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How elastic is labor demand? A meta-analysis for the German labor market

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Abstract

The own-wage elasticity of labor demand measures the effect of higher wages on firms' demand for labor and, thus, determines the impact of supply shocks, minimum wages, and collective wage agreements on the labor market. I carry out a comprehensive meta-analysis to shed light on the nature of this parameter, leveraging 705 elasticity estimates from 105 studies on the German labor market. The average elasticity is −0.43, but entails important heterogeneity: Labor demand turns out particularly elastic for low- and high-skilled workers, in the long run, and for internationally operating firms. While empirical designs that address endogeneity deliver more negative elasticities, the analysis does not support any systematic differences by region or by margin of adjustment.

Keywords Labor demand, Wage rate, Meta-analysis, German labor market

JEL Classification J23, J30, D22, C83

1 Introduction

The own-wage elasticity of labor demand is a key determinant of the labor market, reflecting the responsiveness of firms' employment decision to wage changes (i.e., the inverse slope of the labor demand curve). In general, the own-wage elasticity of labor demand determines the effectiveness of labor market policies that shape the incentives behind employers' employment and hours decisions (Hamermesh 1993). If a minimum wage is set above the equilibrium wage rate, firms in competitive labor markets will reduce their labor demand, and, hence, unemployment arises (Stigler 1946). The resulting increase in unemployment is a function of the own-wage elasticity of labor demand (Lee and Saez 2012). Moreover, depending on this parameter, an increase in the statutory overtime premium will make firms substitute incumbent workers' overtime hours by additional workers (Ehrenberg 1971; Trejo 1993). In collective bargaining, a higher own-wage elasticity of labor demand reduces the wage claims of unions (Dunlop 1944; Nickell and Andrews 1983). Other than that, an influx of migrants may have negative effects on native workers' wage rates. Specifically, the decline in wages increases with the slope of the labor demand curve (Borjas 2003).

Apart from labor economics, the own-wage elasticity of labor demand plays also a key role in many other subfields. Regarding public finance, wage elasticities of labor demand govern the incidence of payroll taxes (Harberger 1971; Brittain 1971). Specifically, increased responsiveness of firms to wage changes raises workers' share in the deadweight loss from taxation. Hence, elasticities of labor demand constitute an important input for optimal taxation models (Jacquet et al. 2014). In international economics, globalization is supposed to flatten the demand curve (Rodrik 1997; Slaughter 2001). Consequently, wage elasticities serve as a key parameter in models of trade (Rauch and Trindade 2003). Finally, estimates of the own-wage elasticity of labor demand serve as inputs for the calibration of computable general equilibrium models (Boeters and Savard 2013) and microsimulation models of labor markets (Peichl and Siegloch 2012).

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Due to the wide range of applications, a vast number of studies has estimated own-wage elasticities of labor demand of various types. The elasticity depends on firms' production technology as well the structure of underlying product and labor markets. Hence, variation in this elasticity reflects systematic differences across employers, workers, and time. In this paper, I perform an extensive meta-regression analysis to systematically explore the nature and heterogeneity of the own-wage elasticity of labor demand. To this end, I collect a total of 705 elasticity estimates from 105 different studies that refer to the German labor market. Specifically, I examine whether the reported elasticities support the implications from labor demand theory—relating to firms' output decision and the time horizon. Another aim of this meta-analysis is to show whether the own-wage elasticity of labor demand is sensitive to the choice of the empirical specification, such as imposing theoretical structure on or using instrumental variables in the estimation. Finally, the meta-regressions will inspect potential heterogeneity of the own-wage elasticity of labor demand regarding different types of firms (e.g., by region or export status) and workers (e.g., by education or contract type).

Several studies already provide meta-analytic evidence on labor demand for single non-European countries (Doucouliagos 1997; Mora and Muro 2019) and the international literature (Lichter et al. 2015). Despite this evidence, the German labor market deserves a meta-analysis on its own. On the one hand, the German economy—the world's fourth largest by GDP with a total of 45 million workers—features several idiosyncrasies that may govern firms' responsiveness to wage changes in a special way: namely strong labor market rigidities (Schneider and Rinne 2019), an economic divide between West and East German labor markets (Schnabel 2016), the importance of the dual vocational system (Rhein et al. 2013), an extraordinarily high export share (Lichter et al. 2017), and long-term demographic decline (Hamm et al. 2008). Given the specific nature of the German labor market, it is therefore likely that domestic peculiarities do not surface in the existing meta-analyses. In the course of this meta-study, I will therefore discuss all the above-mentioned German idiosyncrasies through the lens of the results, addressing East–West differences, various types of educational attainment, and international activities of firms explicitly as covariates in the meta-regression analysis. In doing so, this study expands early literature reviews on German labor demand that summarize merely a handful of studies (Riphahn et al. 1999; Sinn et al. 2006).

On the other hand, in the recent past, the German labor market has been hallmarked by two events whose implications are largely determined by the wage elasticity of labor demand, thus prompting the need for a thorough examination of this parameter in the national context. To begin with, the first-time introduction of a nation-wide minimum wage in 2015 triggered heated debates among researchers and policy-makers about the magnitude of potential lay-offs. Based on labor demand elasticities from single studies or values deemed plausible, ex-ante simulations predicted negative employment effects ranging from 425,000 up to 1.4 million workers (Müller and Steiner 2013; Arni et al. 2014; Henzel and Engelhardt 2014; Knabe et al. 2014) which, however, did not materialize in the end (Bossler and Gerner 2020; Dustmann et al. 2022). In addition, migration into Germany accelerated over the past decade, resulting in a net migration inflow of around 4.6 million people between 2011 and 2020 (Bundesamt für Migration und Flüchtlinge 2022). The high levels of immigration raise some concerns about a decline in wages for native workers which, according to partial equilibrium theory, may occur through an expansion of labor supply along a finitely-elastic labor demand curve. While experimental research on earlier migration waves shows mixed results (Glitz 2012; Dustmann et al. 2017), the own-wage elasticity of labor demand can lead to a ballpark estimate for the wage decline in the absence of general equilibrium effects. Taken together, by synthesizing the entire literature rather than relying on singular studies, a separate meta-analysis for the German labor market can shed further light on these two important issues and may guide researchers in building models to assess minimum wage policies (e.g., Müller 2009) or migration flows (e.g., Felbermayr et al. 2010).

This meta-analysis offers 12 main results for the German labor market. First, the average own-wage elasticity of labor demand is −0.43, which lies in the middle of the interval between −0.75 and −0.15 bracketed by Hamermesh (1993). This value is around 20% less elastic than the global average in the meta-study by Lichter et al. (2015), which may reflect Germany's relatively high level of employment protection legislation. Second, reduced-form models frequently fail to deliver negative scale effects which is at odds with theory of labor demand. Third, empirical designs that explicitly address endogeneity of the wage rate feature significantly more negative estimates than naive OLS regressions, seemingly mitigating the confounding impact from uncontrolled-for labor demand shocks and unobserved firm heterogeneity. Fourth, all other things being equal, labor demand responds more elastically in the long than in the short run. Fifth, there is evidence that the own-wage elasticity of labor demand turns out more negative at the firm than at the aggregate level since the latter does not account for employment shifts within the aggregate (e.g., when firms lay off workers who take up a job in another firm in the same industry). Sixth, the analysis suggests that labor demand is not systematically more wage-elastic when relating to total hours worked rather than the number of workers. Seventh, systematic differences in the responsiveness of labor demand are not apparent between West and East German firms. Eighth, labor demand is more elastic in exporting or multinational firms than in firms that do not operate internationally. Ninth, there is an inverse U-shaped pattern between the own-wage elasticity of labor demand and workers' skill levels: the demand for medium-skilled workers (i.e., workers who completed the dual vocational system) is less elastic than for low- and high-skilled workers. Tenth, conditional on output, demand for workers in atypical employment is more wage-elastic than for workers in typical (i.e., full-time regular) employment. Eleventh, labor demand has become less elastic over time which may reflect labour hoarding in the wake of long-term demographic decline in Germany. Twelfth, the German labor demand literature is apparently characterized by publication bias, favoring significant elasticities that comply with microeconomic theory.

In the most far-reaching meta-study on labor demand, Lichter et al. (2015) perform meta-regressions of the own-wage elasticity of labor demand, building on 1334 elasticity estimates from 151 international studies (see Sect. 3). My meta-study differs in five important aspects from their work. First, while such an international meta-analysis on 40 countries is able to trace out systematic relationships across countries, national peculiarities remain hidden in unobserved country heterogeneity. To leverage intranational variation, this study focuses solely on evidence from the German labor market. Second, this meta-study constitutes the most comprehensive compilation of own-wage elasticities of labor demand for the German labor market. With 705 observations, this meta-study comprises more than twice as many observations as the subsample of 302 estimates for the German labor market in the international meta-study by Lichter et al. (2015).[1] Third, if wage changes make firms not only adjust the number of employees (i.e., the extensive margin) but also the number of working hours per employee (i.e., the intensive margin), the own-wage elasticity of labor demand becomes more negative. In this regard, this meta-analysis examines whether the own-wage elasticity of labor demand systematically varies by the underlying margin of adjustment. Fourth, trade theory implies that, due to increasing globalization, better substitution possibilities and greater price sensitivity of consumers render labor demand more wage-elastic. This meta-study is the first to examine whether the responsiveness of labor demand differs between internationally operating (i.e., exporting or multinational) firms and firms who are involved only in the national market. Fifth, in addition to marginal effects in the meta-regression analysis, this study also reports separate averages of the own-wage elasticity of labor demand by different dimensions of heterogeneity. Importantly, these values may guide researchers in calibrating their models of the labor market.

The remainder of the paper is structured as follows. Section 2 briefly sketches the conceptual background in terms of labor demand theory and the estimation of the own-wage elasticity of labor demand. Section 3 summarizes key results about the elasticity of interest from available reviews or meta-analyses. Section 4 describes the properties of the meta-sample for the German labor market. Section 5 delivers the results from the meta-regression analysis. Section 6 inspects whether the German literature is characterized by publication bias. Finally, Section 7 concludes.

2 Conceptual background

The following section offers a non-technical description of labor demand theory and the econometrics behind the own-wage elasticity of labor demand. This conceptual background provides important guidance for the selection of variables included in the meta-sample in Sect. 4. Moreover, it will help the reader to better interpret the results in the meta-regression analysis in Sect. 5.

Definition In his seminal work, Hamermesh (1993, p. 3) defines labor demand in its broadest sense as "any decision made by an employer regarding the company's workers—their employment, their compensation, and their training". The modern core of the subfield of labor demand involves the production of a firm, its implications on the number of workers and hours demanded, and the responses of these outcomes to external shocks. The own-wage elasticity of labor demand η is defined as the percentage change in labor demand L when the wage rate w is increased by 1%:

$$\eta = \frac{\partial \, ln\, L}{\partial \, ln\, w} = \frac{\partial L}{\partial w} \cdot \frac{w}{L} \quad (1)$$

Theoretical models and the existing body of empirical work suggest that the own-wage elasticity of labor demand has a negative sign. Hence, the labor demand curve is falling in the wage rate. Labor demand is usually referred to as "(in-)elastic" when the own-wage elasticity of labor demand lies below (above) −1. If labor demand

[1] On the one hand, the search for adequate studies was directed towards the German labor market and, thus, has brought forth many earlier studies that did not enter the international study. On the other hand, the later publication date of this article allows another decade of studies to be included in the meta-analysis.

is (in-)elastic, the percentage reduction in labor demand exceeds (falls short of) the underlying percentage increase in wages. Therefore, higher wage rates reduce (increase) the wage bill.

