Essays on Minimum Wages, Labour Supply and Public Finances

The German Experience over the Last Two Decades

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Dipl.-Vw. Maximilian Joseph Blömer

Präsidentin der Humboldt-Universität zu Berlin:
Prof. Dr. Julia von Blumenthal

Dekan der Wirtschaftswissenschaftlichen Fakultät:
Prof. Dr. Daniel Klapper

Gutachter:
1. Prof. Bernd Fitzenberger, Ph.D.
2. Prof. Dr. Andreas Peichl

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Abstract

This dissertation consists of three essays on the minimum wage, labour supply, and public finances. The selected essays focus on the German experience and developments over the last two decades.

The first essay is an analysis of unemployment effects of the German minimum wage in an empirical equilibrium job search model. An equilibrium search model is estimated using German administrative data and used for counterfactual analyses of a uniform minimum wage. The model with worker and firm heterogeneity does not restrict the sign of employment effects a priori; it allows for different job offer arrival rates for the employed and the unemployed and lets firms optimally choose their recruiting intensity. Results show that unemployment is a non-monotonic function of the minimum wage level. Effects differ strongly by labour market segment defined by region, skill, and permanent worker ability.

The second essay is on the topic of labour supply elasticities in Germany. In order to analyse recent trends in labour supply in Germany, a static discrete choice model of unitary household labour supply is estimated for each year 1998 to 2018. Findings are that own-wage labour supply elasticities implied by the models have increased over the last two decades, especially for couples around the turn of the century, and for single males. While females became less sensitive to their partner's wage, the responsiveness of males to the partner's wage slightly increased. A decomposition analysis, using counterfactual model-data combinations, shows that compositional changes in demographics play only a minor role in the shift in males' own- and cross-wage elasticities, since most of the changes in elasticities are driven by preferences or labour market restrictions. For females, changes in composition play a bigger role in the rise of elasticities.

The third essay reviews German public finances through the financial crisis 2008/2009. The German experience of the financial crisis was very different from that of most other European countries. Germany was hit by a very strong shock that was relatively concentrated on the exporting, manufacturing industries. In addition, the German labour market was very resilient during the crisis due to earlier labour market reforms and policy instruments facilitating labour hoarding. As a consequence, the public finances were only moderately affected and not many policy reforms had to be enacted. The essay starts with a presentation of the macroeconomic situation and how the crisis unfolded in Germany, before focusing on the situation of the public finances. Finally, the distributional effects of policy responses to the financial crisis are analysed on the individual level using microsimulation.

Zusammenfassung

Diese Dissertation umfasst drei Aufsätze zu Mindestlöhnen, zum Arbeitsangebot sowie zu öffentlichen Finanzen. Der Fokus liegt dabei auf den Entwicklungen und Erfahrungen in Deutschland innerhalb der letzten zwei Jahrzehnte.

Der erste Aufsatz untersucht Beschäftigungseffekte des Mindestlohns in einem Modell der Sucharbeitslosigkeit. Dazu wird ein strukturelles Gleichgewichtsmodell mit Arbeitsmarktfriktionen mit administrativen Daten geschätzt und für kontrafaktische Analysen von Mindestlöhnen in Deutschland genutzt. Das Modell bildet die Heterogenität auf Arbeitnehmer- und Arbeitgeberseite ab und schränkt die Richtung der Beschäftigungseffekte nicht von vornherein ein. Es erlaubt eine unterschiedliche Frequenz der Stellensuche von Beschäftigten und Arbeitslosen und modelliert die Rekrutierungsintensität der Unternehmen. Die Ergebnisse zeigen, dass die Arbeitslosigkeit eine nicht-monotone Funktion des Mindestlohns ist. Die Auswirkungen von verschiedenen Mindestlöhnen unterscheiden sich stark nach Arbeitsmarktsegmenten in Ost- und Westdeutschland, sowie nach Qualifikation und Produktivität der Beschäftigten.

Der zweite Aufsatz befasst sich mit Arbeitsangebotselastizitäten in Deutschland. Um Trends in der Entwicklung des Arbeitsangebotsverhaltens zu analysieren, wird ein statisches diskretes Wahlmodell des Arbeitsangebots für die Jahre von 1998 bis 2018 geschätzt. Die von den Modellen implizierten Arbeitsangebotselastizitäten bezüglich des eigenen Lohns haben in den letzten zwei Jahrzehnten zugenommen, insbesondere für Paare und für alleinstehende Männer um die Jahrtausendwende. Während Frauen inzwischen weniger sensitiv auf Lohnerhöhungen ihres Partners reagieren, nahm die Sensitivität von Männern auf den Lohn ihrer Partnerin leicht zu. Eine Zerlegungsanalyse zeigt, dass Veränderungen in der Demografie nur eine geringe Rolle bei der Verschiebung der Eigen- und Kreuzlohnelastizitäten von Männern spielen, da der größte Teil der Veränderungen durch Präferenzen oder Arbeitsmarktrestriktionen bedingt ist. Bei Frauen hingegen spielen demografische Veränderungen eine größere Rolle für den Anstieg der Elastizitäten.

Der dritte Aufsatz befasst sich mit den deutschen Staatsfinanzen sowie mit Reformen aufgrund der Finanzkrise 2008/2009. Die deutsche Erfahrung mit der Finanzkrise unterschied sich stark von derjenigen der meisten anderen europäischen Länder. Insbesondere die exportorientierte, verarbeitende Industrie wurde von einem sehr starken Schock getroffen. Der deutsche Arbeitsmarkt war jedoch aufgrund früherer Arbeitsmarktreformen und politischer Instrumente wie Kurzarbeit während der Krise sehr widerstandsfähig. Daher wurden die öffentlichen Finanzen nur mäßig stark beansprucht und der Reformdruck war vergleichsweise gering. In dem Aufsatz werden zudem die Verteilungswirkungen der Reformen im Steuer- und Transfersystem mithilfe von Mikrosimulationen untersucht.

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Chapter 1.

Introduction

Since reunification, there have been many changes in the German labour market and various accompanying reforms have been implemented. While some policies are driven by global trends, there are also issues specific to Germany. Among the most important issues in Germany are increases in wage and income equality since the 1990s. Labour market participation and employment structures have changed. Employment among females has increased, and part-time jobs have become more common. The labour market reforms of the 2000s (the Hartz reforms) meant major structural changes. In the global financial crisis of 2008, Germany was hit by a strong shock in the manufacturing sector. Nevertheless, in Germany there were comparatively few policy measures during the subsequent European sovereign debt crisis, also due to existing instruments such as short-time work. The introduction of a uniform minimum wage in 2015 is another comprehensive measure, the effects of which continue to be studied academically. Other topics include migration and, more recently, the impact of the Corona pandemic and the war in Ukraine.

What has been the German experience over the last two decades? This dissertation contributes to the literature on this question. I focus on three economic areas and developments in Germany. The questions cover areas on frictional labour markets and heterogeneity in productivity (Chapter 2), trends in labour supply (Chapter 3), and public finances (Chapter 4). Chapters 2 and 4 include impact analyses of specific labour market reforms such as minimum wages and reforms as a response to the crisis 2008. Chapter 3 is an analysis of trends in labour supply elasticities over the last two decades. All research questions focus on the time before the Corona pandemic.

Methodologically, this dissertation heavily builds on the structural modelling of economic behaviour. Chapter 2 is based on an empirically estimated equilibrium job search model with heterogeneity on worker and firm side and endogenous recruiting intensity. The foundations of the model used in the second chapter build on the wage-posting model by Bontemps et al. (1999), which is extended in various dimensions. Search frictions may lead to market power which allows firms to set wages below the marginal productivity of labour. This feature has received increasing attention in the literature, accompanied by a resurgence of interest in monopsony models (e.g., Azar et al., 2019; Ashenfelter et al., 2022; Manning, 2021). Chapter 3 is based on an empirical discrete choice model of unitary household labour supply. Empirical approaches using discrete choice models have been pioneered by McFadden (1974). Work by van Soest (1995) and Aaberge et al. (1995) has led to a class of structural models and specifications that have become a standard for the analysis of household labour supply. In addition to these frameworks, Chapters 3 and 4 make use of microsimulation methods.

