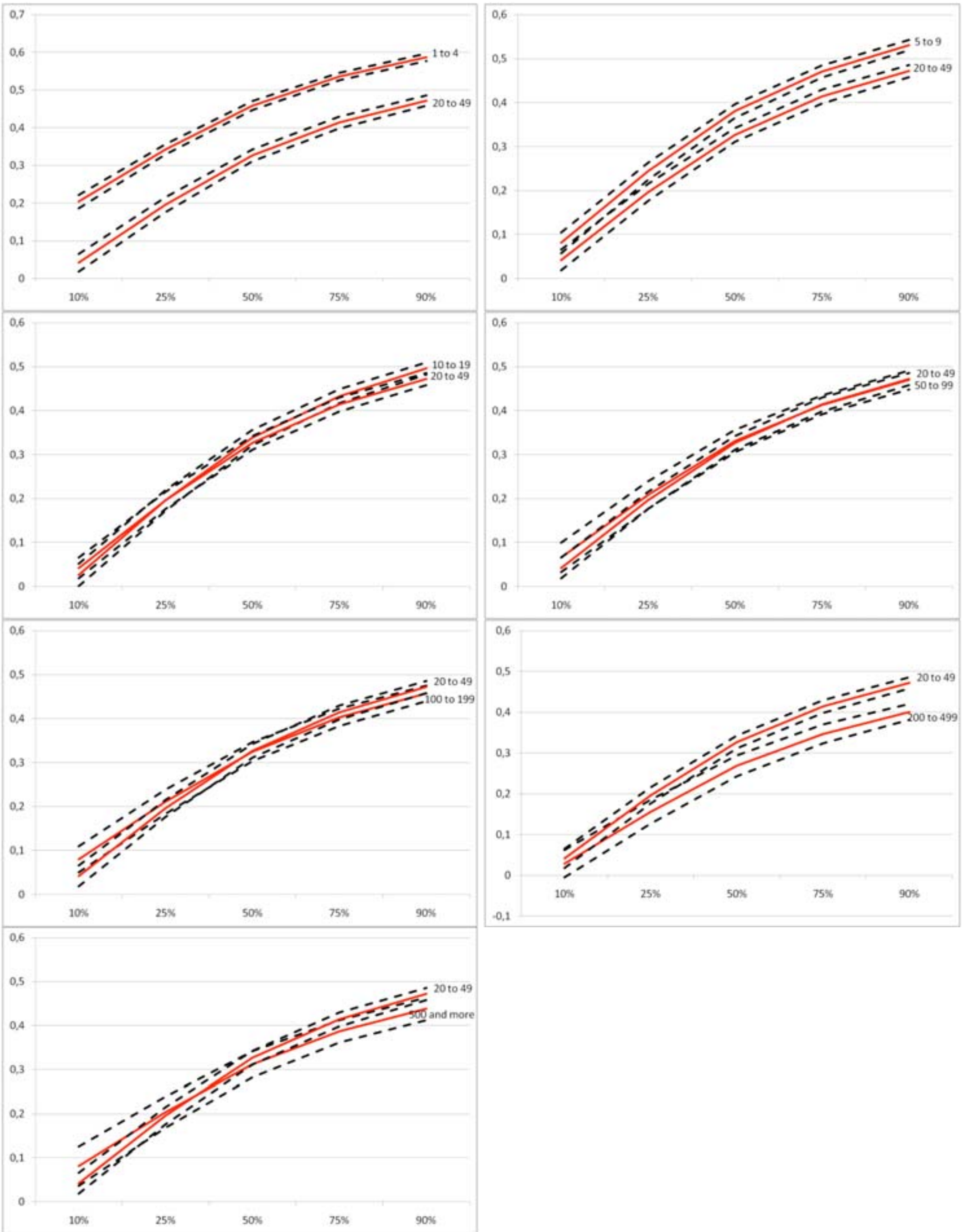





Some size classes show significant differences over the distribution of the wage share compared to the reference group of firms with 20 to 49 employees. Especially small establishments with 1 to 4 and 5 to 9 workers show this picture over the major part of the distribution. The other size classes are very close to the reference group. Nevertheless, significant differences are only indicated for the same percentile of the distribution. The wage elasticity of an establishment with 5 to 9 employees is maybe significantly larger in absolute values than the elasticity of the reference group both measured at the same percentile of the distribution, but the elasticity for small firms with a large wage share is lower in absolute values than for an establishment with 20 to 49 workers and a small wage bill. This pattern also occurs for the other firm sizes. Therefore, one can conclude, it is not only the firm size that matters when new jobs are created or destroyed. Also the size of the wage share and the actual use of the factor labor influence changes in the demand for labor. These results go along with the well known Hicks-Marshall conditions of derived demand (cf. Hamermesh 1993, 22pp). Thus, there is no simple recipe for employment strategies that use a relationship between job creation and firm size.