In the standard supply–demand framework, the negatively sloped labor demand curve interacts with the positively sloped labor supply curve to determine the equilibrium wage and employment. When the labor supply curve shifts, the new equilibrium will materialize along the labor demand curve. The relative change in equilibrium outcomes hinges on the magnitude of the own-wage elasticity of labor demand. If labor demand is rather (in-)elastic, the labor demand curve runs pretty flat (steeply). Consequently, a negative labor supply shock will result in a relatively small (large) increase in the wage rate whereas the reduction in employment will turn out to be relatively large (small).

Optimal labor demand Hicks (1932) emphasizes that labor demand does not have a value in itself for the firm but rather constitutes a derived demand that stems from firms' willingness to achieve profits by satisfying consumers' product demand. Optimal behavior implies that profit-maximizing firms choose labor demand such that the value of the marginal product equals the wage rate. When the wage rate increases, firms will reduce labor demand for two reasons: negative substitution effects and negative scale effects (Sakai 1974; Nagatani 1978). The negative substitution effect arises from the dual problem of minimizing cost, conditional on a certain volume of output. If labor becomes relatively more expensive, firms will substitute labor by more of other input factors (e.g., capital) to hold production constant. In contrast, the negative scale effect originates from the optimal choice of the volume of output. A higher wage rate raises marginal cost of production which is why firms will lower output and, hence, demand less of all input factors—including labor. Whereas conditional (or constant-output) own-wage elasticities of labor demand merely comprise substitution effects, unconditional (or total) own-wage elasticities of labor demand additionally include scale effects, thus measuring the overall effect of higher wages on labor demand. Taken together, labor demand theory requires the unconditional own-wage elasticities of labor demand to be more negative than its conditional counterpart.

Empirical model Structural-form models closely follow the theory of labor demand. These models estimate the parameters of cost or profit functions to determine wage elasticities of labor demand. Under duality, cost and profit functions reflect the optimization behavior of firms (Mundlak 2001). To estimate the underlying parameters, the researcher must specify the functional form of the cost or profit function, respectively (Hamermesh 1986; Berndt 1991). Ideally, studies employ flexible functions that do not a priori restrict substitution possibilities, such as Translog or Generalized Leontief functions (Christensen et al. 1973; Diewert 1971).[2] From either functional form, researchers derive a system of input equations that is commonly estimated via Zellner's (1962) Seemingly Unrelated Regression or, when relying on instrumental variables, via Three-Stage Least Square Regression (Zellner and Theil 1962).

Reduced-form models follow theory more loosely. Absent any specific functional form, applying logarithms to Shephard's Lemma yields estimable log-linear specifications of factor demand (Hamermesh 1993). Reduced-form models regress labor demand on wage rates and prices of cooperating input factors (all in logs). The resulting own-wage elasticity of labor demand can be directly inferred from the estimated coefficient for the respective log wage rate. For lack of theoretical structure, reduced-form models offer researchers considerable leeway in including additional control variables in their equations (Lichter et al. 2015).

Output decision Whether structural-form models reflect the output decision of firms depends on the researcher's choice between a cost or profit function. On the one hand, cost functions address the problem of cost minimization given a certain volume of output. Hence, estimation of cost functions delivers conditional wage elasticities of labor demand. On the other hand, profit functions relate to profit maximization of firms and, hence, yield unconditional wage elasticities of labor demand.

In reduced-form models, firms' output decision is modeled through the set of covariates. When conditioning on the level of production, the production margin is suppressed and the coefficient of the log wage rate reflects the conditional own-wage elasticity of labor demand (Hamermesh 1993). In contrast, reduced-form models that disregard production (and product prices) allow scale effects to materialize and, thus, provide unconditional wage elasticities of labor demand.[3]

Identification problem The endogeneity of the wage rate poses a threat to the estimation of own-wage elasticities of labor demand. An important source of endogeneity is reverse causality that originates from the interplay between labor demand and labor supply. Shifts of the

[2] Flexible functional forms constitute second-order Taylor approximations to an arbitrary twice-differentiable cost or profit function. On the contrary, the CES function imposes that the elasticity of substitution between any two input factors is constant across all input pairs (Arrow et al. 1961). The Cobb-Douglas (1928) function constitutes a limiting case of the CES function, imposing that the elasticity of substitution is 1.

[3] Usually, the product price is also omitted as output reductions will raise product prices in imperfectly competitive product markets (Hijzen and Swaim 2010).

labor demand curve (of whatever reason) move the wage rate and employment along the labor supply curve. Given the positive relationship between wages and labor supply, these shifts will result in an upward bias. By contrast, no simultaneity bias arises when labor supply is perfectly elastic (horizontal curve), that is, the wage rate is exogenously given. In such a case, variation in the wage rate perfectly traces out the slope of the labor demand curve.

The identifying assumption stipulates that uncontrolled-for shifts in labor demand must have a negligible effect on wage rates. While this assumption seems implausible when entire industries or regions adjust their labor demand, it is more likely to hold for individual firms (Hamermesh 1986). In particular, a single firm faces an exogenously given wage rate when labor markets are perfectly competitive.

In structural-form models, the underlying theory is supposed to depict the correct relationship between wages and the demand for labor. Hence, through the lens of structural modeling, the problem of identification is assumed away (Lichter et al. 2015). However, this assumption might still be violated when the model is run on data.

In reduced-form models, addressing the problem of identification is usually of prime interest. The ideal instrumental variable is a pure shifter of the labor supply curve in the sense that it delivers variation in the wage rate without affecting labor demand other than through the impact on the wage rate itself (Wright 1928; Angrist and Krueger 2001). Unfortunately, credible instruments are scarce. Frequently, researchers rely on past information on wage rates to instrument current wages (Arellano and Bond 1991). However, the identification fails when error terms are serially correlated. A promising alternative is the analysis of quasi-experiments, namely events that exogenously shift the wage rate (Addison et al. 2014). Most importantly, a large strand of the literature examines variation in minimum wage legislation (Brown et al. 1982; Card and Krueger 1995).[4] Besides, other studies have instrumented wage rates by changes in social security taxes, firing costs, or massive immigrant shocks.

Omitted variable bias from unobserved heterogeneity constitutes another source of endogeneity. For instance, it is a stylized fact that large firms pay higher wages (Oi and Idson 1999). With longitudinal data on firms, the inclusion of firm fixed effects will capture time-invariant unobserved differences between employers (Addison et al. 2014). In such a case, the respective elasticity estimates stem from pure variation within firms.

Time horizon When adjustment cost increase more than linearly with the size of adjustment, rational firms will dynamically optimize labor demand to reach their steady-state level only in the long run (Gould 1968; Hamermesh and Pfann 1996). Thus, an exogenous reduction in the wage rate will cause the firm to stagger the desired employment expansion over several periods (Holt et al. 1960). A simple typology will help to classify own-wage elasticities of labor demand with regard to the underlying time horizon: Adjustment cost rationalize sluggish responses in labor demand, implying that labor is out of equilibrium in the short run. In the medium run, labor demand can fully adjust to its equilibrium but the capital stock remains still fixed. In the long run, the fixity of the capital stock no longer holds.

To estimate long-run elasticities, structural-form models usually treat all input factors, including capital, as flexible (i.e., by modelling total costs or profits within a fully static model).[5] By contrast, when the capital stock is modelled as quasi-fixed (Morrison 1988; Bergman 1997), structural-form models trace out medium-run elasticities (i.e., by considering only variable costs or profits in a partially static model).[6] Few studies estimate dynamic versions of cost or profit functions using error correction models (Anderson and Blundell 1982), which allow input demands to deviate from steady-state equilibria in the short run.

Absent theoretical complexity, reduced-form models can more easily incorporate dynamics by including lagged versions of the dependent variable (Tinsley 1971). The coefficient of the lagged dependent variable reflects firms' inertia in adjusting towards their static equilibrium.[7] In such a dynamic framework, the wage coefficient represents the short-run elasticity of labor demand which, along with the coefficient of the lagged dependent variables, determines the medium- or long-run elasticities. The determination of either medium- or long-run

[4] The majority of quasi-experimental studies do not estimate labor demand equations as described, but rather make use of difference-in-difference or event-study designs. Nevertheless, these studies constitute reduced-form models in the sense that they do not impose any theoretical structure on the empirical model.

[5] Alternatively, many long-run models ignore the capital stock and, thus, assume that capital is perfectly separable from the modeled inputs.

[6] In addition to medium-run effects, partially static models also allow for the estimation of long-run elasticities. For this purpose, studies additionally determine the long-run optimal capital stock by comparing the shadow price with the user cost of capital (Brown and Christensen 1981) If adjusting the stock of capital is costly, the partially static model outperforms the fully static model, which abstracts from adjustment cost.

[7] Dynamic panel bias leads to a spurious estimate for the coefficient of the lagged dependent variable (Nickell 1981). To circumvent this bias, econometricians have proposed to instrument differences of the lagged dependent variable by higher-order lags in levels (Anderson and Hsiao 1982; Arellano and Bond 1991).

responses hinges on whether the specification conditions on the capital stock or not.[8]

Unit of observation Wage elasticities of labor demand differ also with regard to the unit of observation. As personnel decisions take place at the level of the firm, micro-level data are best suited to infer the demand responses of employers. By contrast, elasticity estimates based on aggregate data, such as data on industries or regions, will underestimate the true response of firms to wage variation to the extent that workers switch employers within the aggregate (Hamermesh 1993). Nevertheless, the impact of higher wage rates on aggregate labor demand is relevant as well, in particular because shifts in aggregate labor demand do not only capture responses of operating employers but also entries and exits of firms.

Margin of adjustment Labor demand usually refers to headcount demand for workers. Some studies emphasize that working hours normally vary across individuals and, instead, analyze the overall number of demanded hours. If, in addition to workers, firms also reduce the number of hours worked per worker, the own-wage elasticity of labor demand becomes more negative.

Firm characteristics The responsiveness of firms' employment decision may also be driven by sectoral and regional differences. Industries differ in their production technologies and, thus, could feature different marginal productivity curves and a varying ease of substituting labor. Moreover, drivers of the own-wage elasticity of labor demand, such as the supply of cooperating (labor) inputs or consumers' price sensitivity, may have a local dimension.

With increasing globalization, a growing number of firms also operates internationally. International trade is supposed to render labor demand more elastic (Slaughter 2001). When facing an increase in domestic wages, multinational firms can move production abroad, implying more scope for substituting domestic labor (Hijzen and Swaim 2010; Senses 2010). Higher globalization will also force domestic firms to face greater foreign competition. As a result, product demand becomes more price-elastic and, thus, the scale effect turns out to be more negative. In addition, exporting firms from high-income countries (such as Germany) are shown to exhibit an overall higher price responsiveness of product demand compared to firms that sell only in the domestic market (Simonovska 2015; Lichter et al. 2017). Therefore, exporters should feature a more wage-elastic demand for labor.

Worker characteristics As labor usually varies along many dimensions, it is of particular interest for labor economists to study the demand for heterogeneous types of workers. Plausible dimensions of heterogeneity include productive and contractual characteristics such as skill level, job tasks, or employment type. Specifically, the capital-skill complementarity hypothesis (Rosen 1968; Griliches 1969) postulates that substitution effects turn out to be less negative, the larger is the magnitude of human capital embodied in the respective labor input (Hamermesh 1986). In general, linked employer-employee data allow the researcher to classify workers along many dimensions (Hamermesh 1999). Some studies on labor demand also differentiate between male and female workers.

Measurement and dataset The quality and structure of data dictate several dimensions when estimating the own-wage elasticity of labor demand. The wage rate is best operationalized as average earnings per working hour.[9] In terms of measurement, Hamermesh (1983) highlights that narrow measures of labor cost ignoring fringe benefits, paid vacations, or provisions might yield misleading results. In general, measurement errors can be minimized when relying on administrative sources rather than information from surveys (Lichter et al. 2015). Unlike cross-sectional or time-series data, panel data allow researchers to account for unobserved heterogeneity via fixed effects.