Chapter 2 is titled "Unemployment Effects of the German Minimum Wage in an Equilibrium Job Search Model" and is joint work with Nicole Guertzgen, Laura Pohlan, Holger Stichnoth, and Gerard J. van den Berg. In 2015, Germany introduced a statutory minimum wage at a uniform level of EUR 8.50. Prior to this, minimum wages had existed only at the sectoral level in a few industries. We study the employment effects of different minimum wages in the context of the German labour market around 2015. The effects of minimum wages on employment have been studied in a large literature using reduced-form approaches (see, for instance, the surveys by Bruttel, 2019 and Caliendo et al., 2019, for Germany, or the surveys by Dube, 2019 and Neumark, 2019 for international evidence). Most of these studies have found only small negative effects on employment and this result often serves as an argument by proponents of minimum wage increases (e.g. for the minimum wage increase to EUR 12.00 in Germany in 2022). However, ex-post studies do not provide an explicit sense for extrapolations as the level of minimum wages potentially has a non-linear effect. In this paper, we structurally estimate an equilibrium job search model that takes such non-linearities into account. Also, the wage-posting model with two-sided heterogeneity and endogenous recruiting intensity does not restrict the sign of unemployment effects of minimum wages a priori. Furthermore, the structural approach is informative about the underlying transmission mechanisms and allows us to assess the effects of counterfactual policies. Our empirical analysis relies on a large administrative data set, the IAB Sample of Integrated Employment Biographies, and we focus on full-time employment. We study the German labour market structure before the introduction of the uniform minimum wage in 2015 and analyse segments by region, skill group and permanent worker ability.

Using our structural model, we find that the introduction of the minimum wage of EUR 8.50 in 2015 had a small positive effect on the employment of the group of low- and medium-skilled individuals. This is driven by West Germany, where unemployment falls by 0.4 percentage points (5% of the benchmark level). For East Germany, the introduction of the minimum wage leads to an increase in the unemployment rate of 1.8 percentage points, or 20% of the benchmark level. Our estimates suggest that the segments of the German labour market differ in the distribution of reservation wages, firm productivity, search frictions, and the ensuing degree of employers' market power. These differences mean that, while the general mechanisms of the minimum wage effects on unemployment are the same throughout, they operate with different strength and set in at different levels of the minimum wage.

Chapter 3 is titled "Recent Trends in Labour Supply Elasticities in Germany". Labour supply has changed over the last decades. In particular, female labour force participation has increased and part-time work is now more common, also for males. These trends could be due to changes in real wages, changes in institutions or compositional changes. They could also be due to shifts in fundamental preferences, labour markets restrictions, or a mixture of the above. Because of simultaneous trends it is difficult to infer only from labour supply *outcomes* whether underlying preferences have in fact changed over time. A typical measure that summarises labour supply preferences, reflecting the individual consumption-leisure trade-off, is the own-wage elasticity.

There is extensive literature on labour supply elasticities for different subgroups, years, and time periods. By comparing results from various studies, time trends in elasticities can be found. While this can be done for some countries and subgroups (e.g., Bargain and Peichl, 2016), for Germany, there are too few methodologically comparable data points available to demonstrate robust trends, especially not for multiple subgroups. Therefore, I estimate a structural labour supply model for Germany for each cross-section 1998 to 2018, and document the evolution of implied labour supply elasticities over time. Currently, there is no estimation of elasticities for Germany with a consistent methodology over a longer time span. The unitary household labour supply model used is based on the structure proposed by van Soest (1995), which has become a standard in the literature. The estimations are performed using the German Socio-Economic Panel, a representative household survey, and a detailed microsimulation model for the German tax and transfer system.

I find that own-wage labour supply elasticities implied by the models have increased over the years 1998 to 2018. On the intensive margin, elasticities have continuously increased, especially for couples and single males. In contrast, for single females, there has only been moderate growth in their total labour supply elasticity. On the extensive margin, elasticities increased only for single males, while females became less sensitive to their own wage. Cross-wage elasticities for couples also changed. For males, the cross elasticities became more negative, meaning that the responsiveness to the partner's wage increased. In contrast, females became less sensitive to their partner's wage.

In order to check the relevance of composition changes over time, I conduct an analysis using counterfactual model-data combinations. This decomposition analysis reveals that compositional changes play only a minor role in the shift in elasticities for males, since most of the change in elasticities is driven by estimated preferences or labour market restrictions. Cross-wage elasticities of females are getting closer to zero, mainly due to a strong model effect. For couple-females, changes in composition play an equally strong role in the rise of elasticities as the changes in the model component. Notably, for single females, changes in behaviour and restrictions would have led to further shrinking elasticities over the last 20 years. However, changes in composition suggest an opposing effect which counterbalances this. In this chapter, I also discuss potential explanations for the increase in labour supply elasticity, in particular the model component.

Chapter 4 is titled “German Public Finances through the Financial Crisis” and is joint work with Mathias Dolls, Clemens Fuest, Max Löffler, and Andreas Peichl. We investigate the German experience of the financial crisis 2008/2009 and discuss the impact on public finances and policy responses. As the global crisis unfolded 2008, global demand went down and the German economy was hit by a strong shock on the exporting, manufacturing industries. In 2009, exports fell by 14 percent and GDP by more than five percent. However, the German labour market was very resilient during the crisis. Policy instruments such as short-time work facilitated labour hoarding, leading to only mild effects on unemployment rates. As a response to the crisis, the German government enacted multiple policy reform packages. We break down the additional fiscal burden for the years after the crisis. The biggest changes in household taxation happened through ‘Economic Stability Plan 2’. We also present an analysis of the changes to the tax and benefit system introduced after the crisis using a microsimulation model. Most of the tax and benefit changes were not designed as a reaction to the crisis but resulted in a small increase in real net household income (below one percent on average). The tax and transfer changes after the crisis slightly decreased household income inequality as the lower two income deciles benefited more (up to 1.7 percent, in the first income decile).

The remainder of the dissertation consists of three chapters which are self-containing and can be read independently.

Chapter 2.

Unemployment Effects of the German Minimum Wage in an Equilibrium Job Search Model[1]

2.1. Introduction

A large number of empirical studies have examined the labour market effects of minimum wages (see Dube, 2019 and Neumark, 2019 for recent surveys). Most of these studies have found only small negative effects on employment. The absence of negative employment effects is often used as an argument by proponents of minimum wage increases. However, the ex-post studies of the effects of actually observed minimum wage levels provide only limited guidance about the potential effects of minimum wage increases if these effects are characterised by non-linearities (Christl et al., 2018; Neumark, 2019).

In this paper, we structurally estimate an equilibrium job search model that takes such non-linearities into account. Because of search frictions, employers have market power that allows them to set wages below the marginal productivity of labour. The effects of firms' market power on wages have received increasing attention in the literature, accompanied by a resurgence of interest in monopsony models (e.g., Ashenfelter et al., 2022; Manning, 2021). Azar et al. (2019) explicitly focus on how the employment effects of a minimum wage

[1]This chapter is joint work with Nicole Guertzgen, Laura Pohlan, Holger Stichnoth, and Gerard J. van den Berg. A previous version has been published as CESifo Working Paper 7160, as ZEW Discussion Paper 18-032, and in Pohlan (2018). We are grateful to Richard Blundell, Philipp Dörrenberg, Bernd Fitzenberger, Clemens Fuest, Mario Meier, Fabien Postel-Vinay, Jean-Marc Robin, Sebastian Siegloch, Jan Tilly, Carsten Trenkler as well as participants of a ZEW Workshop on Labour Market Policy Evaluations, the ZEW Summer Workshop on Structural Models for Policy Evaluation, the ESPE, EEA, SaM, VfS, and EALE conferences, a Workshop of the German Minimum Wage Commission and various seminars for helpful comments. We thank Andrew Shephard for kindly having shared programming routines with us. Financial support by the State of Baden-Württemberg is gratefully acknowledged. Paul König, Julius Koll and Pierre Poulon provided excellent research assistance.

depend on the degree of firms' monopsony power. While Azar et al. measure monopsony power using regional variation in the concentration of online job postings, our study derives monopsony power from structurally estimated parameters.