In addition, this paper deals with short run reactions of labor demand to changes in factor prices and demand for goods and services. Even if firms with a high wage share maybe show a high job creation rate in the short run, it is not clear whether this is also valid in the long run. This depends also on the technology used and the productivity of establishments. Normally, firms with a higher productivity also have a lower wage share because the same amount of goods or services (Y) is then produced with less labor inputs (L). Given that the firms have to pay equal market wages, the wage share decreases. If these firms have a higher growth in the long run, useful employment strategies become even more complicated.

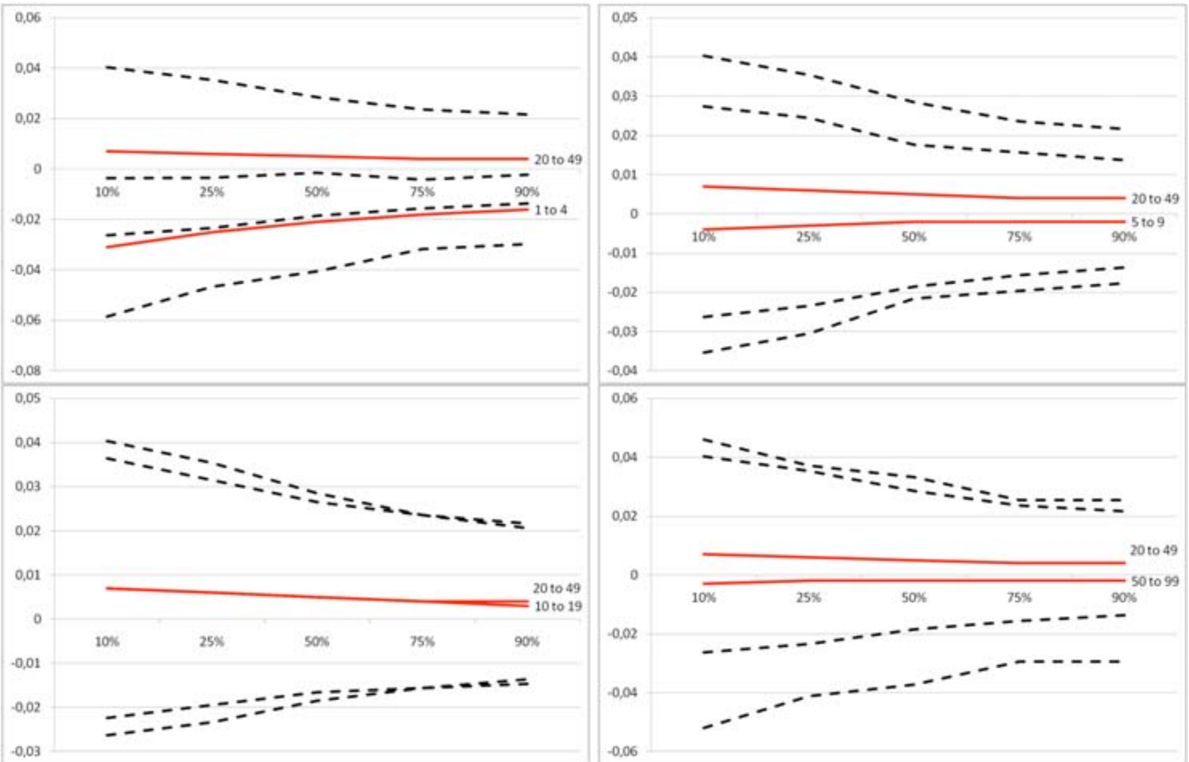
**Figure 5: Confidence Intervals of Demand Elasticities.**

