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The Statutory Minimum Wage in Germany and the Labor Demand
Elasticities of Low-Skilled Workers: A Regression Discontinuity
Approach with Establishment Panel Data

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The Statutory Minimum Wage in Germany and the Labor Demand

Elasticities of Low-Skilled Workers:

A Regression Discontinuity Approach with Establishment Panel Data

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This study uses the IAB Establishment Panel, Waves 2013-2018. 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 subsequently remote data access (Project-No. FDZ1045).

The Statutory Minimum Wage in Germany and the Labor Demand Elasticities of Low-Skilled Workers:

A Regression Discontinuity Approach with Establishment Panel Data

Abstract

This study examines the influence of the statutory minimum wage on labor demand elasticities regarding low-skilled workers. For this, a regression discontinuity analysis is conducted using company panel data from 2013 to 2018. In addition, a possible endogeneity of the remuneration for low-skilled workers was considered using an IV estimation. It is shown that the monopsonistic structures of the labor market may continue to exist after the introduction of the minimum wage. Additionally, the own-wage elasticity for low-skilled workers did not change over the period considered. However, in the short run, stronger substitutive relationships with medium-skilled workers seem to exist, and probably also with highly qualified employees in the long run.

1. Introduction

Since the seminal work of Card and Krueger (1994), there has been an ongoing and often controversial discussion about the impact of minimum wages on employment (cf. Neumark et al. 2014). While a part of the researchers stresses that the monopsonistic structure of the labor markets for low skilled workers prevents the negative effect of wages on employment (cf. Manning 2003), the others points to the negative impact of larger wages on employment using the neoclassical models of the labor market. It is argued that job losses usually occur not through dismissals but through reduction in working hours and other structural adjustments (Neumark 2018). Presently, with the decision of the Federal Government to introduce a statutory minimum wage of 8.50€ from 2015, the discussion has also started trending in Germany. Even at the international level, there is no agreement among researchers on the effect of statutory minimum wage on employment. After several increase in the minimum wage since its introduction, there has been a great deal of discrepancy about its impact on the economy. While some emphasizes the positive effects on the income of low wage earners and the minor negative effects on the number of employees subject to social insurance contributions, the others states that

there has been a considerable reduction in the number of working hours demanded; a significant proportion of the workers concerned do not receive the minimum wage and that the socio-political effects have not been achieved (cf. Bruttel et al. 2019, Caliendo et al. 2019).

These studies are mainly concerned with the direct employment effect of minimum wages, but not the structure of the labor market. Besides the changes in employment, the introduction of minimum wages could also change the demand elasticities of workers in the low-income class and thus influence future reactions of wage increase in regard to the demand for labor. Hence, in addition to the short-term effects on the number of employees, there may also be long-term effects that changes or possibly worsen the market position of low-skilled workers. This applies to the direct demand of low-skilled workers as measured by the own-wage elasticities, as well as to changes in demand for other production factors. Substitutive or complementary correlations can be expressed by the cross-wage elasticities. The size of wage elasticities that depend on substitution and scale effects resulting from a change in the wage rate are relevant here (Cahuc et al. 2014, 41ff.). In particular, drastic wage increases probably rise the share of wage costs and therefore elevates the search for possible substitution. Finally, this would result in higher wage elasticities. After the introduction of the statutory minimum wage, it was further increased in 2017, 2019 and 2020 to currently 9.35€. A further increase to 10.45€ is also planned from July 1, 2022. Most previous analyses only refer to the introduction of the minimum wage, which had been accompanied by a rather high salary increase for most minimum wage recipients. However, since the data used here covers up to 2018, the effects of the increase in 2017 can also be analyzed below.

The present study examines the possible changes in labor demand of low-skilled workers caused by the introduction of the statutory minimum wage in Germany in 2015, and by the increase in 2017. Nevertheless, the analysis did not calculate the direct quantitative effects on income and employment, but rather the relationships between the variables represented by the demand elasticities. In particular, it investigates whether the demand elasticity of low-skilled workers themselves and the complementary or substitutive relationships with other production factors changed. For this purpose, a labor

demand model for low-skilled workers will be estimated using data from the IAB Establishment Panel. A regression discontinuity analysis is applied to describe the differences in labor demand between the periods: before and after the introduction of the minimum wage and after its first increase, respectively. Since there is a well-founded assumption of monopsonistic market structures for the demand of low-skilled workers, these probable endogeneities of remuneration must be considered in an empirical study. The own wage elasticity of demand will be clearly biased if this endogeneity is not taken into account, which may imply that the introduction as well as the increase of the minimum wage had no influence on the magnitude of elasticity. After the introduction of the minimum wage, an increase was observed in the substitutive relationship between low-skilled and medium-skilled workers. Since 2017, a significantly higher substitution elasticities between low- and highly qualified workers became apparent. This indicates that, in addition to changes in employment and working hours, there could also be a change in the employment structure in the long term.

This work enriches existing literatures in several fields. First, the focus here is not entirely on employment and wage effects of the statutory minimum wage, but also on the elasticities of both, which has not been explicitly analyzed before in any study of German context. Secondly, this study does not only present the effects of the introduction of the minimum wage, but also its subsequent increase in 2017. Finally, the IV approach employed here allows an unbiased estimation of labor demand function, so that the influence of actual market structures on the German labor market can be shown.

The subsequent sections are organized as follows. Section 2 includes an overview of the literature, the theoretical foundations of the research and the hypotheses. Section 3 is the presentation of the data and the estimation model. Section 4 contains the results of the estimation, and finally, section 5 gives the summary.