Our model is based on the wage-posting model by Bontemps et al. (1999). The model accounts for heterogeneity in both firms' productivity and unemployed workers' reservation wages. It does not restrict the sign of unemployment effects of minimum wages a priori and allows for non-linearities in the effects. Following Shephard (2017), we extend the model to allow for different job offer arrival rates for the employed and the unemployed and let firms optimally choose their recruiting intensity.

We study the employment effects of a minimum wage in the context of Germany, which introduced a statutory minimum wage in 2015. Prior to this, minimum wages had existed only at the sectoral level in a small number of industries. The minimum wage introduced in 2015 was set at a uniform level of EUR 8.50.[2] Estimating our model for a country in which a minimum wage was only recently introduced has an important advantage. The shapes of the heterogeneity distributions are important determinants of the magnitude of minimum wage effects. However, data from a market with a minimum wage are not informative on the shapes of the left-hand tails of these distributions, as the minimum wage effectively left-truncates wage outcomes (see e.g. Bontemps et al., 1999). To study counterfactual minimum wage effects, it is useful to have data from periods without minimum wages, as the latter data enable identification of the heterogeneity distributions across agents on larger parts of their support. In particular, in the German context, data from before 2015 allow for identification of the effects of minimum wages below the minimum wage that was imposed in 2015. In the paper, we return to the policy change in 2015 at various instances. Furthermore, we use the extensive quasi-experimental literature to validate the out-of-sample predictions of our model.

Our empirical analysis relies on a large administrative data set, the IAB Sample of Integrated Employment Biographies (SIAB). The SIAB is a two percent random sample of individuals subject to social security contributions during the time period 1975 to 2014. We focus on data from the period 2010–2013 and leave out 2014 because of potential anticipation effects. The SIAB data provide an ideal basis for estimating a structural equilibrium search model for several reasons. First and most importantly, the data allow us to precisely measure the duration of different labour market states and transitions between them, notably job-to-

[2]While a number of transitional measures respected existing collective agreements and those signed in the meanwhile, the uniform minimum wage applied to all industries by 2017 at the latest. A further transitory exemption was given to those industries where industry-specific minimum wages had already been introduced prior to 2015 via the Posting of Workers Act (*Arbeitnehmerentsendegesetz*). The bargaining parties in an industry subject to this legislation may request that the Federal Ministry of Labour declares its (minimum wage) agreement to be generally binding for the entire industry.

job as well as employment-to-unemployment transitions. These transitions are crucial to the identification of the model's central parameters, such as job arrival and destruction rates.

Second, as the data are based on employers' notifications to the social security authorities, they are less prone to measurement error than comparable information from survey data. Additional advantages over survey data include the larger sample size and absence of panel attrition. We focus on low- and medium-skilled individuals because for these groups the assumption of a wage posting model is more convincing than for high-skilled individuals. The SIAB data do not include information on hours worked. We therefore focus on full-time employment spells and disregard individuals who are employed part-time during the time period under consideration.

Estimating the model based on this sample, we demonstrate that our model does quite well in replicating unemployment rates and 1-year labour market transitions. We also show that the model's ability to replicate the data varies across different labour market segments. In addition to differences between East and West Germany, we document differences by skill group and permanent worker ability.

Using our structural model, we find that the introduction of the minimum wage of EUR 8.50 in 2015 had a small positive effect on the employment of this group. According to our simulations, the unemployment rate falls from 8.4% (in the baseline level without a minimum wage) to 8.1%, a decrease of 0.3 percentage points. The positive effect is driven by West Germany, where unemployment falls by 0.4 percentage points (5% of the benchmark level). For East Germany, the introduction of the minimum wage leads to an increase in the unemployment rate of 1.8 percentage points, or 20% of the benchmark level.

Our paper contributes to several strands of the literature on minimum wage effects. A first strand of literature has evaluated the introduction of the minimum wage in 2015 using quasi-experimental variation. These reduced-form studies have found no or at most a small negative effect on employment (see the surveys by Bruttel, 2019 and Caliendo et al., 2019 and Section 2.7.4 below). Connecting our findings to this literature, we document that our model is able to generate unemployment responses that are broadly consistent with these studies. A second strand of literature structurally models unemployment responses to minimum wage policies based on models with perfect competition (Ragnitz and Thum, 2008; Bauer et al., 2009; Knabe and Schöb, 2009; Braun et al., 2020). In such a framework, the effects of a minimum wage on employment can by construction only be zero (if the minimum wage is not binding) or negative. The predictions from these studies stand in sharp contrast to those from the quasi-experimental literature as well as to our findings that the minimum wage leads to a reduction (or at most a slight increase) in unemployment.

Most importantly, our paper is related to the literature quantifying minimum wage effects using structural search and matching models. See, e.g., the papers by Flinn (2006), Ahn et al. (2011) and Engbom and Moser (2022).[3] Our paper is the first that uses the extended wage posting model with reservation wage heterogeneity to study the effect of minimum wage policies on unemployment.[4] Engbom and Moser (2022) use a similar wage-posting model, extended for heterogeneity in workers' ability and search efficiency, to study the role of the minimum wage in the decline of earnings inequality in Brazil. In our framework, worker heterogeneity derives from heterogeneity in reservation wages, i.e. workers differ in their reservation wages by nature. We additionally allow for heterogeneous worker ability by segmenting the sample along observed skill groups and quartiles of worker fixed effects from a decomposition in the spirit of Abowd et al. (1999). Unlike in Engbom and Moser (2022), reservation wages also differ within labour market segments and firms do not use the value of a job applicant's reservation wage when setting their wage offer. This implies that unemployed workers may either accept or reject wage offers.

Our structural approach is informative about the underlying transmission mechanisms and, importantly, allows us to assess the effects of counterfactual policies. We find that, in the German context of 2010–2013, unemployment is a non-monotonic function of the minimum wage level, which is in line with recent reduced-form evidence for the United States (Clemens and Strain, 2021). A major contribution of our study is therefore that it allows us to assess the scope of unemployment neutral minimum wage increases. For a relatively wide range of minimum wage levels, the unemployment rate is slightly lower than its benchmark level because a higher share of the unemployed receive acceptable wage offers. This unemployment-reducing effect tapers out at a minimum wage level of about EUR 12.50 because there is little mass left in the reservation wage density beyond this point. Thereafter, unemployment is almost exclusively frictional. At a minimum wage of EUR 13.50, the unemployment rate reaches its baseline level again from below. The search frictions and hence the unemployment rate then continue to grow as firms respond to higher minimum wages by lowering their recruiting intensity.

Our estimates suggest that the different segments of the German labour market differ in the distribution of reservation wages, firm productivity, search frictions, and the ensuing degree of employers' market power. These differences mean that, while the general mechanisms of the minimum wage effects on unemployment are the same throughout, they operate with

[3]A related literature analyses structural models in which imperfect labour market competition arises from imperfect substitutability in workers' preferences across different jobs. The study by Hurst et al. (2022) embeds monopsonistic competition among homogenous firms into a directed search model framework to quantify short- and long-run distributional effects of an increase in the U.S. minimum wage. Berger et al. (2022) develop a similar framework with oligopsonistic labour markets to conduct a normative analysis of the optimal level of the minimum wage.