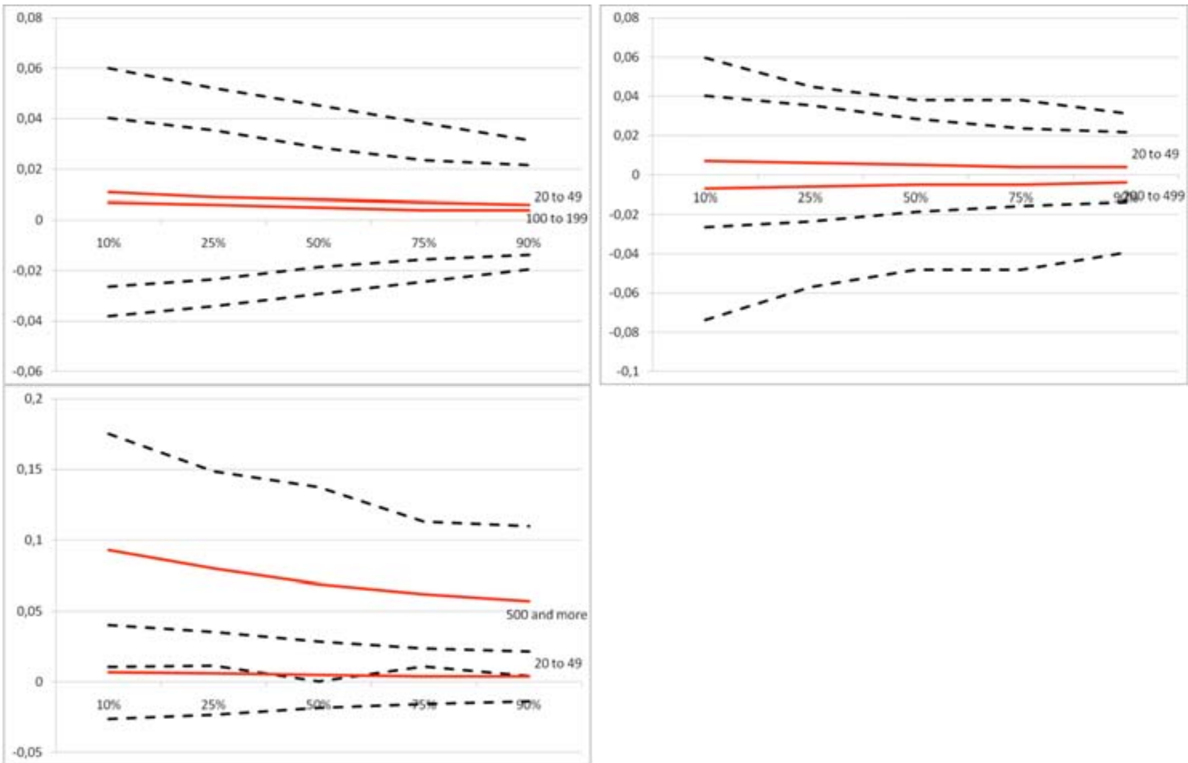


The distribution of the size specific demand elasticities are compared in Figure 5. The results are similar to those in Figure 4 but with the opposite sign. Again there are some size classes with statistical significant differences at all points of the distribution, but if firms in different size classes with low and high wage shares are compared, the variation vanishes. Therefore, it comes to the same conclusion as for the wage elasticities.

Figure 6 contains the elasticities for changes of the interest rates. There are no significant deviations among the size classes. Establishments with 4 or less employees picture negative and but insignificantly lower elasticities than firms in the reference group. This result is independent from the distribution of the wage share. Also the calculated elasticities for larger firms are higher and significantly different from zero in some cases even if the deviation from the reference group is not significant on a conventional level. Again, this is maybe a weak confirmation of the assumption of Gertler and Gilchrist (1994) that small firms are more restricted to the capital market. The following conclusion will sum up the available results.

**Figure 6: Confidence Intervals of Capital Price Elasticities**






## VI. Conclusion

This paper analyses the assumption of a relationship between firm size and employment dynamics. A long history of literature beginning with “Gibrat’s Law” covers this topic and a negative correlation among firm size and job creation is often the background of official employment strategies like in the EU. This subject also contains some methodological problems that result in controversial outcomes. Unlike in other papers, the presented work uses theoretical labor demand model to identify the sources for differences in the employment dynamics by firm size. Methodological problems such as regression and reclassification biases are considered within this framework. A fractional panel probit model is used to estimate the multivariate model for each respective size class.