2. Recent Research and Theoretical Background

As already mentioned, a generally applicable minimum wage of 8.50€ was introduced in Germany at the beginning of 2015, and was increased by 4% to 8.84 €, in January 2017. After two further increases,

the wage is currently 9.35€ since January 2020. There are plans to further increase it to 10.45 € by July 2022. In total, about 4 million jobs (approx. 11%) were affected by the introduction of the minimum wage (Federal Statistical Office 2018). The minimum wage is enacted by the federal government on the basis of the recommendation of the minimum wage commission with equal representation of employers and employees¹.

The minimum wage was accompanied by extensive scientific studies before and after its introduction. Even before 2015, the effect of the minimum wage on employment was a controversial topic (cf. Knabe et al. 2014, Möller 2012). Most studies that analyzed the effects of the minimum wage after its introduction concluded that the number of jobs did not change respectively only decreased moderately until the Covid19 pandemic (Ahlfeldt et al. 2018, Bachmann et al. 2020, Bonin et al. 2018, 2020, Bossler 2017, Bossler & Gerner 2019, Bossler et al. 2020, Bruttel 2019, Caliendo et al. 2018, Dustmann et al. 2020, Friedrich 2020, Garloff 2019, Holtemöller & Pohle 2019, Pestel et al. 2020). This however, does not mean there have been no structural changes in employment in the minimum wage sector, where especially, marginal forms of employment have very often been converted into jobs subjected to social insurance contributions (Ahlfeldt et al. 2018, Bonin et al. 2018, Bossler & Gerner 2019, Caliendo et al. 2018, Pestel et al. 2020). In addition, the employment effects are not uniform and differ based on the condition of the labor market (Bossler et al. 2019). On the one hand, the effects are largely negative where there is a high level of competition on the product market (Bossler et al. 2018, 2020), while on the other hand, employment cuts are particularly evident when the individuals to be employed are those that mostly benefit from the introduction of the minimum wage, like women, low-skilled workers and workers from non-EU countries (Bonin et al. 2018). These adjustments processes were more evident in the Eastern Germany compared to Western Germany (Bossler & Gerner 2020). Further structural adjustments may be reflected in higher capital input or efficient production (Koch et al. 2020,

¹ For details please see www.mindestlohn-Kommission.de

Bossler et al. 2020). Similarly, a shift of employees towards larger entities with better earning opportunities can be observed (Dustmann et al. 2020).

In the US or UK for example, (cf. Metcalf 2008, Schmitt 2015), after the introduction or increase of the minimum wage, the demand for labor is also adjusted through working hours. Studies showed that between one and two-fifths of firms in Germany had reduced working hours in response to the introduction of the minimum wage (Kann 2018, Bellmann et al. 2016). Burauel et al. (2020a). This leads to an observed reduction in working time of 11% for marginally employed workers and 5% for employees subject to social security contributions. Caliendo et al. (2018) found a decrease of 3.5% for the lower wage quintile. Bonin et al. (2018), however, found no decline in the overall volume of work and Bachmann et al. (2020) showed that the initial decline in working time was reversed over time and that the increase in 2017 had no effect on the working hours.

This effect on the working hours can also have possible consequences on the income of minimum wage recipients. While most studies show significant wage increases per working hour for the employees concerned (Ahlfeldt et al. 2018, Bachmann 2020 et al., Bossler & Gerner 2020, Burauel et al. 2020b, Dustmann 2020), there were no uniform data with regard to the monthly wages. Burauel et al. (2020b) and Bachmann et al. (2020) concluded that the monthly salaries have hardly changed, but Bossler and Schank (2020) and Bossler et al. (2020) found a significantly higher monthly wages for these workers. In addition, Bachmann et al. (2020) further states that there was no significant increase in the hourly wages after the increase of the minimum wages in 2017. Another problem that affects the remuneration of low-wage earners is the circumvention of the payment. This can mean a higher number of unpaid overtime (Koch et al. 2020) or lower pay than required by law (Burauel et al. 2020b, Fedorets et al. 2019). However, the estimates are based on very uncertain data and in some cases fluctuate considerably, so that no precise conclusion is reached regarding the significance of this problem (Verbeek et al. 2020).

If the labor market largely corresponds to the conditions of a competitive market, the reaction of labor demand to the introduction of the minimum wage will depend on the wage elasticity of demand. Therefore, according to the fundamental laws of demand (Cahuc et al. 2014, 91ff.), the demand for workers affected by the minimum wage should decrease, since the demand elasticity is negative with respect to the increase in the wage of this group (cf. Hamermesh 1993). This pattern changes if there are monopsonistic market structures, e.g. if there are only a few employers for the minimum wage recipients (cf. Manning 2003). Hence, the observed demand elasticities become positive. Bossler et al. (2020) conducted separate analyses for economic sectors with and without monopsonistic power. Following existing literature, they identified retail trade and the hotel and restaurant industries as economic sectors with high monopsonistic power (Bachmann and Frings 2017). These industries were found to have less negative reaction to the introduction of the minimum wage than competitive industries. In the estimates of labor demand elasticities, monopsonistic market structures will lead to an endogeneity of the wage rate, since employment is determined by labor supply and thus by remuneration (Manning 2003). This must be taken into account in the regressions, for example, by using an instrument variable (IV) approach. If the wage rate is increased by introduction of the minimum wage to an extent that employment is determined by the labor demand function, then this endogeneity should no longer play a role and the IV estimation should no yield different results from the common approach (Cahuc et al. 2014, 794).

Estimates of labor demand elasticities are therefore an indicator of the influence of monopsonistic structures in the labor market. If the results of the IV estimations and the estimates without endogeneity correction no longer differ significantly, it can then be assumed that the labor supply does not influence the outcome of labor demand and that the general minimum wage could reduce monopsonistic structures. Since the estimated parameters can be interpreted as the mean influence of all variables in the regression model, a larger elasticity in absolute terms could indicate a reduction of the influence of the monopsonistic market structures.