3 Literature review

This section provides an overview of available literature reviews and meta-analyses on the own-wage elasticity of labor demand.

International evidence In an early review on the U.S. literature, Hamermesh (1976) summarizes own-wage elasticities of labor demand from reduced-form models that incorporate dynamic adjustment. He concludes that the likeliest value for the conditional own-wage elasticity of labor demand is −0.15 in the short run. A decade later, Hamermesh (1986) reviews international evidence on the own-wage elasticity of labor demand from both structural- and reduced-form models. The review suggests that the aggregate conditional own-wage elasticity of labor demand falls roughly in the range between −0.50 and −0.15 in the long run. The author notes that studies which are based on small entities and are therefore less likely to suffer from simultaneity bias provide a similar range of elasticities. In terms of heterogeneous labor, the overall evidence suggests that conditional labor demand is more elastic for blue-collar than for

[8] From an econometric point of view, medium-run models involve two advantageous properties (Hijzen and Swaim 2010). On the one hand, controlling for the capital stock avoids measurement problem related to the user cost of capital. On the other hand, these models alleviate confounding shifts in the labor demand curve that arise from adjusting the stock of capital.

[9] If information on hours is missing, studies frequently rely on average earnings per (working) day and restrict the analysis to the demand for full-time workers who are supposed to work a similar number of hours.

white-collar workers, seemingly mirroring the capital-skill complementarity.

In his widely known textbook, Hamermesh (1993) gives an extensive review on the international literature. For models based on highly aggregated data, the author calculates an average of −0.39 for the own-wage elasticity of labor demand. For less aggregated data, the mean of the estimates is −0.45. In general, few studies provide estimates below −1 whereas, at the other extreme, estimates that exceed 0 are rare. The majority of estimates is bracketed by the interval [−0.75;−0.15]. Given this interval, the author argues that a value of −0.3 constitutes a plausible "best guess" for the conditional own-wage elasticity of labor demand. This value is sometimes referred to as the "3 for 10 rule" (Hamermesh 2014), implying that a 10% increase in the wage rate results in a reduction in labor demand by 3%. Moreover, studies on heterogeneous labor typically find that labor demand for blue-collar workers is more elastic than for white-collar workers. As implied by theory, long-run elasticities turn out to be more negative than respective short-run effects. Overall, dynamic models suggest that labor demand adjusts rapidly to shocks. Specifically, half of the adjustment occurs within a quarter and the bulk of adjustment is made within a year.

Espey and Thilmany (2000) collect 84 wage elasticities from 29 studies on labor demand of agricultural firms. The average elasticity is −0.74 and over 85% of the estimates fall within the −1.5 to 0 range. In a meta-regression, the authors find that farms' labor demand is more elastic in the long-run than in the short-run. When controlling for scale effects, the wage elasticity of labor demand becomes less negative.

Lichter et al. (2015) provide the most comprehensive review on the literature to date. Specifically, the authors carry out a meta-analysis that is based on 151 observational studies with 1334 elasticity estimates from 40 countries. The average own-wage elasticity of labor demand is −0.55 (median: −0.42), and 83% of the estimates lie between −1 and 0. In line with theory, the meta-regression finds that, all other things being equal, unconditional estimates turn out to be more negative than estimates for the conditional own-wage elasticity of labor demand when being derived from a structural-form model. In contrast, estimates from reduced-form models do not statistically differ with regard to the output decision, thus failing to comply with theory.[10] Labor demand turns out to be significantly more elastic in the short run than in the medium or long run. In countries with lower employment legislation protection, labor demand tends to be more wage-elastic. When relying on administrative sources, firm-level estimates turn out significantly more negative than industry-level estimates. The meta-regression suggests that demand for unskilled and atypical workers is more elastic than for the average worker. Furthermore, a negative time trend implies that labor demand has become more elastic over the last decades, which is attributed to technological progress and increased globalization. Finally, the authors find evidence for downward publication bias: the elasticities appear to be selectively reported in favor of negative estimates that comply with theory.

Evidence on single countries Doucouliagos (1997) delivers meta-analytic evidence on the own-wage elasticity of aggregate labor demand for the Australian labor market. Building on 15 studies, the author reports an average elasticity of −0.48. The author notes that none of the studies in his meta-sample establishes causality and thus, the meta-analysis cannot do either. Nevertheless, the analysis reveals that, ceteris paribus, model-based estimates arrive at more negative correlations between real wages and aggregate labour demand than model-free estimates. Further, in regressions with lagged dependent variables (i.e., in short-run analyses), labor demand turns out particularly inelastic.

For the Columbian labor market, Mora and Muro (2019) collect 28 estimated long-run own-wage elasticities of labor demand from a total of 17 studies. The mean elasticity is −0.37, with the 95% confidence interval ranging from −0.43 to −0.31. In addition, the authors report evidence in favor of downward publication bias.

Evidence on the German labor market Riphahn et al. (1999) provide an early literature review on estimated own-wage elasticities of labor demand for the German labor market. Given eight studies, the authors conclude that estimates range between −1.2 and −0.1. For low-wage workers, the elasticity lies between −0.9 and −0.3. In another study, Sinn et al. (2006) summarize estimates from five studies on the German labor market and use a plausibly held value of −1 for further analysis.[11]

4 Meta-sample

Collection of estimates To provide a more recent and comprehensive summary of the literature, I carry out a meta-analysis for estimated own-wage elasticities of

[10] The most obvious explanation for this difference relates to the empirical set-up. While structural-form models explicitly model the firm's output decision by relying on differing functional specifications, reduced-form models lack theoretical structure and address the output decision by merely including an additional control variable.

[11] On a related topic, Möller (2012), Fitzenberger and Doerr (2016), and Caliendo et al. (2019) provide narrative reviews about employment effects of sectoral and national minimum wage policies in the German labor market.

Table 1 Construction of meta-sample

Step	Source	Additional studies	Additional estimates
1	Hamermesh (1993)	10	48
2	Riphahn et al. (1999)	4	51
3	Sinn et al. (2006)	2	6
4	Lichter et al. (2015)	44	308
5	Google Scholar	25	209
6	Bibliography of Studies Identified in Steps 1–5	20	83
1–6	Total	105	705

The table displays the sources used to construct the meta-sample of own-wage elasticities of labor demand for the German labor market. Source: Own illustration

labor demand from the German labor market. As shown by Table 1, the construction of the meta-sample involved six steps. In a first step, I screened the standard textbook from Hamermesh (1993, Chapters 3 and 7) for relevant studies. In the second, third, and fourth step, I drew on the literature surveys for the German labor market by Riphahn et al. (1999) and Sinn et al. (2006) as well as the international meta-study by Lichter et al. (2015). The fifth step involved a Google Scholar search on 8 September, 2021 and on 11 October, 2022. In both cases, the search query combined two terms: "labor demand" and "Germany". In a last step, I examined the bibliographies from papers found in the previous steps to identify additional studies.

To be included in the meta-analysis, the study must report estimated or calculated own-wage elasticities of labor demand whose underlying variation is (at least partly) based on German data. I refrain from gathering elasticities of substitution which are nested in but conceptually different from the own-wage elasticity of labor demand. For lack of conceptual comparability, and in line with Lichter et al. (2015), I do not collect estimates that originate from differences-in-differences or event-study designs (e.g., the majority of minimum wage studies).[12] Since the majority of studies provide more than a single estimate, I collect only elasticities that differ in an important source of heterogeneity (i.e., in terms of the empirical model, output decision, identification strategy, time horizon, margin of adjustment, modeling of the capital stock, firm and worker characteristics, structure of the dataset, or the underlying sample). If estimates vary along slight differences in the specification, I select the authors' baseline estimate. When there is no preferred estimate, I include the elasticity from the most comprehensive specification. If available, I also collect the respective standard errors or calculate them from reported t statistics. In the end, I arrive at a meta-sample comprising 105 studies with 705 elasticity estimates. In Additional file 1, I provide systematic overviews on the main attributes of these studies (Table A1) and the dimensions and sources of the estimates (Table A2).

Descriptive statistics Figure 1 visualizes the distribution of the 705 collected estimates. The estimates of the own-wage elasticity of labor demand average −0.430, and the median elasticity is −0.310. The underlying standard deviation is 0.556. Overall, 49.5% of the estimates lie within Hamermesh's (1993) interval between −0.75 and −0.15. The vast majority of estimates (84.8%) corroborate that labor demand is inelastic (i.e., the elasticity lies between −1 and 0). 7.5% of estimates feature a positive sign, thus failing to comply with theory. By and large, the mean and median of elasticities turn out around 20% less elastic than in the international meta-analysis by Lichter et al. (2015). A natural explanation is employment protection legislation which, in Germany, is relatively high by international standards (Schneider and Rinne 2019), resulting in less labor market flows (Lazear 1990).

Table 2 presents descriptive statistics for the meta-sample, separately for the attributes identified as main drivers of heterogeneity in Sect. 2. Structural-form models account for 57.3% of estimates in the meta-sample, whereas the remaining 42.7% pertain to reduced-form models. Remarkably, only 7.8% of estimates refer to unconditional labor demand, that is, they not only comprise substitution but also scale effects. In terms of the identification problem, 24.7% of estimates instrument the wage variable to address bias from uncontrolled-for labor demand shocks, while 59.7% include unit fixed effects to account for unobserved heterogeneity. Regarding the time horizon, the elasticities spread relatively evenly over short-, medium- and long-run effects. The short-run elasticity averages −0.17 and, in line with substantial cost of adjusting the labor input, is less negative than the average medium- or long-run elasticity (−0.50). The units of observation are distributed as follows: 35.6% characterize labor demand of single firms, 62.0% reflect industries or regions, and the remaining 2.4% of estimates relate to the economy as a whole. On average, the own-wage elasticity of labor demand for the economy (−0.29) is considerably higher (i.e., less negative) than the elasticity for industries or regions (−0.43) or single firms (−0.44). The majority of estimates (81.7%) measures labor demand in terms of headcount employment whereas another 16.2% examine the total number of hours worked.

[12] In this respect, Popp (2021, Figure 6) provides an overview of own-wage elasticities of labor demand that stem from minimum wage variation in the German labor market.

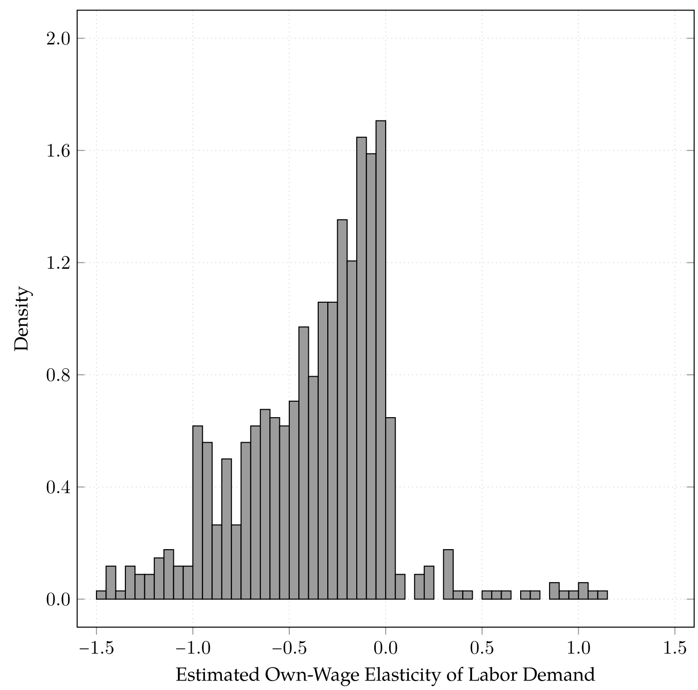

Fig. 1 Distribution of own-wage elasticity of labor demand. The histogram illustrates the distribution of estimated own-wage elasticities of labor demand for Germany. For better illustration, the graph is truncated at ±1.5. Source: Own illustration

Concerning the industry, most of the estimates refer either to the overall economy (43.3%) or the manufacturing sector (45.8%), while the non-manufacturing sector is reflected by only 10.9% of the estimates.[13] 44.7% of estimates refers to German territory as a whole whereas 48.8% describe labor demand in West German firms. As studies are available only after reunification in 1990, elasticities for East Germany make up only 6.5% of the estimates. 11.3% of the estimates reflect the employment decision of "internationally operating" (i.e., either exporting or multinational) firms, whereas 1.7% of the estimates relate to non-exporting or national firms. From a pure descriptive point of view, the average elasticity of internationally operating firms is more negative (−0.56) than the average across all firms (−0.41) and those firms that are not internationally operating (−0.50).