[4]Flinn (2006) applies a model with wage bargaining to analyze minimum wage effects; see also Breda et al. (2019). Finally, Drechsel-Grau (2022) opts for a model in which workers receive a fixed and exogenous share of output.

different strength and set in at different levels of the minimum wage.

The remainder of the paper is structured as follows: Section 2.2 gives a brief overview of the model. Section 2.3 provides a description of the data set and the construction of our main variables of interest, and Section 2.4 presents descriptive statistics. Section 2.5 outlines the estimation procedure. Section 2.6 contains the estimation results and graphical representations of the key steady-state relationships along with an analysis of the model's within-sample fit. Section 2.7 shows simulation results for the counterfactual introduction of different minimum wage levels and compares our findings with the quasi-experimental literature. Section 2.8 concludes.

2.2. Theoretical model

In this section, we provide a brief description of the model. The framework is based on the model by Bontemps et al. (1999), which is extended by allowing the job offer arrival rate to differ across employed and unemployed individuals and by letting firms optimally choose their recruiting intensity and thus the job offer arrival rates, as in Shephard (2017) and Engbom and Moser (2022). We start by describing firms' and individuals' strategies. Individuals maximise their expected steady-state discounted future income and differ by unobserved opportunity costs of employment denoted by b, which may include search costs and unemployment benefits. Later, we will also allow individuals to differ along other dimensions, by segmenting labour markets by skill group and permanent worker ability among others (see Section 2.2.1). The distribution of b is denoted by H, assumed to be continuous over its support $[\underline{b}, \overline{b}]$. Job offers arrive at endogenous rate $\lambda_u > 0$ ($\lambda_e > 0$) for the unemployed (employed) and are characterised by a draw from a wage offer distribution F with support $[\underline{w}, \overline{w}]$.[5] Note that, in contrast to directed search models, random wage offers rule out that wages drive job seekers' application and search behavior.[6] Layoffs arrive at constant rate δ. Unemployed individuals searching for a job face an optimal stopping problem, the solution to which consists in accepting any wage offer w such that $w > \phi$. Employed individuals, in contrast, accept any wage offers strictly greater than their present wage contract. By imposing this assumption, our model does not allow for job-to-job transitions

[5]By imposing the assumption that each job is characterised by a single, time-invariant wage, the model abstracts from wage growth resulting from human capital accumulation or pure seniority. See, e.g., the model by Bagger et al. (2014) who explicitly incorporate human capital accumulation into a job search model. To address this issue, we conduct various robustness checks with respect to the wage definition in our estimations (see Section 2.6.4).

[6]The question of whether random or directed search provide a more realistic description of search behavior is difficult to answer. While the study by Banfi and Villena-Roldán (2019) provides some evidence for directed search, the authors emphasise that explicit wage information is rather selective and that most job advertisements at best convey only implicit wage information. We are not aware of any study exploring the prevalence of directed search in Germany.

that are associated with wage cuts.[7] As in Mortensen and Neumann (1988) and Bontemps et al. (2000), the reservation wage is implicitly defined as

$$\phi = b + (\kappa_u - \kappa_e) \int_{\phi}^{\overline{w}} \frac{\overline{F}(x)}{1 + \frac{\rho}{\delta} + \kappa_e \overline{F}(x)} dx, \tag{2.1}$$

where ρ denotes individuals' discount rate, $\overline{F}(x) = 1 - F(x)$, and $\kappa_i = \frac{\lambda_i}{\delta}$, $i = u, e$. The distribution of reservation wages, A, is then given by

$$A(\phi) = H\left(\phi - (\kappa_u - \kappa_e) \int_{\phi}^{\overline{w}} \frac{\overline{F}(x)}{1 + \frac{\rho}{\delta} + \kappa_e \overline{F}(x)} dx\right). \tag{2.2}$$

Equating equilibrium flows into and out of unemployment[8], the number of unemployed individuals with a reservation wage no larger than ϕ for $\phi \leq \underline{w}$ is represented by

$$uA_u(\phi) = \frac{1}{1 + \kappa_u} A(\underline{w}). \tag{2.3}$$

For $\phi > \underline{w}$, the number is given by

$$uA_u(\phi) = \frac{1}{1 + \kappa_u} A(\underline{w}) + \int_{\underline{w}}^{\phi} \frac{dA(x)}{(1 + \kappa_u \overline{F}(x))}. \tag{2.4}$$

From this, one can derive the steady-state equilibrium unemployment rate as

$$u = \underbrace{\frac{1}{1 + \kappa_u} A(\underline{w})}_{\substack{\text{(1) unemployed} \\ \text{who accept any job offer}}} + \underbrace{\int_{\underline{w}}^{\overline{w}} \frac{dA(x)}{(1 + \kappa_u \overline{F}(x))}}_{\substack{\text{(2) unemployed} \\ \text{who accept/reject offers}}} + \underbrace{(1 - A(\overline{w}))}_{\substack{\text{(3) unemployed} \\ \text{who accept no offer}}} \tag{2.5}$$

[7]Postel-Vinay and Robin (2002) allow firms to counter outside offers that their workers receive from competing firms. Workers may accept lower wages than in their current job from more productive firms, by trading off lower wages today for increased chances of higher wages tomorrow. While our framework assumes that firms either cannot observe reservation wages or cannot pay different wages to workers with different reservation wages, the model by Postel-Vinay and Robin (2002) implies that firms offer unemployed workers their reservation wages. As a result, their model cannot capture positive employment effects of a minimum wage that arise from high-reservation wage workers accepting more job offers. Jolivet et al. (2006) allow for wage cuts by modelling reallocation shocks, which are drawn from the wage offer distribution and which workers cannot reject. In their model such reallocation shocks are formally equivalent to a layoff immediately followed by a job offer. While in their model the only alternative to acceptance is to become unemployed, heterogeneous reservation wages in our framework would create incentives for some workers to switch back to unemployment.

[8]For details see Bontemps et al. (1999, equations (2)–(5)).

Moreover, similar to Bontemps et al. (1999) one can show that in steady-state there exists a unique relationship between the unobserved distribution of wage offers and the observed distribution of earnings (i.e., *accepted* wages). Equating the flow of layoffs and upgraded wages of those with a wage lower than or equal to w and the flow of unemployed individuals accepting w, the distribution of earnings $G(w)$ is derived as

$$G(w) = \frac{A(w) - \left[1 + \kappa_u \overline{F}(w)\right] \left[\frac{1}{1+\kappa_u} A(\underline{w}) + \int\limits_{\underline{w}}^{w} \frac{1}{1+\kappa_u \overline{F}(x)} dA(x)\right]}{\left[1 + \kappa_e \overline{F}(w)\right] (1-u)}. \tag{2.6}$$

Each firm offers only one wage and incurs a flow p of marginal revenue per worker. Firms are heterogeneous in their productivity p. The distribution of p across active firms is denoted by $\Gamma(p)$ and is assumed to be continuous over its support $[\underline{p}, \overline{p}]$. Following Shephard (2017), firms choose their optimal level of recruiting intensity ν, which allows them to alter the rate at which they encounter potential employees independent of the offered wage rate. The cost of recruiting effort, c, is a function of ν and p, such that $c(\nu, p)$ may differ across firms. The recruiting cost function takes the form $c(\nu, p) = c(p) \cdot \nu^{\eta}/\eta$, with $c(p) > 0$ and $c(0, p) = 0$ for all p. To ensure convexity of this function, η needs to be greater than one. Shephard (2017) sets η equal to two. We set η equal to 1.75, which is closer to estimates based on German data.[9]