The present analysis is focused on low-skilled workers. It is assumed that most employees receiving the minimum wage belong to this group (Neumark 2018). Substitutional or complementary relationships with other inputs are expressed by the cross-wage elasticities of labor demand. The overall effect of the minimum wage introduction can be described by a substitution effect and a scale effect. When there are more than two factors of production, the total price elasticity is given by (Hamermesh 1993, 35):

$$(1) \quad \eta_{ij} = s_j \sigma_{ij} - s_j \eta,$$

with η_{ij} as cross-wage elasticity between inputs i and j , η as the price elasticity of the goods produced or services by the firm, s_j as the share of labor costs of input j to total costs, σ_{ij} as the partial elasticity of substitution, indicating changes in the relative use of the two factors because of relative wage changes without altering the output. If i equals j , η_{ij} is equal to the own-wage elasticity. The first term of equation (1) indicates the short-run substitution effect with constant output levels, while the second term is the size of the long-run scale effect. Because of the dual approach in optimizing the firms' behavior, it is possible to calculate σ_{ij} from the production or the cost function. Thus, it is possible to calculate the partial elasticity of substitution by:

$$(2) \quad \sigma_{ij} = \frac{C \cdot C_{ij}}{C_i \cdot C_j},$$

with C as cost function and C_i or C_j as derivatives of the cost function according to i and j . The elasticity of demand for the goods and services produced (η) describes the influence of price increases resulting from the introduction of the minimum wage on the demand for labor. Surveys showed that between 18 and 44 percent of companies concerned stated that they used price increments to cushion the effect of the introduction of the minimum wage on their operation (Bellmann et al. 2016, Federal Statistical Office 2018, Link 2019). Koch et al. (2020) showed that a majority of the surveyed firms had to increase the prices for products or services as a result of the introduction and subsequent increase of the statutory minimum wage. Some of the entities surveyed attributed the price increases not only to higher wage costs, but also to other cost increases. The limits of price increases seemed to have been

set differently depending on the industry and region. According to the data, the possibility of passing on the increased wage costs to customers through price adjustments depended on various factors, which includes a competitive environment and the willingness of customers to accept the increase. Company strategies to promote the acceptance of price increases consists of intensive and active communication about the minimum wage-related reasons for the price increases, customer-specific price adjustments, and flexibilisation of services and gradual price adjustments. Link (2019) estimated price elasticities for services and for manufacturing at -0.89 and -0.67, respectively. He concludes that the comparatively low employment effects of the minimum wage until now can be explained by, among other things, the adjustment of consumer prices. If one assumes in the following that the price elasticity of demand is exogenous and constant over the short term, then the scale effect differs only through the share of wage costs for the respective type of employee s_j . A series of studies on the introduction of the minimum wage, found a significantly higher increase in the gross wage bill in firms employing workers with the minimum wage compared to similar firms without minimum wage recipients (Bossler et al. 2020). This indicates that the own-wage elasticity is becoming more negative: the complementary correlations are weakened while the substitutive correlations are strengthened, since the cost shares of other employment groups can become smaller to the same extent.

Besides the influence of cost shares and the price elasticity of demand for goods and services, there are other fundamental laws of demand that are important here (Cahuc et al. 2014). The (absolute) wage elasticity of labor demand becomes higher, the easier it is to replace labor with other production factors. A rising wage implies that labor becomes relatively more expensive and other factors of production relatively cheaper. As a result, firms try to reduce the use of low-skilled labor and increase the use of other inputs into the production process. The better a firm's ability to substitute a production factor, the more the affected production factor is replaced. This can be illustrated by the cross-price elasticities of labor demand. However, such substitution efforts also impact on the costs of the other production factors. Assume that a firm affected by a wage increase substitutes labor with capital, if the additional demand for capital leads to a significant increase in the price of capital, then the relative

price change between the factors of labor and capital is small and the incentive to substitute labor is low. Similarly, the wage elasticity of the demand of labor hardly changes. This becomes important when the supply of other factors of production is limited, e.g. in the case of a lack of skilled workers. If the labor market of other kinds of workers (i.e. medium or highly skilled) did not change in the last few years, then the actual changes of labor demand elasticities will not be affected because of the introduction of a statutory minimum wage.

[Figure 1 near here]

Figure 1 shows the development of gross hourly wages and the increase in wages for minimum wage recipients. According to a study by Kann (2018), using data from the German Federal Statistical Office, the introduction of the statutory minimum wage in 2015 resulted in an average increase in earnings of about 15%, while gross wages increased by less than 5% during the same period. Employees with a minimum wage have thus become relatively more expensive and it is possible to detect an increased substitution with other groups of employees. However, after 2015, the increases of payments due to the minimum wage rise in 2017 and 2019 were lower than the general wage increase. This should remove the incentive to replace minimum wage earners with other production factors as the wage increase is lower, and other workers will become relatively expensive and the substitution processes reversed. Following the theory and the review of existing literature, the following hypotheses are proposed:

Hypothesis I: If the minimum wage changes or weakens monopsonistic structures on the labor market, the influence of labor supply on estimates of labor demand should be reduced.

In a monopsony, employers exploit the composition of labor supply to determine wage and employment in a profit-optimal manner. If a minimum wage counteracts this behavior, the influence of labor supply on labor demand decreases or disappears. This should also be reflected in the empirical estimates of labor demand. The influence of labor supply becomes apparent here as endogeneity of

wages. Thus, the estimates of IV models should show only slight deviations from the models in which the endogeneity is not taken into account.

Hypothesis II: On a labor market with monopsonistic structures a minimum wage leads to higher (absolute) own-wage elasticities.

If the introduced minimum wage is below the wage on a competitive market, there should be no job losses. Therefore, the share of the labor costs for low-skilled workers in the total costs should increase. However, according to the laws of labor demand, this should lead to higher labor demand elasticities in absolute terms.