The results of the regressions and the calculated elasticities show at first hand that the firm size matters in the case of employment dynamics. The derived elasticities for changes of wages or demand for goods and services indicate that smaller firms tend to have a significantly larger response to economic shocks compared to larger establishments. This outcome only occurs, when the distribution of the wage bill is introduced to the analysis. If alterations of the capital costs occur, the elasticity of labor demand slightly increases with firm size and remotely confirms the hypothesis that smaller firms are more constraint to capital markets, so that capital is a complement good for labor for these entities. However, these results are rather weak and not always significant in a statistical sense.

Nevertheless, according to the findings firm size is not the only source for differences in employment dynamics. Also, the use of labor itself influences the increase or decrease of labor demand if economic changes appear. The results confirm one of the Hicks-Marshall conditions of derived demand that an establishment with a high factor share also exhibits larger absolute factor elasticities. Therefore, firms with a high labor share also have larger employment dynamics. It seems that the rates of job creation and destruction result from a mixture of at least two different effects, a size effect and an effect reflecting the technology that determines the use of labor. From this point of view, an analysis of employment dynamics that uses firm size as the only explanatory variable is too simple and the outcomes of that kind of analysis will differ depending on the use of labor in the observed establishments.

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## Appendix

### A.1 Calculation of Elasticities

Starting with the total differential of s:

(A.1) $$\partial s = \partial w \frac{L}{Y} + \partial L \frac{w}{Y} - \partial Y \frac{wL}{Y^2} = \frac{\partial w}{w} s + \frac{\partial L}{L} s - \frac{\partial Y}{Y} s = \left( \frac{\partial w}{w} + \frac{\partial L}{L} - \frac{\partial Y}{Y} \right) s$$

it is easy to derive the labor demand elasticities from the partial marginal effects:

(A.2) $$\frac{\partial s}{\partial (\ln w)} = \frac{\left( \frac{\partial w}{w} + \frac{\partial L}{L} - \frac{\partial Y}{Y} \right) s}{\frac{\partial w}{w}} = b_1 .$$

$$\Leftrightarrow \quad \frac{\left( \frac{\partial w}{w} + \frac{\partial L}{L} - 0 \right)}{\frac{\partial w}{w}} = \frac{b_1}{s}$$

$$\Leftrightarrow \quad \frac{\partial L}{L} \Big/ \frac{\partial w}{w} + 1 = \frac{b_1}{s}$$

$$\Leftrightarrow \quad \frac{\partial L}{L} \Big/ \frac{\partial w}{w} = \frac{b_1}{s} - 1$$

(A.3) $$\frac{\partial s}{\partial (\ln Y)} = \frac{\left( \frac{\partial w}{w} + \frac{\partial L}{L} - \frac{\partial Y}{Y} \right) s}{\frac{\partial Y}{Y}} = d .$$

$$\Leftrightarrow \quad \frac{\left( 0 + \frac{\partial L}{L} - \frac{\partial Y}{Y} \right)}{\frac{\partial Y}{Y}} = \frac{d}{s}$$

$$\Leftrightarrow \quad \frac{\partial L}{L} \Big/ \frac{\partial Y}{Y} = \frac{d}{s} + 1$$

(A.4) $$\frac{\partial s}{\partial(\ln r)} = \frac{\left(\frac{\partial w}{w} + \frac{\partial L}{L} - \frac{\partial Y}{Y}\right)s}{\frac{\partial r}{r}} = b_2 .$$

$$\Leftrightarrow \qquad \frac{\partial L}{L} \Big/ \frac{\partial r}{r} = \frac{\left(0 + \frac{\partial L}{L} - 0\right)}{\frac{\partial r}{r}} = \frac{b_2}{s}$$