The number of workers that a firm attracts at wage w and recruiting intensity ν is denoted by $l = l(w, \nu)$. In what follows, the conditional firm size will be defined as $l(w, \nu) = \bar{l}(w, \nu) \cdot \nu / V$, with V representing the aggregate recruiting intensity:

$$V = \int\limits_{\underline{p}}^{\overline{p}} \nu(p) d\Gamma(p),$$

where $\nu(p)$ denotes the recruiting intensity of a firm with productivity p. The number of workers, $\bar{l}$, per unit intensity attracted by a firm that offers wage w solves

$$\bar{l}(w) = \frac{d(1-u)G(w)}{dF(w)},$$

[9] Using a stylised labour demand model, Muehlemann and Pfeifer (2016) estimate an elasticity of recruiting costs with respect to the number of hires of 1.3 to 1.4. In an earlier discussion paper version, the authors also provide estimates of the elasticity of job posting costs with respect to the number of hires, which amounts to about 1.7 to 1.8 (Muehlemann and Pfeifer, 2013).

and therefore

$$\bar{l}(w) = \frac{\kappa_e A(w)}{(1+\kappa_e \overline{F}(w))^2} + \frac{\kappa_u - \kappa_e}{(1+\kappa_e \overline{F}(w))^2}\left[\frac{1}{1+\kappa_u}A(\underline{w}) + \int_{\underline{w}}^{w} \frac{1}{1+\kappa_u \overline{F}(x)} dA(x)\right]. \tag{2.7}$$

It can be shown that $\bar{l}(w)$ is a non-decreasing function of the offered wage. Note that the last term distinguishes $\bar{l}(w)$ from the original model by Bontemps et al. (1999), where $\lambda_u = \lambda_e$ and therefore $\kappa_u = \kappa_e$. The term reflects that if $\lambda_u \neq \lambda_e$, the number of employed and unemployed individuals that are attracted by the firm at a wage w may differ from each other.

Each firm seeks to maximise its steady-state profit flow, by choosing its optimal wage $w(p)$ and recruiting intensity $\nu(p)$. The latter are determined by

$$(w(p), \nu(p)) = \underset{w(p),\nu(p)}{\operatorname{argmax}}\left[\overline{\pi}(w,p)\cdot\frac{\nu}{V} - c(\nu,p)\right].$$

$\overline{\pi}(p,w) = (p-w)\cdot\bar{l}(w,\nu)$ represents the expected profit flow per unit intensity, with $\bar{l}(w,\nu)$ denoting the size of a firm's labour force per unit intensity, such that $l(w,\nu) = \bar{l}(w,\nu)\cdot\nu/V$. The first-order condition defining the optimal recruiting intensity, ν, is given by

$$\frac{\overline{\pi}(w(p),p)}{V} = c(p)\cdot\nu(p)^{\eta-1}.$$

Following Shephard (2017), we set $\nu(p) = 1$ in the benchmark, such that $c(p) = \overline{\pi}(w(p),p)$ in the pre-reform setting.[10] With $w = K(p)$ denoting the function that maps the support of the productivity distribution Γ into the support of the wage offer distribution F, we have $F(K(p)) = \int_{\underline{p}}^{p}\nu(y)/V d\Gamma(y)$. With $\nu(p) = 1$ in the benchmark, $F(K(p)) = \Gamma(p) = \Gamma(K^{-1}(w))$. The solution to the optimal wage setting problem of a p-type firm is represented by

$$K(p) = p - \left\{\frac{\kappa_u(\underline{p}-\underline{w})}{(1+\kappa_u)(1+\kappa_e)}A(\underline{w}) + \int_{\underline{p}}^{p}\bar{l}(K(y))dy\right\}\frac{1}{\bar{l}(K(p))}. \tag{2.8}$$

To complete the model, the total flow of matches is given by $M(V,S)$, with V denoting the aggregate recruiting intensity as defined above. S is the number of employed and unemployed individuals weighted by their search effort, i.e. $S = s_u\cdot u + s_e\cdot(1-u)$, with s_u and s_e being the search effort of unemployed and employed individuals, respectively. M is assumed to increase in both, V and S, and to be concave and linearly homogeneous. The model is closed

[10] As shown by Shephard (2017, Appendix F.1), the worker equilibrium does not depend on the assumptions concerning the recruiting cost function.

by specifying unemployed and employed individuals' job offer arrival rates, λ_i, with $i = u, e$, as the search effort weighted meeting rates, such that $\lambda_i = s_i \cdot M(V, S)/S$. The matching function is parametrised as Cobb-Douglas, i.e. $M(S, V) = V^{\theta} \cdot S^{(1-\theta)}$. As in Shephard (2017), we set θ equal to 0.5.

2.2.1. Labour market segments

The model assumes that worker productivity is homogeneous and that worker heterogeneity derives solely from unobserved opportunity costs. This implies, for instance, that all workers draw offers from the same wage offer distribution. To relax this assumption, we follow Bontemps et al. (1999) and estimate the model by different labour market segments. In this way, we treat each segment as a separate labour market characterised by its own structural parameters and its own distributions of reservation wages and firms' productivities. Because each segment will feature its own wage offer distribution, this approach assumes that firms are able to observe the characteristics defining the segments. A further underlying assumption is that there is no mobility between segments and no competition among firms across different segments. As will be motivated in more detail below, we segment the labour market by region, skill group and permanent worker ability (see Section 2.3).

Apart from imposing homogeneous worker productivity, the model makes further assumptions, such as a uniform wage distribution for the employed and unemployed and exogenous job destruction rates. To assess the plausibility of these assumptions across labour market segments, we will use the separate estimations to explore the in-sample model fit by labour market segment (Section 2.6.3).

2.3. Data

Sample selection and variables Our empirical analysis uses German register data, the IAB Sample of Integrated Employment Biographies (SIAB). This administrative data set, which is described in more detail by Ganzer et al. (2017), is a two per cent random sample of all individuals who have at least one entry in their social security records between 1975 and 2017 in West Germany and between 1991 and 2017 in East Germany, respectively. The SIAB data cover approximately 80 per cent of the German workforce, providing longitudinal information on the employment biographies of 1,833,313 individuals. Self-employed workers, civil servants, and individuals doing military service are not included in the SIAB.

The data provide an ideal basis for estimating a structural equilibrium search model for several reasons. First and most importantly, the data contain daily information on employment records subject to social security contributions, unemployment records of benefit recipients as well as of registered job seekers. This permits us to precisely measure the duration of different labour market states and the transitions between them, notably job-to-job transitions as well as transitions between employment and unemployment (while receiving or not receiving benefits). Second, due to their administrative nature the data are less prone to measurement error than comparable information from survey data. Additional advantages over survey data include the larger sample size and a much more limited degree of panel attrition.

Sample selection proceeds in several steps. Before restricting the sample to a specific time span and population, we fill in missing values using all the information available in the full dataset (see Appendix A.1). For the estimation of our model, we construct a stock sample by keeping only those employment and unemployment spells[11] including the set date 1 January 2010 and restrict the sample to the period 2010 to 2013, i.e., the years before the introduction of the minimum wage on 1 January 2015. We omit 2014 so that our estimates are not affected by the potential anticipation of the minimum wage. This leads to a sample of 688,869 individuals.

From this sample we select only individuals who are part of the workforce. The data do not make it possible to distinguish between involuntarily unemployed individuals not receiving benefits and individuals who voluntarily left the labour force or who became self-employed or civil servants. To distinguish more precisely between voluntary and involuntary unemployment, we follow the assumptions proposed by Lee and Wilke (2009) (see Appendix A.2).