Hypothesis III: The statutory minimum wage increases the substitutive relationships of low-skilled labor with other production factors.

The introduction of the statutory minimum wage not only lead to an absolute increase in the wage rate but also to a change in relative prices. As a result, low-skilled work becomes relatively more expensive compared to other factors of production, therefore, leading to an increased desire to replace the relatively expensive factor by other relatively cheaper ones. If one assumes a flexible production possibility, this should lead to a larger substitution between the factors of production and thus increase the cross-wage elasticities of labor demand. In addition, the demand for low-skilled workers who are the major recipients of the minimum wage show a stronger reaction to changes in wages. In this case, the own-wage elasticities should also increase in absolute terms.

3. Empirical Model and Data

Previous theoretical analysis indicates that a particular cost function is needed to calculate the elasticities. Next to the Cobb-Douglas generalized Leontief or CES-functions, the translog cost function is very common in literature (e.g. Freier & Steiner 2010). The translog cost function is an approximation of the CES function by a second-order Taylor polynomial at the point where the CES equals the Cobb–Douglas case. These kinds of flexible functions have the advantage that the σ are not restricted to a constant

but instead depend on the values of the factor prices. The translog cost function in its heterothetic form is given by (Berndt & Khaled 1979):

$$(3) \quad \ln C = \ln Y + a_0 + \sum_i a_i \cdot \ln w_i + 0.5 \sum_i \sum_j b_{ij} \cdot \ln w_i \cdot \ln w_j + \sum_i d_i \ln Y \cdot \ln w_i$$

where a_0 , a_i , b_{ij} , and d_i are the parameters, and $\ln C$, $\ln Y$, and $\ln w$ are the logarithms of C , Y , and w , respectively. In the following, it is assumed that the function is heterothetic; this is a more general case compared to a linear homogenous cost function. In a heterothetic cost function, total costs are related to the factor prices and also depend on the scale of the output Y , which 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. Taking the first derivative of $\ln C$ to $\ln w_i$, assuming that b_{ij} equals b_{ji} and applying Shephard's lemma to the labor input $\left(\frac{\partial C}{\partial w_i} = L_i\right)$ yields the following equation for each type of labor:

$$(4) \quad s_i = a_i + b_{ii} \cdot \ln w_i + \sum_{i \neq j} b_{ij} \cdot \ln w_j + d_i \cdot \ln Y$$

Equation (4) is often used in empirical investigations since its formal structure allows the application of usual econometrical methods (cf. Lichter et al. 2015). After some reformulation, the usual expression for the own- and cross- wage elasticities at a constant output from a translog cost function obtained for η_{ii} and η_{ij} are (Hamermesh 1993, 41):

$$(5) \quad \eta_{ii} = \frac{b_{ii}}{s_i} + s_i - 1$$

$$(6) \quad \eta_{ij} = \frac{b_{ij}}{s_i} + s_j.$$

As the endogenous variable is a share, it is not useful to estimate a linear model. One way to estimate equation (6) using panel data is the fractional panel probit regression (Papke & Wooldridge 2008). This is based on the fractional nature of the wage share. By assuming a normal distribution of the dependent share s_{it} (e.g., a probit model), the model in equation (4) becomes:

$$(7) \quad (s_{it} | \ln w_{it}, \ln w_{jt}, \ln Y_t, z_{it}, c_i) = \Phi \left(b_{ii} \cdot \ln w_{it} + \sum_{i \neq j} b_{ij} \cdot \ln w_{jt} + d_i \cdot \ln Y_{it} + \delta_i \cdot z_{it} + c_i \right),$$

where Φ is the standard normal cumulative distribution function (cdf), z_{it} is the additional exogenous variables of the model that are explained later, δ is the additional parameters and c_i is the unobserved firm specific heterogeneities. Since the fixed firm effects c_i cannot be observed directly, the Mundlak/Chamberlain device is used to model the unobserved heterogeneity as a linear function of the time averages with different coefficients for each number of observations for an entity with unbalanced data (Wooldridge 2019). From estimates of equation (7), it is possible to calculate the average partial effects as the first derivative of $\Phi(\cdot)$ to the particular variable of interest and therefore, the average elasticities according to equations (5) and (6).

The analysis uses a regression discontinuity approach to identify the effects of the statutory minimum wage on the labor demand elasticities. As there is no economic incentive to pay higher wages for workers in advance, especially those that lacks a large number of alternative job offers, a sharp regression discontinuity design is used to restrict the regressions to a short period before and after the introduction particularly during the raise of the statutory minimum wage (Wooldridge 2010, 954ff.). Three time periods are defined in this analysis with altering parameters for the variables that determine the wage elasticities. In particular, two dummy variables for the periods after the introduction (in 2015) and the raise (in 2017), and then multiplied with the variables containing the wage information. The parameters for the observed time periods are calculated by adding the individual estimates.

Further, as recipients of minimum wages probably face a monopsonistic labor markets, the regression model has to take into account the endogeneity of wages for low skilled workers. Therefore, a 2 stage least squares (2SLS) model is applied as an instrumental variable (IV) regression in a recursive model, where the remuneration of low skilled workers is estimated on the first stage and the outcome is used in the structural model on the second stage².

² The IV model is estimated with the STATA module cmp (Roodman 2011)

The data used is taken from the IAB Establishment Panel and consist of representative observations of German establishments from 2013 to 2018. The Institute for Employment Research of the Federal Employment Agency collected data of the IAB Establishment Panel since 1993 in western Germany and since 1996 in the new federal states. However, due to the regression discontinuity approach, only observations since 2013 are used in this analysis. The population of the IAB Establishment Panel includes all German establishments with at least one employee subject to social insurance contributions. The survey is a stratified random sample of 17 sectors, 10 employment size classes and in 16 regions (federal states) from the population. The survey shows a very high response rate: over 70% to 80% for firms that participated more than once. However, the data is unbalanced as new establishments are replacing panel mortality with exits and non-response. In total, about 16,000 yearly observations are available for our survey (Fischer et al. 2009). These data are supplemented by information from the Establishment History Panel, which is the official data from the employment statistics at the firm level, providing detailed information on various qualifications and their respective daily remuneration in the entities observed (Eberle & Schmucker 2017).