In terms of worker characteristics, 60.1% of the estimates do not represent a certain educational type of worker (i.e., labor is treated as homogeneous input factor). The remainder of estimates show an inverse U-shaped relationship: in terms of averages, the own-wage elasticity of labor demand turns out more negative for low- (−0.72) and high-skilled workers (−0.44) than for medium-skilled workers (−0.33). Apart from skill level, few studies differentiate labor by other worker characteristics, such as job type (7.1%), contract type (15.2%), and gender (10.5%). For lack of information on individual hours worked, studies based on the German social security data (Müller and Wolter 2020) usually restrict their analysis to workers in typical employment (i.e., in regular full-time employment).

Regarding the data structure, 73.8% of estimates stem from panel data. Time series and cross-sectional data make up 21.4% and 4.8% of the estimates. 53.3% of the estimates stem from peer-reviewed journal articles whereas 33.2% stem from non-refereed articles. 13.5% of the estimates originate from books or edited collections of articles.

To ease the later interpretation of the meta-regression results, Table A3 in Additional file 1 displays shares of the different study attributes in the estimates, differentiating between certain (sub-)samples. The full sample covers the entire set of the 705 collected elasticities. The baseline sample is limited to 440 estimates with reported or calculable standard errors. Regarding the proportions of the attributes, there are no systematic differences between both samples. In the full sample, the estimates' average of the centralized year in the underlying data is 1993 and the mean year of publication is 2004.[14] As the

[13] In this meta-study, I operationalize the "manufacturing sector" by the aggregates B (mining and quarrying), C (manufacturing), D (electricity, gas, steam, and air conditioning supply), or E (water supply; sewerage, waste management, and remediation activities) from the International Standard Industrial Classification (ISIC). The remaining aggregates A and F-U form the "non-manufacturing" sector.

[14] In the full sample, the time span covered in the underlying data ranges from the years 1923 to 2019. On average, the estimates' underlying data cover an interval of 12.9 years.

Table 2 Own-wage elasticity of labor demand by attributes

	Own-wage elasticity of labor demand				
	Mean	**Median**	**Standard deviation**	**Observations**	**Share**
Empirical model					
Structural-form model	− 0.493	− 0.395	0.637	404	0.573
Reduced-form model	− 0.346	− 0.229	0.410	301	0.427
Output decision					
Conditional	− 0.423	− 0.290	0.564	650	0.922
Unconditional	− 0.509	− 0.460	0.449	55	0.078
Instrumentation of wage variable					
Without instrumental variable	− 0.412	− 0.320	0.502	531	0.753
With instrumental variable	− 0.485	− 0.270	0.694	174	0.247
Within-unit variation					
Without unit fixed effects	− 0.339	− 0.208	0.516	284	0.403
With unit fixed effects	− 0.491	− 0.380	0.574	421	0.597
Time horizon					
Short-run	− 0.174	− 0.091	0.235	152	0.216
Medium-run	− 0.496	− 0.390	0.569	241	0.342
Long-run	− 0.504	− 0.409	0.618	312	0.443
Capital stock					
Quasi-fixed	− 0.441	− 0.330	0.550	282	0.400
Flexible	− 0.444	− 0.285	0.634	267	0.379
None	− 0.385	− 0.299	0.404	156	0.221
Unit of observation					
Firm	− 0.443	− 0.360	0.607	251	0.356
Industry or region	− 0.428	− 0.280	0.533	437	0.620
Economy	− 0.288	− 0.240	0.233	17	0.024
Margin of adjustment					
Worker	− 0.428	− 0.311	0.542	576	0.817
Hours per worker	− 0.348	− 0.120	0.436	10	0.014
Overall hours	− 0.455	− 0.320	0.638	114	0.162
Not stated	− 0.296	− 0.270	0.314	5	0.007
Industry					
Overall	− 0.453	− 0.360	0.536	305	0.433
Non-manufacturing	− 0.504	− 0.265	0.786	77	0.109
Manufacturing	− 0.390	− 0.263	0.506	323	0.458
Region					
Overall	− 0.510	− 0.440	0.560	315	0.447
West Germany	− 0.350	− 0.235	0.558	344	0.488
East Germany	− 0.483	− 0.370	0.423	46	0.065
Open economy					
Overall	− 0.412	− 0.300	0.558	613	0.870
Non-exporting or national firm	− 0.502	− 0.427	0.426	12	0.017
Exporting or multinational firm	− 0.557	− 0.391	0.546	80	0.113
Skill level					
Overall	− 0.387	− 0.260	0.493	424	0.601
Low-skilled	− 0.720	− 0.635	0.811	104	0.148
Medium-skilled	− 0.325	− 0.280	0.410	79	0.112
High-skilled	− 0.435	− 0.352	0.533	79	0.112
Medium- or high-skilled	− 0.213	− 0.190	0.144	19	0.027

Table 2 (continued)

	Own-wage elasticity of labor demand				
	Mean	Median	Standard deviation	Observations	Share
Job type					
Overall	− 0.432	− 0.313	0.558	655	0.929
White-collar	− 0.265	− 0.141	0.609	18	0.026
Blue-collar	− 0.479	− 0.381	0.484	32	0.045
Contract type					
Overall	− 0.400	− 0.270	0.547	598	0.848
Typical employment	− 0.603	− 0.496	0.649	81	0.115
Atypical employment	− 0.576	− 0.627	0.278	26	0.037
Gender					
Overall	− 0.410	− 0.289	0.543	631	0.895
Male	− 0.652	− 0.512	0.737	44	0.062
Female	− 0.527	− 0.395	0.436	30	0.043
Data					
Time series	− 0.373	− 0.250	0.589	151	0.214
Cross section	− 0.486	− 0.420	0.613	34	0.048
Panel	− 0.443	− 0.324	0.542	520	0.738
Publication format					
Refereed article	− 0.417	− 0.311	0.520	376	0.533
Non-refereed article	− 0.434	− 0.315	0.560	234	0.332
Book or collection	− 0.472	− 0.273	0.674	95	0.135
Overall	− 0.430	− 0.310	0.556	705	1.000

The table displays descriptive statistics for the own-wage elasticity of labor demand by different attributes in the full meta-sample. Source: Own illustration

early literature did not report standard errors by default, the average across centralized years in data and the mean year of publication increases slightly, when looking only at estimates from the baseline sample.[15]

Finally note that, in general, it would be desirable to differentiate the wage effect on labor demand by some further characteristics. Unfortunately, few studies report elasticities for attributes other than those shown in Table 2. Thus, given the limited size of the meta-sample of 105 studies and 705 estimates, this paucity results in a lack of statistical power. As a consequence, an examination of further attributes would not deliver statistically meaningful effects in the later meta-regression analysis. Nevertheless, the interested reader is referred to the following studies that differentiate the own-wage elasticity of labor demand by further attributes, namely by firm size (Blechinger and Pfeiffer 1999; Lachenmaier and Rottmann 2007), by federal state (Fauser 2011), by more detailed industries (Koebel 1998; Fitzenberger 1999), by ownership status (Kölling 2019, 2021), by level of job requirement (Kölling 1998), by income group (Schneider et al. 2002), and by task type (Peichl and Popp 2022).

5 Meta-regression analysis

Meta-regression model In a next step, I carry out meta-regressions to more systematically inspect whether the own-wage elasticity of labor demand in the German labor market differs along the underlying dimensions of heterogeneity, controlling for the impact of the remaining attributes. In line with standard meta-regression techniques, the ith estimate of the own-wage elasticity of labor demand from study s, referred to as η_{is}, is assumed to originate from an econometric model in such a way that the elasticity varies around its true value η_0 due to study-specific

[15] As the choice of the empirical model partly dictates the dimensions reflected by the estimates, Table A3 further divides the full sample into 404 estimates from structural-form and 301 estimates from reduced-form models. The distinction between the model types underlines that instruments are more frequently used in reduced-form models (33.2%) than in structural-form models (18.3%). Given their static framework, structural-form models focus on medium- or long-run responses in labor demand. Dynamic versions of structural-form models are rarely estimated to determine short-run elasticities (0.7%). Using lagged dependent variables, short-run dynamics are more easily integrated in reduced-form models (49.5%). By contrast, multi-factor demand systems for heterogeneous types of labor (e.g., for skills) are more often analyzed in structural-form models than in reduced-form models, with the latter mainly focusing on the demand for homogeneous labor.

characteristics X_s, estimate-specific characteristics Z_{is}, and sampling error ε_{is}:

$$\eta_{is} = \eta_0 + X_s^T \beta + Z_{is}^T \gamma + \varepsilon_{is} \tag{2}$$

Specifically, the baseline version of Eq. (2) regresses the point estimate for the own-wage elasticity of labor demand on a constant, the set of study- and estimate-specific attributes from Table 2 (except for the publication format), the centralized year in the underlying data, and year of publication fixed effects to address methodological progress in the literature (e.g., the use of linked employer-employee data). As the precision of the elasticity estimates decreases with the respective standard error, the baseline regression performs a weighted least squares (WLS) estimation of Eq. (2) using the estimates' inverse variance as regression weight to account for heteroscedasticity. Moreover, Stanley and Doucouliagos (2015) have shown that the weighted least squares estimator outperforms conventional meta-regression techniques (such as random-effects meta-regressions) in the presence of publication bias (see Sect. 6). Further, I cluster standard errors at the study level to account for study-specific peculiarities.

Results Table 3 displays the results from the meta-regressions. In the first column, I begin with estimating the equation using OLS for the full sample of elasticities, regardless of the availability of standard errors. In the second column, the OLS estimation is restricted to the baseline sample of estimates that feature standard errors. In the third column, I display the baseline WLS regression using the estimates' inverse variance as regression weight. The fourth column includes an additional interaction effect to highlight the different modeling of the output decision in structural- and reduced-form models. To ease interpretation, the fifth column performs a WLS estimation for the narrower sample of conditional own-wage elasticities of labor demand (i.e., comprising only substitution effects).

The regression results turn out fairly robust across the five specifications. All other things being equal, the use of a reduced-form model over a structural-form model has no statistically significant effect on the magnitude of the elasticities (Columns 1–4), except when analyzing substitution effects only (Column 5). The unconditional own-wage elasticity proves to be more negative than the conditional own-wage elasticity of labor demand, mirroring negative scale effects. In the baseline WLS regression (Column 3), this negative effect is significantly different from zero and conceals important heterogeneity: Scale effects turn out considerably larger in structural- than in reduced-form models (Column 4).[16][17] This finding echoes the international meta-analysis by Lichter et al. (2015) that reports negative scale effects in structural-form models but zero effects in reduced-form models. The authors attribute the frequent appearance of zero or positive scale effects in reduced-form models (e.g., Revenga 1997; Slaughter 2001; Hijzen and Swaim 2010) to a lack of theoretical structure, implying that the mere inclusion of an output variable does not suffice to fully capture the scale effect.

Despite scepticism expressed in the literature, regressions that instrument the wage rate arrive at significantly more negative elasticities than OLS regressions across all five regressions. Thus, the available instrumental variables seem to (partly) succeed in addressing upward bias from uncontrolled-for labor demand shifts along the positively sloped labor supply curve. In nearly all specifications, the inclusion of unit fixed effects results in more negative elasticities, likely because these designs eliminate unobserved time-invariant heterogeneity, such as the large-firm wage premium.