To focus on individuals in the workforce, we restrict the sample to individuals who are at least 20 years old and younger than 63 years. The sample is further restricted to low- and medium-skilled individuals.[12] We exclude highly skilled individuals because this group is less likely to be in a labour market that is characterised by a wage-posting mechanism. We then drop individuals who have missing values in the relevant observables such as daily wages and employment status, or in the variables that we use to define the sub-samples (region, skill level, permanent worker ability). Furthermore, we exclude agricultural jobs because their employment durations are often characterised by seasonality. This leads to a new sample size of 283,180 individuals.

The SIAB data do not include information on hours worked. We therefore focus on full-time employment spells and disregard individuals who are predominately part-time employed during the time period under consideration. Moreover, we exclude individuals if their relevant wage information comes from a part-time spell.[13]

[11] Details on the definition of the different labour market states are given in Appendix A.2.

[12] Details on the definition of the different skill groups are given in Appendix A.1.

[13] In our sample, 14.5% of our employees are predominantly part-time employed. For these workers, the median hourly wage amounts to EUR 11.28 (p25: 7.56; p75: 16.58). For predominantly full-time workers the median is EUR 17.09 (p25: 12.62; p75: 22.41).

To calculate hourly wages for full-time employment spells, we impute the number of hours worked based on information from the German Microcensus. The imputation is done separately by region, sex, sector, job classification, and skill group.[14]

In the model, each job is characterised by a single, time-invariant wage. For individuals who were employed on 1 January 2010, we compute this wage as the weighted average of the wages earned over the past year in the same job, where the weights are given by the length of time over which a particular wage was received. Likewise, the wage after an unemployment-to-employment spell is based on the weighted average over the first year after the transition.[15] To reduce the influence of outliers, we discard observations with implausibly low hourly wages (wages below EUR 3 or below the existing sectoral minimum wages). As will be explained below, we split our sample by quartiles of person fixed effects, in order to define our labour market segments based on permanent worker ability. To further mitigate the influence of outliers within quartiles, we truncate the resulting quartile-specific distributions at their first and 99th percentile. Overall, this procedure results in a lowest observed wage of EUR 3.64, which is close to what has been found based on survey data (Burauel et al., 2017). The resulting final sample contains information on 208,626 individuals.

The wage information in the IAB data is censored since there is an upper contribution limit in the social security system. We do not include observations with censored wages.[16]

Definition of labour market segments As spelled out in Section 2.2.1, estimating the model separately by labour market segments involves the assumption that there is no mobility between segments and no competition among firms across different segments. As individuals of different gender or age are likely to compete within one segment, we define the segments based on two regions (East Germany and West Germany including Berlin), two skill groups (low- and medium-skilled) and individual-specific (or 'permanent') worker ability (see Appendix A.6). The latter dimension is supposed to capture time-invariant productivity characteristics other than the formal educational attainment, which are typically not directly observed in data. To operationalise this 'permanent worker ability', we employ wage decompositions along the lines of Abowd et al. (1999) (henceforth referred to as AKM). Specifically, in a first stage, we use worker-specific fixed effects that were estimated on the universe of the Integrated Employment Biographies (IEB) in Germany (cf. Card et al., 2013, 2015), controlling for establishment-specific fixed effects. The details of this decomposition are in Appendix A.7.[17] We use the worker-specific fixed effects (or 'person fixed effects', or

[14]For details, see Appendix A.3.

[15]For details, see Appendix A.4.

[16]For details, see Appendix A.5. In a robustness check, we address this issue by replacing censored observations with imputed wages, following Gartner (2005).

[17]The information can be merged for the vast majority of individuals in our sample.

PFE) to break down labour markets by ability types, assigning individuals to quartiles of the PFE distribution. Next, we estimate and simulate the model separately for the labour market segments delineated by these quartiles.[18]

Overall, these dimensions allow us to define fairly well (though not perfectly) segmented labour markets in terms of worker mobility. Regarding region and skill groups, Tables A.1 and A.3 show that 95.9% of employment-to-employment transitions remain in the same region, and 98.6% remain in the same skill group. As for unemployment-to-employment transitions, 95.2% occur within the same region and 96.8% within the same skill group (see Tables A.2 and A.4).[19] While a transition from low to medium-skilled may measure a true acquisition of a vocational degree, it may also reflect some measurement error. The latter may arise from employers reporting a job's skill requirements rather than individuals' acquired degree. Finally, defining segments based on permanent worker ability has the advantage that the time-constant nature (over the period considered here) of person fixed effects rules out any transitions between different ability segments.

2.4. Descriptives

2.4.1. Transitions

Tables A.5 and A.6 in Appendix A.8 report the type, number, and share of transitions for our stock sample of individuals who were either unemployed (8.1%) or employed (91.9%) on 1 January 2010. Of the 191,710 individuals who were employed on this date, 69% stayed in their job for the next four years while 20% moved to another job and 11% became unemployed. Transitions in the other direction are much more frequent in relative terms: 48% of the 16,916 unemployment spells ended with a transition into regular employment during the four-year period after 1 January 2010. At the same time, 52% of individuals who were unemployed on this date remained without a job over the entire period.[20]

The table also breaks down these statistics by region, skill group and permanent worker ability. About 84% of the individuals in the sample worked or searched for a job in West

[18]One may consider a closer integration of the fixed effects into the structural model. This would not be trivial. There is an ongoing debate on the compatibility of AKM decompositions with search and matching models. For example, decompositions have been criticised for being ill-suited to identify the degree of sorting (see, e.g., Eeckhout and Kircher, 2011). As a more practical issue, the establishment-specific fixed effects that are identified from the German administrative data do not straightforwardly match the concept of an employer or a firm.

[19]Note that there are no transitions from medium skill to low skill because of our imputation procedure, which makes sure that individuals cannot lose their degree.

[20]Left-censoring can occur for the unemployment spells because in some of the data sources for unemployment benefit histories, recording starts at a fixed date which does not necessarily coincide with the beginning of the unemployment spell (see Appendix A.2).

Germany (including Berlin), the remaining 16% in East Germany. On 1 January 2010, the unemployment rate was higher in East Germany (11%) than in West Germany (8%). However, the fraction of unemployed individuals finding a new job over the four-year observation window was almost identical in East and West Germany (49% versus 48%). Looking at transitions of employed individuals, we find that most individuals stayed at their current employer, while around 20% of employed individuals in both West and East Germany changed their employer within the four years. The relative frequency of transitions into unemployment was higher in East Germany (13%) than in West Germany (10%).

Breaking down the sample by skill group, the unemployment rate for low-skilled individuals was twice as high as for the medium-skilled. As for permanent worker ability, the unemployment rate on 1 January 2010 varied between 19% in the bottom PFE quartile and 3% in the upper PFE quartile. The share of unemployment-to-employment transitions was highest in the second and third PFE quartile and lowest in the bottom and upper PFE quartile.

2.4.2. Durations

Figure A.1 in Appendix A.8 shows non-parametric Kaplan-Meier estimates of the survival function for remaining in the initial state (employment or unemployment) for the whole sample. The survival functions are also shown for the different sub-samples defined by region (Figures A.2), skill group (Figure A.3), and permanent worker ability (Figure A.4). In our estimation sample, the maximum duration of an unemployment spell is nine years.[21] Employment spells can in principle last over the whole observation period: 39 years in West Germany (1975–2013) and 22 years in East Germany (1992–2013).[22]

Transitions out of unemployment The chance of transitioning into employment is particularly high within the first year – about 60% of the unemployed were still without a job after twelve months (cf. panel (a) of Figure A.1). By the second year, about 50% of

[21]'Unemployment benefit I' (ALG I), a non means-tested transfer which is part of the unemployment insurance system, is typically paid for only one year (two years for older workers). Once ALG I runs out, the unemployed are entitled to the much lower and means-tested 'unemployment benefit II' (ALG II), which was introduced on 1 January 2005. Before 2005, ALG I was followed by 'Arbeitslosenhilfe' instead of ALG II. This means that individuals receiving 'Arbeitslosenhilfe' before 2005 were entitled to ALG II afterwards. However, spells of receiving ALG II are only recorded in the data from 1 January 2007 onwards. This makes 1 January 2005 the earliest starting point for unemployment spells in our estimation sample. These spells refer to those individuals who received ALG I benefits during 2005 and 2006 and who were entitled to ALG II afterwards (starting from 2007). As our sample covers the period 2010–2013, the maximum duration of an unemployment spell is nine years.