This work focus on the demand for low-skilled workers in the following regressions. Low-skilled workers are persons with a lower secondary, intermediate secondary or upper secondary school leaving certificate but without vocational qualifications. Here, w_i and L_i represent the pay and employment of low-skilled workers. Assuming there are competitive markets for goods and services, the ratio of the wage sum to the output Y is used to calculate s_i from equation (4) (cf. Hamermesh 1993, 92ff, Lichter et al. 2015). These figures are taken from the Establishment History Panel, though the output is observed as turnover in the IAB Establishment Panel. It is assumed that this group receives the lowest wages and therefore has the highest percentage of minimum wage recipients. Although, there is an ongoing discussion whether the introduction of a statutory minimum wage increased the monthly salary of the concerned workers or not (cf. Burauel et al. 2020b, Bachmann et al. 2020, Bossler and Schank 2020, Bossler et al. 2020). The calculation of the wage share is also influenced by the firms' growth. In total, the wage share of low skilled workers in the observed sample is about 1.96%. This wage share

over time is increased in the sample. In the years before the introduction of the minimum wage (2013 – 2014), the observed wage share in the data was 1.87%, 1.90% in 2015 and 2016, and 2.11% in the two years after the first raise. A t-test on equal means indicate significant differences on a 99%-level between the outcome of 2017 & 2018, 2013 & 2014 and 2015 & 2016, respectively. Nevertheless, the raise in the shares are about 0.002 and therefore, put some doubt on the influence of increasing s_i on the wage elasticities. Assuming there are constant price elasticities of goods and services in the observed period, then, the long-run scale effect has been almost constant since the introduction of the minimum wage. In addition, no significant changes are found in the wage shares of other qualifications in the data.

The Establishment History Panel provides additional information on the mean and median daily wage of full-time employees for all observed qualifications. The median wage is used for this analysis because it is less affected by random inference and censorship. The variable includes special payments such as vacation pay or 13th month salary, but only include values up to the earnings ceiling for contributions to the statutory pension insurance. This means that about 10% of the data is censored and the earnings means are distorted. To resolve this censoring problem, the data provider regularly calculates the daily wage data according to the method of Card, Heining and Kline (2015). This inaccuracy of the data is probably a problem of negligence for the wages of low-skilled workers. In 2013 and 2014, the median daily wage for full-time employed low skilled workers in the sample was about 74.81 €. This value increased to 79.72 € after the introduction of the minimum wage and to 83.12 € since the first raise in 2017. Although, the pay is larger but close to the usual remuneration of a minimum wage recipient, the size of the wage indicates that probably a large part of the low skilled workers receives this payment. The regressions also included wage information from medium and highly skilled

workers³ to show complementary or substitutional relationships between the skill levels, i.e. cross-wage elasticities.

The model in equation (7) is very useful for an empirical analysis, however, it needs to be extended by additional variables z_i to represent complex relationships (Groshen 1991). The IAB Establishment Panel contains information on the turnover of enterprises in the year preceding the survey. Since this study uses the turnover, firms that do not report turnover, including banks, insurance companies and public administrations, are excluded from the database. However, turnover is not directly used here, instead the value added was used, where intermediate materials were eliminated from the turnover. Other variables used by the IAB Establishment Panel are the share of part-time employees, female employees, fixed-term employees, employees subject to social insurance contributions, and dummies on collective bargaining agreements, West Germany, size of the firm, sectors and years, profitability, machinery condition, whether the firm reports restrictions in hiring workers or high competition, and whether it is managed by the owner. The Establishment History Panel in addition contains information about the age and nationality of employees. The regressions therefore also include the proportion of employees who are younger than 25 and older than 50. The percentages of foreign workers from EU countries and from outside the EU is also used here. Further, the German Federal Bank provides information about the firms' capital costs. Thus, the log. of commercial banks average effective interest rates of new loans to non-financial corporations is used as additional variable in the regressions.

As mentioned above, the monopsony position of firms is probably the source of the endogeneity, which prevents a falling labor demand curve from being observed, therefore, in addition an IV regression model is used. In the first stage of the 2SLS approach, the wage level for low-skilled workers was estimated as a linear regression. Among others, these estimated instruments are valid if the regressions from the first step fulfill the "exclusion restriction". This requires the use of additional variables

³ Medium-skilled employees are individuals with a lower secondary, intermediate secondary or upper secondary school completion certificate and a vocational qualification. High-skilled employees of an establishment are those who have a degree from a university (including universities of applied sciences "Fachhochschule").

that are highly dependent on the wage level and are not used in the second step of the model. A possible instrument is the regional unemployment rate at the district level, which indicates the conditions on the local labor market. Although the unemployment rate results from the interaction of labor supply and demand, and would therefore possibly continue to be endogenous in the regression model. However, the influence of a firm's labor demand on the unemployment rate should be rather small. According to the Federal Statistical Office, there are currently more than 41 million people in employment on the German labor market⁴. Related to the 401 districts⁵, this results in an average labor market of more than 100,000 employees. More than 97% of the companies employ less than 50 employees⁶. Assuming that each company determines its employment in a profit-maximizing way, the individual influence of an establishment on the local labor market should be negligible due to the small size of the entities. Only a few very large firms probably exert an influence, but these cannot significantly affect the results in the data set, since there are only very few relevant observations in the data. In addition, the data set is checked for outliers. The local unemployment rate is therefore used as an additional instrument in the subsequent wage regressions of the first stage in the IV model. The second stage consist of the model of labor demand in equation (7).