The medium- and long-run response in labor demand turns out more wage-elastic than in the short run, pointing towards substantial cost of adjusting the labor input. In nearly all cases, these differences are statistically different at 1% levels. By contrast, the differences between the medium- and long-run horizon are not statistically different. However, the latter finding may stem from measurement error given the difficulty to obtain credible information on firms' capital stock (e.g., Müller 2008). Accordingly, the way of modeling the capital stock also shows no significant effect on the own-wage elasticity of labor demand either.

For all specifications, the industry- or region-level estimates are slightly more positive than the firm-level estimates, reflecting the turnover of workers between firms within the aggregate. However, this effect is significant only when the sample is restricted to conditional elasticities (Column 5). Nevertheless, this cushioning effect turns out larger at the economy level and is significantly different from zero in all of the five regressions. An obvious explanation for the larger effect size is the fact that

[16] In reduced-form models, the marginal effect of "Unconditional" (i.e., the scale effect) equals −0.248 (= 0.822–1.070) in Column 4. This effect is significantly different from zero at the 1% level (p=0.005).

[17] In the German sample, unconditional elasticities almost exclusively stem from reduced-form models. In fact, only Peichl and Popp (2022) use a structural-form model to determine unconditional own-wage elasticities of labor demand. In line with theory, they arrive at negative scale effects across all input factors.

an entire economy is able to absorb more laid-off workers than a single industry or region.

Regarding the margin of adjustment, the regressions indicate that the demand for labor does not become markedly more wage-elastic when analyzing overall working hours rather than headcount employment. In the baseline regression, the additional impact of the intensive margin is negligibly small, which casts doubt on a systematically negative effect of wages on the demand for individual hours worked. In light of this result, the common practice of analyzing the responsiveness of labor demand along only the extensive margin proves to be an admissible simplification when information on individual working hours is not available (e.g., in the German social security records).

The elasticities do not exhibit systematic differences between the overall economy, the non-manufacturing sector, and the manufacturing sector. Nevertheless, substitution effects seem to be weaker in the non-manufacturing sector (p=0.262) where scope for automation is more limited than in the manufacturing sector (Column 5). Since the reunification in 1990, Germany is characterized by an economic divide between the traditionally market-oriented western part of the country and the post-communist eastern part. In particular, East Germany features higher unemployment rates (Smolny 2009), lower productivity levels (Ragnitz 2007; Brenke 2014), and a more limited coverage of collective bargaining agreements (Addison et al. 2013) than West Germany. Despite these structural disparities, the meta-regressions do not yield any significant differences in the wage elasticity between West and East German firms. In line, Schnabel (2016) synthesizes the reunification literature and concludes that there is no East–West divide in terms of employer behavior. Against the background of the prevailing right-to-manage system in Germany (Hirsch and Schnabel 2014), relative increases in collectively agreed wages (which used to be regionally differentiated in course of the reunification process) are unlikely to have a different impact on employment between West and East Germany.

Trade theory suggests that globalization renders labor demand more wage-elastic, both in terms of larger substitution and scale effects. In line with theory, labor demand in non-exporting or national firms turns out less elastic than in exporting or multinational firms across the five specifications. In the baseline regression (Column 3), this effect is sizeable and statistically significant. In Column 5, the effect is roughly halved (p=0.128), showing that increased trade openness not only magnifies the substitution effect (i.e., facilitated offshoring of workers) but also the scale effect (i.e., higher price sensitivity of consumers abroad).

In terms of skill demand, I observe that labor demand is more elastic for low- and high-skilled workers than for medium-skilled workers.[18] Importantly, the pattern remains when the sample is restricted to conditional own-wage elasticities of labor demand (Column 5). Hence, the meta-analysis provides evidence for an inverse U-shaped relationship between substitution effects and skills, which has been reported in many studies for Germany (e.g., Fitzenberger and Franz 1998; Fitzenberger 1999; Koebel 2002; Peichl and Siegloch 2012; Lichter et al. 2017; Peichl and Popp 2022). Reluctance of German firms to substitute medium-skilled workers may reflect the high-match quality arising from the dual apprenticeship system in Germany, which combines education at a vocational school with workplace-based training in a firm (Rhein et al. 2013). As a result, medium-skilled workers account for almost two third of overall employment in Germany, mirroring a relatively high productivity of this worker group (German Statistical Office 2022).[19]

Regarding the job type, the results turn out mixed and insignificant. Thus, employers' wage responsiveness does not seem to vary between blue- and white-collar workers, despite different task profiles and the associated risk of automation. In terms of contract type, the demand for typical (i.e., regular full-time) workers is less elastic than for the average worker (p=0.143) in the baseline WLS regression. The conditional demand for atypical workers turns out significantly more elastic than the average (Column 5), implying that atypical jobs can be substituted more easily. If firms were inclined to lay off female workers when wage levels rise, such discriminatory behavior would manifest in a more negative own-wage elasticity of labor demand for women. Contrary to this notion, the regressions indicate that the elasticities do not systematically differ by gender.

In general, estimates from cross-sectional and panel data deliver more positive elasticities than time-series estimates, probably because the (additional) between-firm variation confounds the regression results.[20] Finally, in the WLS regressions, the coefficient for the centralized year of the underlying data turns out positive, suggesting that, all other things being equal, labor demand has become less elastic over time. A plausible explanation

[18] In contrast to low-skilled workers, medium-skilled workers completed vocational training whereas high-skilled workers hold a university degree.

[19] Under perfect competition with a numeraire good, the input share in total cost is equivalent to the production elasticity of the input factor: $s^L = \frac{w \cdot L}{C} = \frac{Y_L \cdot L}{Y}$.

[20] Note that, as the regressions already condition on the inclusion of unit fixed effects, which is feasible only with panel data, the meta-coefficient for "Panel" delivers the marginal effect of analyzing panel data absent unit fixed effect (i.e., with within- and between-unit variation) vis-à-vis time-series data.

for the positive time trend stems from long-term macroeconomic trends in the German labor market. In the last decades, Germany has been characterized by demographic decline (Hamm et al. 2008) while, in recent years, the booming economy has brought employment to an all-time high. As a consequence, labor market tightness (i.e., the vacancy-to-unemployed ratio) has risen sharply (Bossler and Popp 2022). To minimize accompanying recruitment problems, firms have been increasingly inclined to hoard labor (Hutter et al. 2020), that is, they maintain their labor demand even when facing adverse shocks such as higher wages.

Sensitivity In the preceding paragraphs, I have determined a variety of factors that contribute to the heterogeneity of the own-wage elasticity of labor demand. In a next step, I examine the sensitivity of the results using slight modifications of the regression equation, a narrower sample of estimates, a different weighting scheme, and an alternative estimator.

In Additional file 1, Table B1 displays the regression results for these sensitivity checks. In Column 1, I augment the baseline WLS regression with a squared term for the centralized year in the data to check the robustness of the positive time trend. In Column 2, I modify the baseline specification to include a linear time trend for the publication year instead of year fixed effects. This regression addresses the concern that year of publication fixed effects, which are designed to capture publication trends in a fully non-parametric way, could absorb overly much variation given that each year features only a handful of publications in the meta-sample (see Table A2). In Column 3, I carry out a WLS regression on the sample of estimates that are statistically significant at the 10% level. In Column 4, I implement study weights (i.e., 1 divided by the number of estimates per study) to assure that each paper is given the same weight in the regression. In doing so, studies with a large number of estimates can no longer contribute excessively to the identification. Another advantage is that this regression can be performed on the full sample of estimates because the weighting scheme is not based on the reporting of standard errors. In Column 5, I apply a conventional random-effects meta-regression to the baseline sample of estimates. Random-effects meta regressions allow for heterogeneity in the estimates beyond the control variables and sampling error by modeling an additional between-study variance (Hedges 1983; Raudenbush 1994).

By and large, the sensitivity checks deliver quite stable estimates, corroborating the robustness of my baseline meta-regression results. Notably, the effect of overall hours becomes more pronounced in some of the sensitivity checks. Moreover, the specification with a quadratic term for the centralized year in the data suggests that the own-wage elasticity of labor demand followed a U-shaped pattern: Whereas the linear effect is significantly negative, the quadratic term turns out significantly positive. This pattern implies that, in line with the globalization argument (Slaughter 2001; Lichter et al. 2015), labor demand was becoming more elastic at the beginning of the observation period while, later on, the responsiveness of labor demand waned over time. Favorably, the latter finding supports the argument that labor shortage which is also a relatively recent phenomenon contributes to the positive time trend in the own-wage elasticity of labor demand.

6 Publication Bias

Next, I analyze whether the German labor demand literature is characterized by publication selection bias. Specifically, published estimates could be selective in a sense that journals and researchers favor significant and theory-compliant results over null findings or results that contradict theory (De Long and Lang 1992; Stanley 2005). If present, this selective reporting limits the inference that can be drawn from the empirical literature about the true underlying economic relationship.

Suppose there is a small, negative underlying own-wage elasticity of labor demand. Due to large standard errors, regressions will occasionally produce fairly distant estimates. When there is no selection bias (i.e., all estimates are reported), the average across these estimates will depict the true relationship quite accurately. However, given the theoretical proposition that the labor demand curve is downward sloping, there might be a strong distaste for reporting positive wage effects on the demand for labor. If positive values are indeed under-reported, the distribution becomes truncated and the associated mean is biased.

To test for publication bias, I examine the relationship between point estimates and their standard errors in the baseline sample (Card and Krueger 1995). Absent publication bias, point estimates and standard errors are unrelated. However, if researchers are inclined to report significantly negative own-wage elasticities of labor demand (i.e., with a t value of less than −1.64 at the 10% significance level), point estimates and standard errors will be negatively correlated given that $t = \frac{b}{se}$. A simple OLS regression of point estimates on respective standard errors yields a significantly negative coefficient of −7.18 (standard error: 1.39), pointing towards considerable publication bias.