[22]1.16% of the employment spells are left-censored which means employment without interruption at the same firm since 1 January 1975 in West Germany or since 1992 in East Germany. We disregard employment spells recorded in 1991 in East Germany.

the unemployed had not found employment, and after the third year the survival function flattens out. As can be seen in panel (a) of Figure A.2, the pattern is similar for East and West Germany, but there is substantial variation across skill groups and permanent worker ability (Figure A.3 and Figure A.4). Low-skilled individuals' unemployment durations are higher than those of the medium-skilled. Regarding permanent worker ability, individuals in the bottom and upper quartile of the PFE distribution exhibit longer unemployment durations than those in the middle PFE quartiles.

Transitions out of employment For individuals who were initially employed, transitions can be either into another job (panel (b) of Figures A.1 to A.4) or into unemployment (panel (c)). The durations of employment spells that end because of unemployment are in general longer than employment spells that end in a job-to-job transition. With regard to employment-to-employment transitions, the probability of still being employed at the current employer is typically around 75% after fifteen years. The durations of employment spells do not differ significantly between East and West Germany. Along the dimension of permanent worker ability, employment stability increases with workers' position in the PFE distribution. Both for transitions into other jobs and for transitions into unemployment, the share of the employed who have left their initial job for one of these destinations is lower in the upper PFE quartiles.

2.4.3. Wage distributions

Figure A.5 in Appendix A.8 shows the distribution of wages before and after a labour market transition for the whole sample. As part of the descriptives, we include all three types of transitions (e $\rightarrow$ e, e $\rightarrow$ u, u $\rightarrow$ e) and also document the wage distributions for right- and left-censored spells. In the estimation, only the wages in the initial employment spell or after a transition from unemployment to employment will be used.

As expected, wages of individuals who change their job tend to be higher than wages before a transition into unemployment. Comparing wages before and after a job-to-job transition, we find that wages earned in the new job are on average slightly higher than the wages earned in the old position. Also in line with expectations, wages after an unemployment-to-employment transition tend to be relatively low. A sizeable fraction of the unemployed move to jobs paying less than EUR 8.50 an hour, the statutory minimum wage introduced in 2015, i.e. after our sampling period 2010–2013. This also holds within the different labour market segments defined by region (Figure A.6) and skill group (Figure A.7 in Appendix A.8). As for permanent worker ability, this share is typically very small for those in the upper quartiles of the PFE distribution (Figure A.8).

These figures also confirm the well-known facts that wages tend to be lower in East

Germany and tend to increase with workers' skills and their position in the PFE distribution.

2.5. Estimation

We begin this section by deriving the likelihood contributions of unemployed and employed workers, taking into account stock sampling as well as left- and right-censoring. We then outline the estimation procedure, which combines the likelihood function with a non-parametric estimate of the wage distribution.

Likelihood – unemployed workers As seen in Equation (2.5), the steady-state unemployment rate has three components. For individuals with low enough opportunity costs of employment, unemployment is purely frictional. In a second group, unemployment is driven by both search frictions and the opportunity cost of employment; these individuals will accept some job offers, but reject others. Finally, there is a third group for whom unemployment is permanent given the wage offer distribution F, as any wage offer is below their reservation wage. As a result, the likelihood contribution of an individual who is initially unemployed is a mixture distribution:

$$\lambda_u^{2-d_{ub}-d_{uf}} \cdot e^{-\lambda_u\left(t_{ub}+t_{uf}\right)} \cdot \frac{A(\underline{w})}{1+\kappa_u} \cdot f(w_u)^{1-d_{uf}}$$
$$+ \int_{\underline{w}}^{d_{uf}\overline{w}+(1-d_{uf})w_u} \left(\lambda_u \overline{F}(x)\right)^{2-d_{ub}-d_{uf}} \cdot e^{-\lambda_u \cdot \overline{F}(x)\cdot\left(t_{ub}+t_{uf}\right)} \cdot \frac{f(w_u)}{\overline{F}(x)}^{1-d_{uf}} \cdot \frac{dA(x)}{1+\kappa_u \overline{F}(x)}$$
$$+ \left[1 - A(\overline{w})\right] \cdot d_{ub} \cdot d_{uf}. \quad (2.9)$$

The first term of the sum corresponds to purely frictional unemployment. As job offers arrive with Poisson rate λ_u, unemployment durations are exponentially distributed. In a flow sample, where the elapsed ('backward') duration t_{ub} is zero by definition, the density of the residual ('forward') duration t_{uf} is given as $h(t_{uf}) = \lambda_u \exp(-\lambda_u t_{uf})$. In a stock sample, we need to consider the total duration $t_{ub} + t_{uf}$, conditional on the elapsed duration t_{ub}. The latter has the density $h(t_{ub}) = \lambda_u \exp(-\lambda_u t_{ub})$. It can be shown (e.g., Lancaster, 1990) that the conditional density $h(t_{uf}|t_{ub})$ is given as $\lambda_u \exp(-\lambda_u t_{uf})$. For the joint density we then obtain $h(t_{ub}, t_{uf}) = h(t_{uf}|t_{ub})h(t_{ub}) = \lambda_u^2 \exp\left(-\lambda_u(t_{ub} + t_{uf})\right)$, which is the term that figures in the likelihood expression above. The term in front of the exponential function is adjusted if either the elapsed or the residual duration is censored ($d_{ub} = 1$ or $d_{uf} = 1$). $f(w_u)$ is the density function of wage offers evaluated at the offer that we observe as the initially unobserved person transits into employment. If the unemployment duration is right-censored ($d_{uf} = 1$), this term drops out of the likelihood function.

The second term of the sum has the same basic structure, but with some adjustments for the fact that individuals in this group are sometimes faced with wage offers that are below their reservation wage. The unemployment spell hazard rate is therefore given not by λ_u, but by the product $\lambda_u \overline{F}(x)$. The second adjustment concerns the wage offer density, which is now truncated at x, so we have $f(w_u)/\overline{F}(x)$.[23]

Finally, the third term applied to individuals who, given F, are permanently unemployed. This implies that the observed unemployment spell must be both left- and right-censored, hence the factor $d_{ub} \cdot d_{uf}$.

Likelihood – employed workers For individuals who are initially employed, the likelihood contribution is

$$(1-u) \cdot g(w_e) \cdot \left[\delta + \lambda_e \overline{F}(w_e)\right]^{1-d_{eb}} \cdot e^{-\left[\delta+\lambda_e \overline{F}(w_e)\right]\left(t_{eb}+t_{ef}\right)} \left[\delta^v \left(\lambda_e \overline{F}(w_e)\right)^{1-v}\right]^{1-d_{ef}} . \quad (2.10)$$

In steady state, a fraction $(1-u)$ of all individuals is employed. g is the density of wages in the initial job. Unlike for the unemployed, the reservation wage of a worker is observed and equals his or her current wage, so there is no mixing distribution for the durations. However, there are now two competing reasons for why a spell may end: layoff (at rate δ) or a better job offer (at rate $\lambda_e \overline{F}(w)$). The indicator v equals 1 in the first case and 0 in the second. t_{eb} denotes the elapsed duration, and t_{ef} the residual duration of the current job. d_{eb} equals 1 if the elapsed duration is left-censored, while $d_{ef} = 1$ means that the residual duration is right-censored, i.e. the individual does not change his or her job during the observation period.