Furthermore, the regressions according to the Mundlak/Chamberlain approach contain the mean values of all time-variable exogenous variables multiplied by a dummy indicating the number of observations of each institution in the unbalanced panel (Wooldridge 2019). Finally, all nominal values are discounted with the producer price index. Furthermore, the labor demand model used here is static and therefore does not contain lagged variables. There is a yearly interval between two observations in the data. Therefore, it is not possible to observe the fluctuation of jobs that take place within the year. Points that justify the statistical approach. Firstly, it is known from other studies that most of the adjustment process takes place within a few months (Brenzel et al. 2016); meaning the annual data is

⁴ <https://www.destatis.de/EN/Themes/Labour/Labour-Market/Employment/Tables/labor-market-key-figures.html>

⁵ https://www.destatis.de/EN/Themes/Countries-Regions/Regional-Statistics/_node.html

⁶ https://www.destatis.de/DE/Themen/Querschnitt/Jahrbuch/jb-prod-gewerbe-dienstleistungen.pdf?__blob=publicationFile

over-aggregated and thus impossible to detect dynamic labor demand behavior. Due to the short time span associated with filling vacancies, it is rather unlikely that the data will allow for the monitoring of adjustment processes. Thus, in the vast majority of cases the observed employment level corresponds to the desired level and deviations from it are probably random. Second, the use of lagged dependent variables to model labor demand dynamics is caused by a specific quadratic function of adjustment costs. This is very restrictive and questionable, since empirical studies with other cost functions, e.g. lumpy or linear costs, show results with at least the same efficiency (cf. Hamermesh 1993). The annex contains the descriptive statistics for the main variables. In the next section, the results of the regression estimates and the calculations of the individual boundary effects and elasticities are presented.

4. Econometric Results

This section contains the results of the estimates of the empirical model from equation (7). Here, the share of the wage bill of low-skilled workers is used as the dependent variable. The independent variables were introduced in the previous section. The differences between before and after the introduction of the minimum wage, and after the first raise in this regression discontinuity approach are indicated with interaction variables of the periods with the wage variables as well as the value added. According to equation (7), the wage data and the value-added are used in logarithmic form. Two versions of the model are estimated: In the first version it is assumed that all covariates are exogenous, while in the second version, a possible endogeneity of the wage rate for low-skilled workers is considered by an IV estimation. In a 2SLS regression, the correlation coefficient ρ is an indicator of the influence of the estimated instrument at the first stage on the structural estimation of the model at the second stage. In the estimation, a significant value at 0.05 level is obtained for ρ ($\rho = 0.147$, s.e.: 0.067), so that an endogenous influence of the remuneration of low-skilled workers cannot be excluded. This indicates that the labor supply exerts an influence on the demand for low-skilled workers and thus can be interpreted as an indication of monopsonistic structures. The estimated parameters for both

models can be found in the appendix. The following table shows the average wage elasticities calculated using equations (5) and (6):

[Table 1]

Table 1 shows the labor demand elasticities calculated from the regression results. As mentioned above, there is a significant correlation between the two estimated equations in the IV model, so that it can be assumed here that the remuneration of low-skilled workers is endogenous. Therefore, there are also significant differences in the estimated parameters for this variable. In the IV regression, the values are much more negative and indicate a very elastic demand for low-skilled workers. If the statutory minimum wage reduces the influence of monopsonistic structures, the estimated parameters should approach the value of the IV estimate. Although the parameter becomes more negative in the first calculation after the introduction of the minimum wage, the change is only slight and after 2017, this development can no longer be observed. Therefore, hypothesis I is not confirmed and it can be assumed that the market for low-skilled work will continue to be characterized by monopsonistic structures.

The own-wage elasticity of demand in the IV model increases very slightly over time. The differences are so small that no significant change in the values can be determined. Therefore, the second hypothesis of this analysis is only partially supported. This is possibly due to the fact that the share of labor costs for the low-skilled has also increased only very slightly (see above). Since previous studies on this subject also conclude that companies hardly changed the number of employees at this skill level after the introduction of the minimum wage, a change in elasticities is unlikely. In addition, the increase in the minimum wage in 2017 was below the average development of wages in Germany, thus removing the incentive to substitute minimum wage recipients.

A clearer picture will emerge with greater substitution of low-skilled work with other production factors. Over the whole period, a substitutive relationship between low- and medium-skilled workers can be seen. In both the base model and the IV estimate, the cross-price elasticities for medium-skilled

workers and capital increased, but the parameter for capital in the IV regression is close to zero. However, it must also be taken into account that in a phase of global low interest rate policy, the price of capital may not be a meaningful indicator. As already mentioned, the increase of the minimum wage in 2017 was below the average of the overall wage development, so that a further substitution of low-skilled workers with other production factors cannot be justified by higher costs. Nevertheless, longer-term processes cannot be ruled out. The output elasticity for low-skilled work was significantly reduced in the preferred IV model, i.e. additional production factor no longer leads to the increase in low-skilled work as before. Similarly, from 2017 onwards, a significant substitutive relationship between highly and low-skilled workers was evident, at least, at the 10% level. Thus, it seems that Hypothesis III cannot be rejected.

5. Summary

This study is the first to examine the relationship between the introduction of a statutory minimum wage in Germany (2015), or its increase in 2017 and the labor demand elasticities for low-skilled workers. From previous results of literatures on the statutory minimum wage in Germany and other theoretical aspects of labor demand, three hypotheses emerged as the subject of this empirical study. Firstly, it was examined whether the introduction of the minimum wage reduced the monopsonistic labor market structures. Secondly, it was expected that own-wage elasticities would increase due to the higher share of the costs of production factors. Finally, it was assumed that the minimum wage made low-skilled work relatively expensive and thus was replaced with other relatively cheap production factors.