Figure 2 illustrates "funnel plots" to visually inspect publication bias. Panel a plots point estimates against the inverse of their squared standard error. In the absence of publication bias, low-precision estimates would increasingly feature more widely dispersed coefficients (i.e., the plot is funnel-shaped). In fact, the distribution is not funnel-shaped but asymmetric: The left tail is much more prominent than the right tail of the distribution

Table 3 Meta-Regressions

Dependent variable: Own-wage elasticity of labor demand	**(1) OLS Full sample**	**(2) OLS Baseline sample**	**(3) WLS Baseline sample**	**(4) WLS With interaction**	**(5) WLS Substitution effects**
Empirical model					
Structural-form model	Reference	Reference	Reference	Reference	Reference
Reduced-form model	− 0.006 (0.113)	− 0.029 (0.115)	− 0.069 (0.159)	− 0.180 (0.153)	− 0.296 (0.112)***
Output decision					
Conditional	Reference	Reference	Reference	Reference	
Unconditional	− 0.181 (0.147)	− 0.195 (0.197)	− 0.365 (0.092)***	-1.070 (0.329)***	
Unconditional × Reduced-form model				0.822 (0.353)**	
Instrumentation of wage variable					
Without instrumental variable	Reference	Reference	Reference	Reference	Reference
With instrumental variable	− 0.240 (0.103)**	− 0.384 (0.133)***	− 0.337 (0.084)***	− 0.343 (0.092)***	− 0.216 (0.098)**
Within-unit variation					
Without unit fixed effects	Reference	Reference	Reference	Reference	Reference
With unit fixed effects	− 0.199 (0.080)**	− 0.032 (0.056)	− 0.082 (0.031)***	− 0.079 (0.030)***	− 0.085 (0.029)***
Time horizon					
Short-run	Reference	Reference	Reference	Reference	Reference
Medium-run	− 0.309 (0.092)***	− 0.098 (0.128)	− 0.308 (0.155)**	− 0.301 (0.145)**	− 0.260 (0.138)*
Long-run	− 0.379 (0.133)***	− 0.285 (0.075)***	− 0.200 (0.095)**	− 0.203 (0.095)**	− 0.205 (0.099)**
Capital stock					
Quasi-fixed	Reference	Reference	Reference	Reference	Reference
Flexible	− 0.126 (0.128)	0.006 (0.119)	0.132 (0.135)	0.098 (0.134)	− 0.130 (0.133)
None	0.055 (0.128)	0.232 (0.099)**	− 0.054 (0.162)	− 0.126 (0.150)	− 0.265 (0.126)**
Unit of observation					
Firm	Reference	Reference	Reference	Reference	Reference
Industry or region	0.102 (0.072)	0.066 (0.073)	0.181 (0.148)	0.072 (0.141)	0.306 (0.124)**
Economy	0.408 (0.222)*	1.138 (0.598)*	2.129 (0.717)***	2.002 (0.636)***	0.822 (0.472)*
Margin of adjustment					
Workers	Reference	Reference	Reference	Reference	Reference
Hours per worker	0.213 (0.114)*	Omitted	Omitted	Omitted	Omitted
Overall hours	− 0.081 (0.080)	− 0.168 (0.059)***	− 0.017 (0.057)	− 0.033 (0.057)	− 0.007 (0.066)
Not stated	0.322 (0.140)**	Omitted	Omitted	Omitted	Omitted
Industry					
Overall	Reference	Reference	Reference	Reference	Reference
Non-manufacturing	− 0.158 (0.116)	− 0.219 (0.126)*	0.015 (0.109)	0.045 (0.103)	0.100 (0.088)
Manufacturing	− 0.098 (0.081)	− 0.164 (0.073)**	− 0.056 (0.115)	− 0.035 (0.111)	0.041 (0.093)
Region					
Overall	Reference	Reference	Reference	Reference	Reference
West Germany	0.266 (0.080)***	0.218 (0.071)***	− 0.117 (0.096)	− 0.075 (0.096)	0.020 (0.093)
East Germany	0.135 (0.122)	0.189 (0.087)**	− 0.119 (0.099)	− 0.077 (0.099)	0.020 (0.093)

Table 3 (continued)

Dependent variable: Own-wage elasticity of labor demand	(1) OLS Full sample	(2) OLS Baseline sample	(3) WLS Baseline sample	(4) WLS With interaction	(5) WLS Substitution effects
Open economy					
Overall	Reference	Reference	Reference	Reference	Reference
Non-exporting or national firm	− 0.002 (0.164)	0.049 (0.200)	0.612 (0.214)***	0.504 (0.188)***	0.246 (0.160)
Exporting or multinational firm	− 0.225 (0.115)*	− 0.138 (0.125)	0.101 (0.176)	0.126 (0.161)	0.058 (0.134)
Skill level					
Overall	Reference	Reference	Reference	Reference	Reference
Low-skilled	− 0.224 (0.129)*	− 0.242 (0.133)*	− 0.115 (0.049)**	− 0.105 (0.041)**	− 0.098 (0.038)**
Medium-skilled	0.207 (0.103)**	0.222 (0.113)*	− 0.023 (0.064)	− 0.017 (0.061)	− 0.021 (0.055)
High-skilled	0.098 (0.096)	0.056 (0.098)	− 0.196 (0.088)**	− 0.187 (0.084)**	− 0.197 (0.088)**
Medium- or high-skilled	0.182 (0.126)	0.026 (0.108)	− 0.105 (0.141)	− 0.004 (0.109)	0.033 (0.061)
Job type					
Overall	Reference	Reference	Reference	Reference	Reference
White-collar	0.212 (0.121)*	0.200 (0.148)	− 0.083 (0.119)	− 0.070 (0.111)	− 0.021 (0.053)
Blue-collar	− 0.103 (0.139)	0.024 (0.119)	0.047 (0.125)	0.085 (0.131)	− 0.103 (0.118)
Contract type					
Overall	Reference	Reference	Reference	Reference	Reference
Typical employment	− 0.304 (0.124)**	− 0.067 (0.160)	0.263 (0.177)	0.102 (0.161)	− 0.083 (0.099)
Atypical employment	− 0.391 (0.205)*	− 0.303 (0.192)	− 0.109 (0.219)	− 0.255 (0.213)	− 0.501 (0.122)***
Gender					
Overall	Reference	Reference	Reference	Reference	Reference
Male	0.120 (0.202)	− 0.196 (0.203)	− 0.175 (0.256)	− 0.097 (0.240)	− 0.339 (0.185)*
Female	0.228 (0.162)	− 0.224 (0.189)	− 0.187 (0.249)	− 0.102 (0.234)	− 0.348 (0.185)*
Data					
Time series	Reference	Reference	Reference	Reference	Reference
Cross section	− 0.253 (0.222)	0.101 (0.171)	0.299 (0.185)	0.284 (0.173)	0.523 (0.201)***
Panel	0.222 (0.116)*	0.417 (0.111)***	0.431 (0.253)*	0.511 (0.226)**	0.833 (0.202)***
Years					
Centralized year in data	0.005 (0.009)	− 0.002 (0.009)	0.019 (0.011)*	0.020 (0.010)**	0.037 (0.010)***
Year of publication fixed effects	Yes	Yes	Yes	Yes	Yes
Constant	− 11.20 (16.95)	5.281 (17.64)	− 40.99 (22.12)*	− 41.52 (19.95)**	− 73.93 (19.80)***
Estimator	OLS	OLS	WLS	WLS	WLS
Sample	Full	Baseline	Baseline	Baseline	Only Conditional
Weight	None	None	Inverse Variance	Inverse Variance	Inverse Variance
Number of observations	705	442	442	442	403
Number of studies	105	73	73	73	65
Adjusted R^2	0.214	0.252	0.946	0.948	0.952

The table shows meta-regressions for own-wage elasticities of labor demand from Germany. The baseline sample refers to all estimates with reported or calculable standard errors. Standard errors (in parentheses) are clustered at the study level. OLS = Ordinary Least Squares. WLS = Weighted Least Squares. * = $p<0.10$. ** = $p<0.05$. *** = $p<0.01$. Source: Own illustration

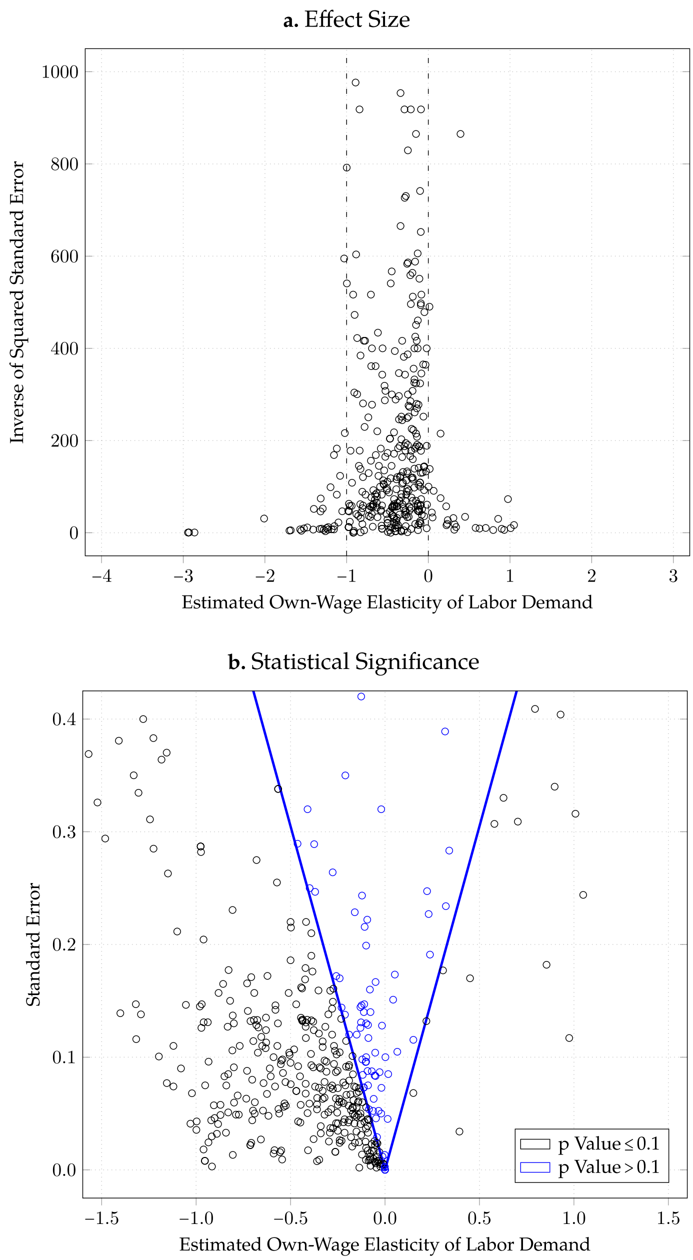

Fig. 2 Funnel Plots. The figure shows funnel plots to examine publication bias regarding own-wage elasticities of labor demand from the German labor market. Specifically, the figures plot point estimates of own-wage elasticities of labor demand against the underlying (inverse of the squared) standard error. In the absence of publication bias, low-precision estimates are supposed to be widely dispersed. The graphs are truncated at the axis edges. In Panel **b**, the blue funnel indicates the 10% significance level (t= ±1.64). Source: Own illustration

(skewness: −2.10), implying a search for the "correct" negative sign. In addition to values above zero, the distribution of effect sizes also appears to be truncated below values of −1. Thus, the literature seems to favor negative but inelastic labor demand responses to wage increases. For the subset of "high-precision" estimates, Panel b examines publication bias regarding the statistical significance more closely. The blue funnel represents absolute t values of 1.64 and, thus, separates insignificant estimates from those that are statistically significant at the 10% level. Obviously, the probability mass increases disproportionately to the left of the funnel, highlighting that the

Table 4 Publication Bias

Dependent variable: Own-wage elasticity of labor demand	(1) WLS	(2) WLS	(3) WLS	(4) WLS
Standard error	− 1.562 (0.590)***	− 1.087 (0.812)	− 0.952 (0.571)*	− 2.249 (1.011)**
Standard error × Reduced-form model		− 1.434 (1.258)		
Standard error × Overall hours			− 2.928 (1.223)**	
Standard error × Non-refereed article				1.382 (1.482)
Standard error × Book or collection				1.388 (1.997)
Constant	9.117 (13.00)	10.04 (13.09)	7.884 (13.18)	18.49 (13.43)
Publication format fixed effects	No	No	No	Yes
Control variables	Yes	Yes	Yes	Yes
Estimator	WLS	WLS	WLS	WLS
Sample	Baseline	Baseline	Baseline	Baseline
Weight	Inverse Variance	Inverse Variance	Inverse Variance	Inverse Variance
Number of observations	442	442	442	442
Number of studies	73	73	73	73
Adjusted R^2	0.916	0.917	0.918	0.922

The table shows meta-regressions for own-wage elasticities of labor demand from Germany. The results stem from augmented versions of the baseline regression model in Column (3) of Table 3, additionally controlling for (interactions of) the standard error of the elasticity estimate. The baseline sample refers to all estimates with reported or calculable standard errors. Standard errors (in parentheses) are clustered at the study level. WLS = Weighted Least Squares. * = p<0.10. ** = p<0.05. *** = p<0.01. Source: Own illustration

literature also tends to favor significant over insignificant own-wage elasticities of labor demand.