## Table A.1: Descriptive Statistics

| Variable | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Share of labor costs | 72,226 | 0.265 | 0.175 | 0.001 | 0.999 |
| Log of turnover | 78,584 | 14.240 | 2.206 | 6.628 | 23.806 |
| Log. wage per cap. | 97,013 | 7.349 | 0.647 | 1.632 | 10.573 |
| Log. of 12 month EURIBOR | 116,558 | 1.169 | 0.263 | 0.811 | 1.573 |
| Share of parttime workers | 113,096 | 0.202 | 0.250 | 0 | 1 |
| Share of temporary employed workers | 113,353 | 0.056 | 0.149 | 0 | 1 |
| Share of workers subj. to the soc. sec. scheme | 113,823 | 0.785 | 0.263 | 0 | 1 |
| Share of female workers | 113,658 | 0.424 | 0.309 | 0 | 1 |
| Share of low skilled workers | 112,989 | 0.178 | 0.246 | 0 | 0.999 |
| Establishments with a collective agreement | 113,111 | 0.742 | 0.438 | 0 | 1 |

Source: IAB Establishment Panel 2000-2007

## Table A.2: Profitability of Establishments

| Value | Obs. |
|---|---|
| 1 (very good) | 3,946 |
| 2 | 23,133 |
| 3 | 28,412 |
| 4 | 16,187 |
| 5 (insufficient) | 10,367 |
| **Total** | **82,045** |

Source: IAB Establishment Panel 2000-2007. Note that in 2003 this variable was excluded from the questionnaire. Therefore, in the estimations the mean of 2002 and 2004 are used as imputed data for 2003.

## Table A.3: Legal Form of Establishments

| Label | Obs. |
|---|---|
| Ind. enterprise | 31,594 |
| Partnership | 6,551 |
| Ltd. company | 48,742 |
| Corp. entities | 4,247 |
| Public comp. | 13,494 |
| Other | 6,815 |
| **Total** | **111,443** |

Source: IAB Establishment Panel 2000-2007.

## Table A.4: Average Labor Demand Elasticities of $\eta_{Lw}$ for Different Firm Sizes and Percentiles of the Wage Distribution

| | Mean | 10% | 25% | 50% | 75% | 90% |
|---|---|---|---|---|---|---|
| **Total** | -0.245** (0.006) | -0.023** (0.008) | -0.179** (0.006) | -0.313** (0.005) | -0.401** (0.005) | -0.461** (0.004) |
| **Firm Size** | | | | | | |
| 5 ≤ N ≤ 9 | -0.214** (0.011) | -0.158** (0.011) | -0.304** (0.009) | -0.428** (0.008) | -0.508** (0.006) | -0.563** (0.006) |
| 10 ≤ N ≤ 19 | -0.202** (0.012) | 0.011 (0.017) | -0.168** (0.015) | -0.319** (0.011) | -0.418** (0.009) | -0.484** (0.008) |
| 20 ≤ N ≤ 49 | -0.209** (0.014) | 0.098** (0.018) | -0.094** (0.017) | -0.255** (0.014) | -0.361** (0.011) | -0.432** (0.011) |
| 50 ≤ N ≤ 99 | -0.244** (0.016) | 0.066** (0.022) | -0.106** (0.019) | -0.251** (0.016) | -0.348** (0.013) | -0.413** (0.011) |
| 100 ≤ N ≤ 199 | -0.253** (0.025) | 0.039 (0.033) | -0.119** (0.029) | -0.255** (0.023) | -0.347** (0.020) | -0.410** (0.018) |
| 200 ≤ N ≤ 499 | -0.267** (0.027) | 0.004 (0.041) | -0.139** (0.034) | -0.264** (0.028) | -0.349** (0.022) | -0.407** (0.022) |
| N ≥ 500 | -0.192** (0.031) | 0.087 (0.051) | -0.055 (0.040) | -0.181** (0.033) | -0.268** (0.030) | -0.329** (0.027) |
| 5 ≤ N ≤ 9 | -0.290** (0.042) | 0.006 (0.056) | -0.128** (0.045) | -0.247** (0.046) | -0.328** (0.037) | -0.385** (0.039) |

Note: Standard errors of the average labor demand elasticities are obtained by bootstrapping using 200 replications. ** and * denote significance at the .01. and .05 levels, respectively.