To test these hypotheses, a labor demand model for low-skilled labor was estimated using panel data from German firms and a fractional panel probit approach. The differences between the periods considered were represented by a sharp regression discontinuity approach. In addition, an IV regression was performed to investigate the endogeneity of remuneration for low-skilled workers. The findings show that the IV estimation should be preferred and that the own-wage elasticities are significantly

higher than the model without endogeneity. These differences can be interpreted as the influence of monopsonistic labor market structures. Since there is no convergence between the two estimates over time, the results do not indicate that monopsonistic structures changed. Hence, hypothesis I is rejected.

Hypothesis II was only partially confirmed. The own-wage-elasticities increased slightly over time. This could be interpreted as an indication of a larger share of labor costs and thus a greater importance of minimum wage recipients in total costs. Although, this portion is still very small, there is only a marginal but significant increase of this value. Clearer results can be seen in the cross-price elasticities. This existing substitutive relationship between employees with low and medium qualification levels is strengthened after the introduction of the statutory minimum wage, but decreased again after the first increase in 2017. However, this may also be due to the fact that the increase in 2017 was lower than the average wage development in Germany and therefore the incentive for higher substitution was no longer given. Nevertheless, Hypothesis III cannot be rejected by the empirical results. In addition, there may also be long-term changes in labor demand, as there is also a significant substitutive relationship between low- and high-skilled workers since 2017.

Although the present study provides further insights on the subject under consideration, there are some limitations to the validity of the analysis. First, the group of minimum wage recipients is not clearly identified. Although it is plausible that there are large overlaps between the group of minimum wage recipients and the unskilled, and thus the results of the analysis can be generalized. However, there are also low-skilled workers with significantly higher wages, so that a certain degree of blurriness remains. The second limitation results from the wage information. The data set contains the average daily salaries of full-time employees. Full-time employment is defined as normal working hours in the considered enterprise without any time specification. Since previous investigations showed that an adjustment of labor demand also occurred through working time, it cannot be clearly shown whether the usual working time for full-time minimum wage employees has changed. This also leads to an

uncertainty of the results. This aspect should be taken into account in future studies, that is, working time should also be included in the analysis and, above all, the long-term effects should be considered.

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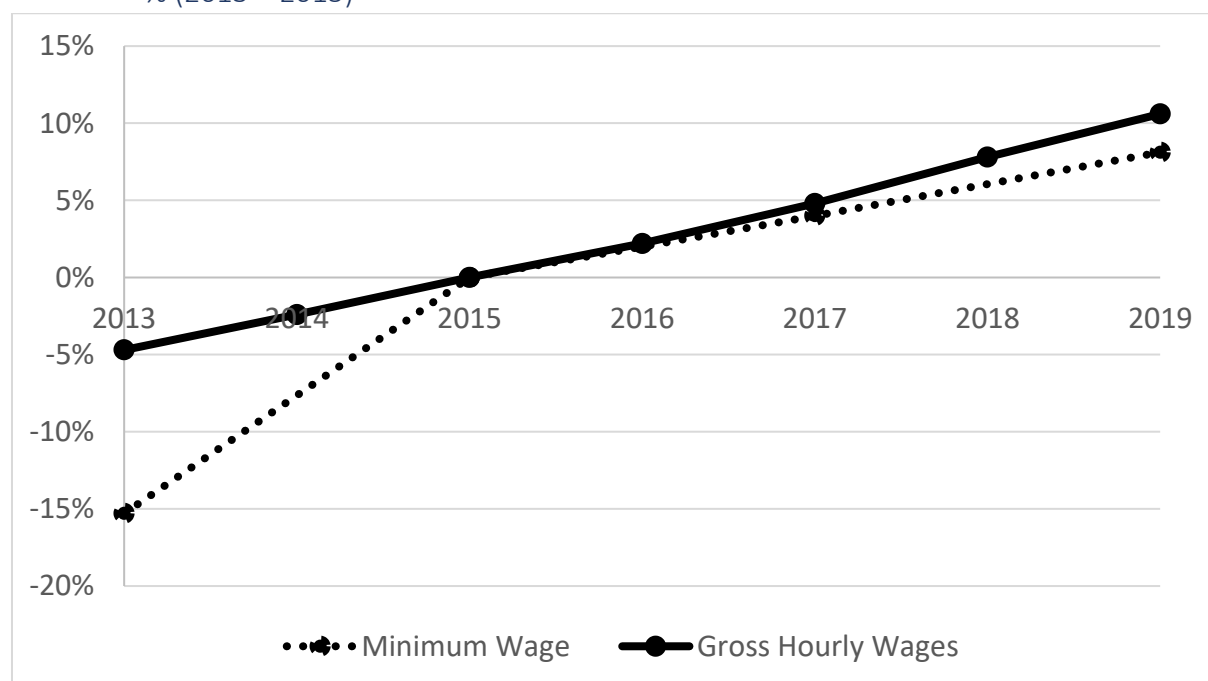
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Figures and Tables

Figure 1: Increase of the Statutory Minimum Wage and Gross Hourly Earnings in Germany in % (2013 – 2015)



Source: German Federal Statistical Office, Kann (2018)

Table 1: Average Labor Demand Elasticities

Years	2013 & 2014	2015 & 2016	2017 & 2018
Base model			
Low skilled workers	-0.806** (0.137)	-0.934** (0.096)	-0.712** (0.132)
medium skilled workers	0.703* (0.309)	1.008** (0.316)	0.579† (0.307)
High skilled workers	-0.016 (0.128)	-0.088 (0.117)	0.219† (0.132)
Capital	0.909 (1.549)	1.307* (0.620)	-0.016 (1.227)

Output	0.482** (0.073)	0.504** (0.070)	0.494** (0.074)
IV model			
Low skilled workers	-2.862* (1.277)	-2.929* (1.208)	-2.942* (1.431)
medium skilled workers	0.898** (0.340)	1.183** (0.364)	0.794† (0.409)
High skilled workers	0.043 (0.151)	-0.077 (0.140)	0.307† (0.177)
Capital	0.330 (1.097)	0.968 (0.790)	0.119 (1.532)
Output	0.434** (0.085)	0.424** (0.085)	0.317** (0.103)

Source: IAB Establishment Panel 2013 - 2018. Note: Standard errors in parentheses. †, * and ** denote significance at the .10, .05 and .01 levels, respectively.