In certain cases, relying solely on funnel plots can lead to false inferences about publication bias.[21] Therefore, in Table 4, I carry out multivariate regressions of point estimates on standard errors to test more rigorously for publication bias. In Column 1, I additionally control for the same set of attributes as in the meta-regression analysis (see Sect. 5). After conditioning on these covariates, the evidence still speaks in favor of publication bias: An increase in the standard error by 0.1 lowers the reported own-wage elasticity of labor demand by 0.16 on average.[22] In Column 2, I include an interaction term between the standard error and the use of a reduced-form model. As expected, publication bias turns out higher in reduced-form models which allow researchers more leeway in specifying their regressions than structural-form models. However, this difference is not statistically significant (p=0.258). In Column 3, the regression differentiates publication bias with regard to the margin of adjustment. Reporting elasticities for overall hours could be more selective as the relative adjustment along the hours margin is supposed to be larger than adjustment along the extensive margin only. In fact, the bias turns out to be much larger if the estimate reflects demand for total hours rather than the number of workers. Finally, Column 4 examines whether the relationship between point estimates and standard errors differs by publication format. Although not statistically different, publication bias turns out less pronounced in discussion papers, books, or edited collection of papers than in peer-reviewed articles.

7 Conclusion

The own-wage elasticity of labor demand is a key parameter in empirical research, governing the slope of the labor demand curve. Regarding the German labor market, general evidence on the responsiveness of firms' labor demand to wage changes was scant: There are two narrative literature reviews, but these refer to only a handful of studies and date back to the past when evidence from linked employer-employee data was hardly available. Although plenty of studies determine own-wage elasticities of labor demand for the German labor market, the growing evidence had not yet been synthesized using meta-regression techniques. Building on 105 studies, this meta-study filled this gap by thoroughly analysing a total of 705 elasticity estimates through the lens of labor demand theory, empirical modeling, and different firm and worker characteristics.

This meta-study has revealed that the estimates for the own-wage elasticities of labor demand average −0.43 for the German labor market. This value is around 20% less elastic than the average in the international meta-study

[21] First, a funnel plot may not adequately predict publication bias if the effect size of high-precision studies differs from the effect size of low-precision studies due to inherent between-study heterogeneity (Lau et al. 2006). Second, depending on the scale of the y axis, the appearance of the funnel plot can change quite dramatically (Tang and Liu 2000).

[22] The bias found here has a similar order of magnitude as in the international meta-study by Lichter et al. (2015).

by Lichter et al. (2015), seemingly reflecting employment protection legislation which, in Germany, is high by international standards. In particular, the meta-study has investigated the impact of further peculiarities of the German economy on the responsiveness of labor demand. Despite structural differences between the West and East German labor market, the meta-regressions do not provide evidence for an East–West divide along the own-wage elasticity of labor demand. Given Germany's extraordinarily high level of foreign trade, the analysis finds that labor demand of internationally operating firms reacts more elastically to wage changes than firms whose activities are limited to the domestic market. In terms of skill demand, the German labor market is characterized by an inverse U-shaped pattern between education levels and substitution effects: Demand for medium-skilled workers, who are trained in the dual vocational system, turns out to be less elastic than the demand for low- and high-skilled workers, holding output constant. For the last decades, the analysis suggests that labor demand has become less elastic, which may reflect labour hoarding in the wake of long-term demographic decline. In line with international evidence, the analysis buttresses that labor demand is more responsive i) when firms adjust their production levels and ii) when firms' employment decision refers to the long run. Moreover, empirical models using unit fixed effects or instrumental variables appear to be effective methods to counteract upward bias from endogeneity of the wage rate.

This meta-study can help economists and policymakers to better assess the economic consequences of minimum wages, immigration waves, or income taxes - to name a few. First, regarding the 2015 minimum wage introduction in Germany, the competitive model in Knabe et al. (2014) predicted a decline in employment by 910,000 workers, using −0.75 as a seemingly plausible value for the own-wage elasticity of labor demand. Interestingly, this value comes close to the average estimate of −0.72 for low-skilled workers reported in this study (see Table 2). Thus, when leaving downward publication bias aside, the apparent discrepancy between the disemployment effects in ex-ante simulations and the close-to-zero effects in ex-post evaluations is rather arising from the bite measurement or the underlying simulation model than from calibration issues. Second, in terms immigration flows, the same elasticity implies that, in the textbook model of a competitive labor market, an increase in the fixed supply of low-skilled workers by 1% leads to a wage reduction of 1.4 (= 1/0.72) percent. However, this value is just a ballpark estimate in a sense that it is based on simplifying assumptions (e.g., perfect substitutability between natives and immigrants) and reflects a partial equilibrium analysis that abstracts from indirect migration effects (e.g., increased product demand).

By and large, when assessing the impact of labor supply shocks or wage policies, relying on a single own-wage elasticity of labor demand delivers an incomplete representation of the German labor market. In light of this meta-analysis, researchers should rather adapt their elasticity to their specific setting (e.g., a short-run analysis with flexible output) and further differentiate it by relevant firm (e.g., by export status) or worker characteristics (e.g., by education or job type). In particular, the descriptions and regressions in this meta-analysis can guide researchers to construct a set of appropriate elasticities, building on solid evidence from more than one hundred studies on the German labor market.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12651-023-00337-8.

Additional file 1. Online Appendix.

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Author contributions
The author is responsible for the entirety of the publication. The author read and approved the final manuscript.

Availability of data and materials
The data on the meta-sample and the code for the analysis are available from the author upon request.

Declarations

Competing interests
The author declares that he has no competing interests.

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References

Addison, J.T., Portugal, P., Varejao, J.: Labor demand research: toward a better match between better theory and better data. Labour Econ. **30**, 4–11 (2014)

Addison, J.T., Teixeira, P., Bryson, A., Pahnke, A.: Collective agreement status and survivability: change and persistence in the German model. Labour **27**(3), 288–309 (2013)

Anderson, G.J., Blundell, R.W.: Estimation and hypothesis testing in dynamic singular equation systems. Econometrica **50**(6), 1559–1572 (1982)

Anderson, T.W., Hsiao, C.: Formulation and estimation of dynamic models using panel data. J. Econ. **18**(1), 47–82 (1982)

Angrist, J.D., Krueger, A.B.: Instrumental variables and the search for identification: from supply and demand to natural experiments. J. Econ. Perspect. **15**(4), 69–85 (2001)

Arellano, M., Bond, S.: Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev. Econ. Stud. **58**(2), 277–297 (1991)
Arni, P., Eichhorst, W., Pestel, N., Spermann, A., Zimmermann, K.F.: Der gesetzliche Mindestlohn in Deutschland: Einsichten und Handlungsempfehlungen aus der Evaluationsforschung. J. Context. Econ. **134**(2), 149–182 (2014)
Arrow, K.J., Chenery, H.B., Minhas, B.S., Solow, R.M.: Capital-labor substitution and economic efficiency. Rev. Econ. Stat. **43**(3), 225–250 (1961)
Bergman, M.A.: The restricted profit function and the application of the generalised leontief and the translog functional forms. Int. J. Prod. Econ. **49**(3), 249–254 (1997)
Berndt, E.R.: The practice of econometrics: classic and contemporary. Addison-Wesley, Reading (1991)
Blechinger, D., Pfeiffer, F.: Qualifikation, Beschäftigung und technischer Fortschritt: Empirische Evidenz mit den Daten des Mannheimer Innovationspanels. J. Econ. Stat. **218**(1–2), 128–146 (1999)
Boeters, S., Savard, L.: The labor market in computable general equilibrium models. In: Dixon, P.B., Jorgenson, D.W. (eds.) Handbook of computable general equilibrium modeling, pp. 1645–1718. Elsevier, Amsterdam (2013)
Borjas, G.J.: The labor demand curve is downward sloping: reexamining the impact of immigration on the labor market. Quart. J. Econ. **118**(4), 1335–1374 (2003)
Bossler, M., Gerner, H.-D.: Employment effects of the new german minimum wage: evidence from establishment-level micro data. Ind. Labor Relat. Rev. **73**(5), 1070–1094 (2020)
Bossler, M., Popp, M.: Labor demand on a tight leash. arXiv Preprint 2203.05593 (2022)
Brenke, K.: Eastern Germany still playing economic catch-up. German Institute for Economic Research, DIW Economic Bulletin 11/2014 (2014).
Brittain, J.A.: The incidence of social security payroll taxes. Am. Econ. Rev. **61**(1), 110–125 (1971)
Brown, C.C., Gilroy, C., Kohen, A.: The effect of the minimum wage on employment and unemployment. J. Econ. Literat. **20**(2), 487–528 (1982)
Brown, R.S., Christensen, L.R.: Estimating elasticities of substitution in a model of partial static equilibrium: an application to US agriculture, 1947–1974. In: Berndt, E.R., Field, B.C. (eds.) Modelling and measuring natural resource substitution, pp. 209–229. MIT Press, Cambridge (1981)
Bundesamt für Migration und Flüchtlinge: Migrationsbericht 2020 (2020).
Caliendo, M., Schröder, C., Wittbrodt, L.: The causal effects of the minimum wage introduction in Germany: an overview. German Econ. Rev. **20**(3), 257–292 (2019)
Card, D., Krueger, A.B.: Myth and measurement: the new economics of the minimum wage. Princeton University Press, Princeton (1995)
Christensen, L.R., Jorgenson, D.W., Lau, L.J.: Transcendental logarithmic production frontiers. Rev. Econ. Stat. **55**(1), 28–45 (1973)
Cobb, C.W., Douglas, P.H.: A theory of production. Am. Econ. Rev. **18**(1), 139–165 (1928)
De Long, J.B., Lang, K.: Are all economic hypotheses false? J. Polit. Econ. **100**(6), 1257–1272 (1992)
Diewert, W.E.: An application of the Shephard duality theorem: a generalized Leontief production function. J. Political Econ. **79**(3), 481–507 (1971)
Doucouliagos, C.: The aggregate demand for labour in Australia: a meta-analysis. Aust. Econ. Pap. **36**(69), 224–242 (1997)
Dunlop, J.T.: Wage determination under trade unions. Macmillan, New York (1944)
Dustmann, C., Lindner, A., Schönberg, U., Umkehrer, M., vom Berge, P.: Reallocation effects of the minimum wage. Quart. J. Econ. **137**(1), 267–328 (2022)
Dustmann, C., Schönberg, U., Stuhler, J.: Labor supply shocks, native wages, and the adjustment of local employment. Quart. J. Econ. **132**(1), 435–483 (2017)
Ehrenberg, R.G.: The impact of the overtime premium on employment and hours in US industry. Econ. Inq. **9**(2), 199–207 (1971)
Espey, M., Thilmany, D.D.: Farm labor demand: a meta-regression analysis of wage elasticities. J. Agric. Resour. Econ. **25**(1), 252–266 (2000)
Fauser, S. G.: Modeling regional labor markets in Germany: insights not only for German policy makers. Empirica **38**, 169–201 (2011).
Felbermayr, G., Geis, W., Kohler, W.: Restrictive immigration policy in Germany: pains and gains foregone? Rev. World Econ. **146**(1), 1–21 (2010)
Fitzenberger, B.: Wages and employment across skill groups: an analysis for West Germany. ZEW Economic Studies 6. Physica, Heidelberg (1999)
Fitzenberger, B., Doerr, A.: Konzeptionelle Lehren aus der ersten Evaluationsrunde der Branchenmindestlöhne in Deutschland. J. Labour Market Res. **49**(4), 329–347 (2016)
Fitzenberger, B., Franz, W.: Flexibilität der qualifikatorischen Lohnstruktur und Lastverteilung der Arbeitslosigkeit: Eine ökonometrische Analyse für Westdeutschland. In: Gahlen, B., Hesse, H., Ramser, H.J. (eds.) Verteilungsprobleme der Gegenwart: Diagnose und Therapie, pp. 47–79. Tübingen, Mohr Siebeck (1998)
German Statistical Office. Bevölkerung und Erwerbstätigkeit: Erwerbsbeteiligung der Bevölkerung, Ergebnisse des Mikrozensus zum Arbeitsmarkt, 2020. Fachserie 1, Reihe 1.4 (2022)
Glitz, A.: The labor market impact of immigration: a quasi-experiment exploiting immigrant location rules in Germany. J. Law Econ. **30**(1), 175–213 (2012)
Gould, J.P.: Adjustment cost in the theory of investment of the firm. Rev. Econ. Stud. **35**(1), 47–55 (1968)
Griliches, Z.: Capital-skill complementarity. Rev. Econ. Stat. **51**(4), 465–468 (1969)
Hamermesh, D.S.: Econometric studies of labor demand and their application to policy analysis. J. Hum. Resour. **11**(4), 507–525 (1976)
Hamermesh, D.S.: New measures of labor cost: implications for demand elasticities and nominal wage growth. In: Tripplet, J.E. (ed.) The measurement of labor cost, pp. 287–308. University of Chicago Press, Chicago (1983)
Hamermesh, D.S.: The demand for labor in the long run. In: Ashenfelter, O.C., Layard, R. (eds.) Handbook of labor economics, vol. 1, pp. 429–471. North Holland, Amsterdam (1986)
Hamermesh, D.S.: Labor demand. Princeton University Press, Princeton (1993)
Hamermesh, D.S.: LEEping into the future of labor economics: the research potential of linking employer and employee data. Labour Econ. **6**(1), 25–41 (1999)
Hamermesh, D.S.: Do labor costs affect companies' demand for labor? IZA World Labor. **3**, 1–10 (2014)
Hamermesh, D.S., Pfann, G.: Adjustment costs in factor demand. J. Econ. Liter. **34**(3), 1264–1292 (1996)
Hamm, I., Seitz, H., Werding, M.: Demographic change in Germany: The economic and fiscal consequences. Springer, Heidelberg (2008)
Harberger, A.C.: Three basic postulates for applied welfare economics: an interpretive essay. J. Econ. Liter. **9**(3), 785–797 (1971)
Hedges, L.V.: A random effects model for effect sizes. Psychol. Bull. **93**(2), 388–395 (1983)
Henzel, S. R. and Engelhardt, K.: Arbeitsmarkteffekte des flächendeckenden Mindestlohns in Deutschland - eine Sensitivitätsanalyse. ifo Institute for Economic Research, ifo Schnelldienst 10/2014 (2014)
Hicks, J.R.: Theory of wages. Macmillan, London (1932)
Hijzen, A., Swaim, P.: Offshoring, labour market institutions and the elasticity of labour demand. Eur. Econ. Rev. **54**(8), 1016–1034 (2010)
Hirsch, B., Schnabel, C.: What can we learn from bargaining models about union power? The decline in union power in Germany, 1992–2009. Manch. Sch. **82**(3), 347–362 (2014)
Holt, C., Modigliani, F., Muth, J., Simon, H.: Planning production, inventories and work force. Prentice Hall, Englewood Cliffs (1960)
Hutter, C., Carbonero, F., Klinger, S., Trenkler, C., Weber, E.: Which factors were behind Germany's labour market upswing? A data-driven approach, Oxf. Bull. Econ. Stat. **84**(5), 1052-1076 (2020)
Jacquet, L., Lehmann, E., Van der Linden, B.: Optimal income taxation with Kalai wage bargaining and endogenous participation. Soc. Choice Welfare **42**(2), 381–402 (2014)
Knabe, A., Schöb, R., Thum, M.: Der flächendeckende Mindestlohn. Perspekt. Wirtsch. **15**(2), 133–157 (2014)
Koebel, B.M.: Tests of representative firm models: results for German manufacturing industries. J. Prod. Anal. **10**(3), 251–270 (1998)
Koebel, B.M.: Can aggregation across goods be achieved by neglecting the problem? Property inheritance and aggregation bias. Int. Econ. Rev. **43**(1), 223–255 (2002)
Kölling, A.: Anpassungen auf dem Arbeitsmarkt: Eine Analyse der dynamischen Arbeitsnachfrage in der Bundesrepublik Deutschland. Beiträge zur