### Table A.5: Average Labor Demand Elasticities of $\eta_{Lr}$ for Different Firm Sizes and Percentiles of the Wage Distribution

| | Mean | 10% | 25% | 50% | 75% | 90% |
|---|---|---|---|---|---|---|
| **Total** | -0.001 (0.005) | -0.001 (0.007) | -0.001 (0.005) | -0.001 (0.005) | -0.001 (0.004) | -0.001 (0.004) |
| **Firm Size** | | | | | | |
| 5 ≤ N ≤ 9 | -0.029* (0.013) | -0.031* (0.014) | -0.025* (0.011) | -0.021* (0.010) | -0.018* (0.007) | -0.016* (0.007) |
| 10 ≤ N ≤ 19 | -0.003 (0.013) | -0.004 (0.016) | -0.003 (0.014) | -0.002 (0.010) | -0.002 (0.009) | -0.002 (0.008) |
| 20 ≤ N ≤ 49 | 0.005 (0.012) | 0.007 (0.015) | 0.006 (0.013) | 0.005 (0.011) | 0.004 (0.010) | 0.003 (0.009) |
| 50 ≤ N ≤ 99 | 0.005 (0.011) | 0.007 (0.017) | 0.006 (0.015) | 0.005 (0.012) | 0.004 (0.010) | 0.004 (0.009) |
| 100 ≤ N ≤ 199 | -0.002 (0.016) | -0.003 (0.025) | -0.002 (0.020) | -0.002 (0.018) | -0.002 (0.014) | -0.002 (0.014) |
| 200 ≤ N ≤ 499 | 0.008 (0.018) | 0.011 (0.025) | 0.009 (0.022) | 0.008 (0.019) | 0.007 (0.016) | 0.006 (0.013) |
| N ≥ 500 | -0.005 (0.024) | -0.007 (0.034) | -0.006 (0.026) | -0.005 (0.022) | -0.005 (0.022) | -0.004 (0.018) |
| 5 ≤ N ≤ 9 | 0.065* (0.027) | 0.093* (0.042) | 0.080* (0.035) | 0.069* (0.035) | 0.062* (0.026) | 0.057* (0.027) |

Note: Standard errors of the average labor demand elasticities are obtained by bootstrapping using 200 replications. ** and * denote significance at the .01. and .05 levels, respectively.

### Table A.6: Average Labor Demand Elasticities of $\eta_{LY}$ for Different Firm Sizes and Percentiles of the Wage Distribution

| | Mean | 10% | 25% | 50% | 75% | 90% |
|---|---|---|---|---|---|---|
| **Total** | 0.311** (0.004) | 0.109** (0.005) | 0.251** (0.004) | 0.373** (0.003) | 0.454** (0.003) | 0.508** (0.003) |
| **Firm Size** | | | | | | |
| 5 ≤ N ≤ 9 | 0.258** (0.009) | 0.204** (0.009) | 0.343** (0.007) | 0.459** (0.006) | 0.536** (0.005) | 0.587** (0.005) |
| 10 ≤ N ≤ 19 | 0.274** (0.009) | 0.081** (0.012) | 0.244** (0.010) | 0.381** (0.008) | 0.471** (0.007) | 0.531** (0.006) |
| 20 ≤ N ≤ 49 | 0.298** (0.010) | 0.026 (0.013) | 0.196** (0.012) | 0.339** (0.009) | 0.433** (0.008) | 0.496** (0.007) |
| 50 ≤ N ≤ 99 | 0.320** (0.008) | 0.042** (0.012) | 0.196** (0.010) | 0.327** (0.008) | 0.414** (0.008) | 0.472** (0.007) |
| 100 ≤ N ≤ 199 | 0.329** (0.012) | 0.066** (0.017) | 0.208** (0.016) | 0.331** (0.013) | 0.413** (0.011) | 0.470** (0.011) |
| 200 ≤ N ≤ 499 | 0.328** (0.012) | 0.080** (0.015) | 0.211** (0.014) | 0.325** (0.011) | 0.403** (0.010) | 0.457** (0.009) |
| N ≥ 500 | 0.278** (0.013) | 0.029 (0.017) | 0.156** (0.015) | 0.269** (0.013) | 0.347** (0.012) | 0.401** (0.010) |
| 5 ≤ N ≤ 9 | 0.352** (0.016) | 0.081** (0.023) | 0.204** (0.018) | 0.312** (0.015) | 0.387** (0.013) | 0.438** (0.013) |

Note: Standard errors of the average labor demand elasticities are obtained by bootstrapping using 200 replications. ** and * denote significance at the .01. and .05 levels, respectively.

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