Appendix

Table A.1: Descriptive statistics of variables in sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Share of low skilled labor costs to total revenue	28.859	0.020	0.049	0	1
Share of medium skilled labor costs to total revenue	28.859	0.217	0.168	0	1
Share of highly skilled labor costs to total revenue	28.859	0.050	0.105	0	1
Log. of daily wages for low skilled	86.688	4.067	0.525	-2.322	8.707
Log. of daily wages for medium skilled	93.766	4.208	0.421	-4.754	6.933
Log. of daily wages for highly skilled	92.018	4.558	0.494	-3.222	8.041
Log. of value added	49.116	13.069	2.100	4.439	23.044
Log. of credit interest rate	115.162	0.547	0.183	0.299	0.792
Share of part-time worker	89.001	0.289	0.282	0	1
Share of fixed-term workers	89.128	0.054	0.139	0	1
Share of workers subject to social insurance contributions	89.831	0.709	0.301	0	1
Share of female workers	89.773	0.441	0.317	0	1
Share of workers from non-EU countries	115.162	0.334	0.456	0	1
Share of workers from EU countries	115.162	0.335	0.456	0	1
Share of workers older than 50	115.162	0.577	0.358	0	1
Share of workers younger than 25	115.162	0.373	0.437	0	1
Firms reporting restrictions in hiring workers	89.251	0.241	0.427	0	1
Firms reporting high competition	89.597	0.320	0.466	0	1
Coverage by collective agreements	89.628	0.370	0.483	0	1
Firms in eastern Germany	94.203	0.597	0.491	0	1

Source: IAB Establishment Panel 2013 - 2018.

Table A.2: Coefficients of Labour Demand Regressions for Low-skilled Workers (Fractional Panel Probit, Dependent Variable: Share of Labor Costs to Total Revenue)

	(a) Base model	(b) IV-Model	
		Share of Labor Costs to Total Revenue	Log. of wages for low skilled per cap- ita
Average unemployment rate on county level ("Kreisebene")			-0.012* (0.005)
Log. of wages for low skilled per capita	0.039 (0.031)	-0.370 (0.251)	
Log. of wages for medium skilled per capita	0.110 (0.069)	0.135* (0.067)	0.043* (0.017)
Log. of wages for high skilled per capita	-0.013 (0.029)	0.000 (0.030)	0.030** (0.009)
Log. of effective interest rates†	0.040 (0.347)	-0.079 (0.216)	-0.455** (0.172)
Log. of value added	-0.116** (0.016)	-0.111** (0.017)	0.009 (0.007)
Interaction variables with dummy indicating 2015 and 2016:			
Log. of wages for low skilled per capita	-0.028 (0.035)	-0.027 (0.034)	
Log. of wages for medium skilled per capita	0.083 (0.057)	0.062 (0.057)	-0.029 (0.015)
Log. of wages for high skilled per capita	-0.020 (0.032)	-0.025 (0.032)	-0.015 (0.010)
Log. of effective interest rates†	0.101 (0.388)	0.128 (0.217)	0.286 (0.184)
Log. of value added	-0.004 (0.010)	-0.006 (0.010)	-0.004 (0.002)
Interaction variables with dummy indicating 2017 and 2018:			
Log. of wages for low skilled per capita	0.054 (0.035)	0.050 (0.035)	
Log. of wages for medium skilled per capita	-0.104 (0.063)	-0.095 (0.059)	0.011 (0.015)
Log. of wages for high skilled per capita	0.074* (0.035)	0.071* (0.035)	-0.004 (0.010)
Log. of effective interest rates†	-0.321 (0.343)	-0.156 (0.320)	0.528** (0.130)
Log. of value added	-0.003 (0.011)	-0.004 (0.011)	-0.001 (0.002)

[Table A.2 cont.]

Log pseudolikelihood	-1,761.49	-14,673.88
LR-Test χ^2 (df.)	5,149.31** (272)	3,613,464.49** (546)
ρ		0.147* (0.067)
Observations	21,528	21,528

Source: IAB Establishment Panel 2013 - 2018.

Note: Columns of (a) and (b) indicate the average partial effects of regressions. † Log. of effective interest rates are the banks average effective interest rates of new loans to non-financial corporations (Source: German Federal Bank / Deutsche Bundesbank). The model also includes the following dichotomous and auxiliary variables: shares of part-time, term limited, foreign, old (50 and older), young (25 and younger) and female workers, share of workers subjected to the social insurance scheme, dummies indicating whether the firm reports restrictions in hiring workers or high competition, is managed by an owner, is covered by a collective bargaining agreement or is located in Western Germany. Additionally, dummies about: establishment size (seven dummies), firm profitability (two), state of machinery (two), industry (fourty-two), year of observation (twenty-one) and a constant. The Chamberlain/ Mundlak approach requires to include the means of the time varying covariates and an indicator that identifies the number of observations of each unit respectively the interactions of both in the regression (Wooldridge 2019). Robust standard errors adjusted for clustering on establishments in parentheses. ** and * denote significance at the .01 and .05 levels, respectively.