Arbeitsmarktforschung 217. Institute for Employment Research, Nuremberg (1998)
Kölling, A.: Family-managed firms and labor demand size matters - but only the small ones are different. Cesifo Econ. Stud. **65**(1), 108–129 (2019)
Kölling, A.: Labor demand, qualifications, and family management: analyzing labor demand of German family-managed firms with panel data. Appl. Econ. Q. **67**(2), 143–175 (2021)
Lachenmaier, S., Rottmann, H.: Employment effects of innovation at the firm level. J. Econ. Stat. **227**(3), 254–272 (2007)
Lau, J., Ioannidis, J.P., Terrin, N., Schmid, C.H., Olkin, I.: The case of the misleading funnel plot. BMJ **333**(7568), 597–600 (2006)
Lazear, E.P.: Job security provisions and employment. Quart. J. Econ. **105**(3), 699–726 (1990)
Lee, D., Saez, E.: Optimal minimum wage policy in competitive labor markets. J. Public Econ. **96**(9–10), 739–749 (2012)
Lichter, A., Peichl, A., Siegloch, S.: The own-wage elasticity of labor demand: a meta-regression analysis. Eur. Econ. Rev. **80**, 94–119 (2015)
Lichter, A., Peichl, A., Siegloch, S.: Exporting and labour demand: micro-level evidence from Germany. Can. J. Econ. **50**(4), 1161–1189 (2017)
Möller, J.: Minimum wages in German industries: what does the evidence tell us so far? J. Labour Market Res. **45**(3–4), 187–199 (2012)
Mora, J.J., Muro, J.: Wage-employment elasticity: a meta-analysis referring to Colombia. J. Econ. Stud. **47**(6), 1495–1505 (2019)
Morrison, C.: Quasi-fixed inputs in US and Japanese manufacturing: a generalized Leontief restricted cost function approach. Rev. Econ. Stat. **70**(2), 275–287 (1988)
Müller, D., Wolter, S.: German labour market data: data provision and access for the international scientific community. German Econ. Rev. **21**(3), 313–333 (2020)
Müller, K.-U.: How robust are simulated employment effects of a legal minimum wage in Germany? A comparison of different data sources and assumptions. German Institute for Economic Research, DIW Discussion Paper No. 900 (2009)
Müller, K.-U., Steiner, V.: Distributional effects of a minimum wage in a welfare state: the case of Germany. German Institute for Economic Research, SOEPpapers on Multidisciplinary Panel Data Resarch No. 617 (2013)
Müller, S.: Capital stock approximation using firm level panel data: a modified perpetual inventory approach. J. Econ. Stat. **228**(4), 357–371 (2008)
Mundlak, Y.: Production and supply. In: Gardner, B., Rausser, G. (eds.) Handbook of agricultural economics, Vol. 1A, pp. 3–85. North Holland, Amsterdam (2001)
Nagatani, K.: Substitution and scale effects in factor demands. Can. J. Econ. **11**(3), 521–527 (1978)
Nickell, S., Andrews, M.: Unions, real wages and employment in Britain 1951–79. Oxf. Econ. Pap. **35**(Supplement), 183–206 (1983)
Nickell, S.: Biases in dynamic models with fixed effects. Econometrica **49**(6), 1417–1426 (1981)
Oi, W.Y., Idson, T.L.: Firm size and wages. In: Ashenfelter, O.C., Card, D. (eds.) Handbook of labor economics, vol. 3B, pp. 2629–2710. North Holland, Amsterdam (1999)
Peichl, A., Popp, M.: Can the labor demand curve explain job polarization? Institute of Labor Economics, IZA Discussion Paper No. 15361 (2022)
Peichl, A., Siegloch, S.: Accounting for labor demand effects in structural labor supply models. Labour Econ. **19**, 129–138 (2012)
Popp, M.: Minimum wages in concentrated labor markets. Bavarian Graduate Program in Economics, BGPE Discussion Paper No. 214 (2021)
Ragnitz, J.: Explaining the East German productivity gap: the role of human capital. Kiel Institute for the World Economy, Kiel Working Paper No. 1310 (2007)
Rauch, J.E., Trindade, V.: Information, international substitutability, and globalization. Am. Econ. Rev. **93**(3), 775–791 (2003)
Raudenbush, S.W.: Random effects models. In: Cooper, H., Hedges, L.V. (eds.) The Handbook of research synthesis, pp. 302–321. Russell Sage Foundation, New York (1994)
Revenga, A.: Employment and wage effects of trade liberalization: the case of Mexican manufacturing. J. Law Econ. **15**(S3), 20–43 (1997)
Rhein, T., Trubswetter, P., Nisic, N.: Is occupational mobility in Germany hampered by the dual vocational system? The results of a British-German comparison. J. Context. Econ. **133**(2), 203–214 (2013)
Riphahn, R.T., Thalmeier, A., Zimmermann, K.F.: Schaffung von Arbeitsplätzen für Geringqualifizierte. Institute of Labor Economics, IZA Research Report No. 2 (1999)
Rodrik, D.: Has globalization gone too far? Institute for International Economics, Washington, D.C. (1997)
Rosen, S.: Short-run employment variation on class-I railroads in the U.S.,1947-1963. Econometrica 36 (3–4), pp. 511–529 (1968).
Sakai, Y.: Substitution and expansion effects in production theory: the case of joint production. J. Econ. Theory. **9**(3), 255–274 (1974)
Schnabel, C.: United, yet apart? A note on persistent labour market differences between western and eastern Germany. J. Econ. Stat. **236**(2), 157–179 (2016)
Schneider, H., Rinne, U.: The labor market in Germany, 2000–2018. IZA World of Labor **379**, 1–12 (2019)
Schneider, H., Zimmermann, K.F., Bonin, H., Brenke, K., Haisken-DeNew, J., Kempe, W.: Beschäftigungspotenziale einer dualen Förderstrategie im Niedriglohnbereich. Institute of Labor Economics, IZA Research Report No. 5 (2002)
Senses, M.Z.: The effects of offshoring on the elasticity of labor demand. J. Int. Econ. **81**(1), 89–98 (2010)
Simonovska, I.: Income differences and prices of tradables: insights from an online retailer. Rev. Econ. Stud. **82**(4), 1612–1656 (2015)
Sinn, H.-W., Holzner, C., Meister, W., Ochel, W., Werding, M.: Redesigning the welfare state: Germany's current agenda for an activating social assistance. Edward Elgar, Cheltenham (2006)
Slaughter, M.J.: International trade and labor-demand elasticities. J. Int. Econ. **54**(1), 27–56 (2001)
Smolny, W.: Wage adjustment, competitiveness and unemployment - East Germany after reunification. J. Econ. Stat. **229**(2–3), 130–145 (2009)
Stanley, T.D., Doucouliagos, H.: Neither fixed nor random: weighted least squares meta-analysis. Stat. Med. **34**(13), 2116–2127 (2015)
Stanley, T.D.: Beyond publication bias. **19**(3), 309–345 (2005)
Stigler, G.J.: The economics of minimum wage legislation. Am. Econ. Rev. **36**(3), 358–365 (1946)
Tang, J.-L., Liu, J.L.: Misleading funnel plot for detection of bias in meta-analysis. J. Clin. Epidemiol. **53**(5), 477–484 (2000)
Tinsley, P.A.: A variable adjustment model of labor demand. Int. Econ. Rev. **12**(3), 482–510 (1971)
Trejo, S.J.: Overtime pay, overtime hours, and labor unions. J. Law Econ. **11**(2), 253–278 (1993)
Wright, P.G.: The tariff on animal and vegetable oils. Macmillan, New York (1928)
Zellner, A.: An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. J. Am. Stat. Assoc. **57**(298), 348–368 (1962)
Zellner, A., Theil, H.: Three-stage least squares: simultaneous estimation of simultaneous equations. Econometrica **30**(1), 54–78 (1962)

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