Estimation procedure Maximum likelihood estimation of the model requires functional form assumptions for H and Γ. The estimation is numerically cumbersome as f, g, and $\overline{F}$ are highly non-linear functions of Γ. In particular, optimisation involves the numerical computation of the inverse K^{-1}, further complicated by the fact that K contains an integral that has to be evaluated numerically as well. Beyond these numerical concerns, there is the issue that most distributions for Γ imply wage distributions that do not fit the data well.

As an alternative, Bontemps et al., 2000 therefore propose a three-step procedure in which the wage distribution is estimated non-parametrically:

1. In a first step, we estimate G and g (the cdf and pdf of the wage distribution) using a kernel density estimator, and estimate $\underline{w}$ and $\overline{w}$ as the sample minimum and maximum of the wages of workers who are employed on 1 January 2010. Based on these non-parametric estimates and a parametric assumption for the opportunity cost distribution,

[23]Note that as $\overline{F}(x) = 1$ for $x < \underline{w}$, the first term of the sum could be integrated into the second term. We choose to present them separately here to better reflect the conceptual difference between the three components behind the unemployment rate.

namely $H \sim \mathcal{N}(\mu_b, \sigma_b^2)$, and setting $\nu(p) = 1$ in the benchmark, we obtain consistent estimates for $\overline{F}$ and f (given $\mu_b, \sigma_b, \lambda_u, \lambda_e, \delta$ and the assumption that $\rho = 0.02$) by numerically solving the following expressions (recall that u is a function of $\overline{F}$):

$$\widehat{\overline{F}}(w) = \frac{A(w) - uA_u(w) - (1-u)\widehat{G}(w)}{\kappa_e \cdot \widehat{G}(w) \cdot (1-u) + \kappa_u \cdot u \cdot A_u(w)} \tag{2.11}$$

and

$$\widehat{f}(w) = \frac{(1-u) \cdot \widehat{g}(w) \cdot (1 + \kappa_e \widehat{\overline{F}}(w))}{\kappa_u \cdot u \cdot A_u(w) + \kappa_e \cdot (1-u) \cdot \widehat{G}(w)}. \tag{2.12}$$

2. The estimates from Step 1 are plugged into the likelihood function, which is then maximised with respect to μ_b, σ_b, λ_u, λ_e, and δ.

3. Once these parameters are known, the productivity of a firm can be inferred from the wage that it offers:

$$\begin{aligned} p &= K^{-1}(w) \\ &= w + \left(\frac{\kappa_u \cdot A'(w) \cdot (1 + \kappa_e \cdot \widehat{\overline{F}}(w))}{(1 + \kappa_u \cdot \widehat{\overline{F}}(w)) \cdot (\kappa_e A(w) + (\kappa_u - \kappa_e)) \cdot u \cdot A_u(w)} + \frac{2 \cdot \kappa_e \cdot \widehat{f}(w)}{1 + \kappa_e \cdot \widehat{\overline{F}}(w))} \right)^{-1} \end{aligned} \tag{2.13}$$

Standard errors are obtained by bootstrapping the three-step procedure.

2.6. Estimation results

2.6.1. Parameter estimates

Table 2.1 reports the estimated parameters and the associated bootstrap standard errors.[24] For the whole sample, we estimate a monthly job destruction rate δ of 0.0063. The rate is about 20% higher in East Germany than in the West (0.0073 vs. 0.0061). Regarding permanent worker ability, the job destruction rates decline monotonically with workers' position in the PFE distribution, from 0.0126 in the lowest quartile to 0.0046 in the highest quartile. The same is true for the skill groups, with an estimated job destruction rate of 0.074 for the low-skilled versus 0.062 for the medium-skilled. These orders of magnitude are similar to earlier studies. For France in the 1990s, Bontemps et al., 1999 find a δ between 0.0032 and 0.0069, depending on the sector. Using SIAB data for an earlier period (1995–2000),

[24]While multiple equilibria cannot be ruled out (see van den Berg, 2003), we have not found evidence of this for any of our estimated or simulated equilibria.

Table 2.1.: Estimation results

	N	δ	κ_e	κ_u	μ_ϕ	σ_ϕ
Whole sample	208626	0.0063	7.10	20.06	6.50	3.60
		(0.0000)	(0.10)	(0.32)	(0.02)	(0.05)
Region						
West	176205	0.0061	7.51	20.85	6.79	4.11
		(0.0000)	(0.10)	(0.34)	(0.05)	(0.06)
East	32421	0.0073	5.11	18.23	5.90	3.48
		(0.0000)	(0.16)	(0.67)	(0.05)	(0.09)
Skill group						
Low-skilled	15542	0.0074	5.59	13.74	5.41	4.93
		(0.0001)	(0.30)	(0.84)	(0.17)	(0.23)
Medium-skilled	193084	0.0062	7.33	20.63	6.59	3.44
		(0.0000)	(0.10)	(0.33)	(0.05)	(0.04)
PFE quartile						
Quartile 1	37049	0.0126	1.97	7.44	4.67	4.09
		(0.0001)	(0.04)	(0.58)	(0.21)	(1.09)
Quartile 2	67970	0.0079	4.76	20.08	7.57	4.56
		(0.0000)	(0.07)	(0.39)	(0.04)	(0.07)
Quartile 3	69438	0.0053	6.28	32.34	10.36	4.46
		(0.0000)	(0.16)	(0.93)	(0.04)	(0.09)
Quartile 4	34169	0.0046	5.24	32.03	12.87	6.22
		(0.0000)	(0.23)	(1.53)	(0.07)	(0.09)

Note: The table reports the estimated parameters for the whole sample, and for subsamples by region, skill group and quartiles of person fixed effects. Data: SIAB-R 7517. Stock sample 1 January 2010. Estimation period 2010–2013. The monthly job destruction rate is denoted as δ. κ_u and κ_e denote the ratios of the job arrival over the job destruction rate for the unemployed and the employed, respectively. μ_ϕ and σ_ϕ denote the mean and the standard deviation of the reservation wage distribution. We set the discount rate ρ to 0.02. Bootstrapped standard errors in parentheses (250 runs).

Nanos and Schluter, 2014 estimate the monthly layoff rate to be between 0.0032 and 0.0243 in Germany. Holzner and Launov (2010), who use data from the German Socio-Economic Panel 1984–2001, estimate a δ of 0.0047.

The estimated κ, i.e., the ratio of the job arrival over the job destruction rate, is greater for the unemployed than for the employed. We find κ_u to be 20.06 and κ_e to be 7.10. Holzner and Launov find a κ_e of 2.2, while their three values of κ for the unemployed (they assume that individuals search on skill-specific labour markets) range between 5.6 and 17.1. In their study for France, Bontemps et al. (2000) also estimate a much higher job arrival rate for the unemployed than for the employed. In all cases, this reflects that continental European labour markets are characterised by relatively little job-to-job mobility compared with the

United States.

The differences between labour market segments are potentially relevant for the design of the new statutory minimum wage in Germany. After a transition period, the minimum wage became uniform for all workers by 2017 at the latest. Our results suggest that the uniform rate applies to labour market segments that differ in the extent of search frictions and thus in firms' monopsony power on the labour market.[25]

As we restrict the parameters in the likelihood function to be positive, the distribution of the opportunity costs of employment has a mean μ_b close to EUR 0 per hour.[26] The standard deviation σ_b is estimated to be 3.6 for the whole sample. However, unlike in the model of Bontemps et al., 1999, the reservation wages are not identical to the opportunity costs of employment. This is because job offer arrival rates are higher when unemployed, so it is optimal for the unemployed to reject certain wage offers in the hope of getting a higher offer in the future (cf. Equation (2.1)). Based on the estimated parameters, we find that the distribution of reservation wages is centred around a value of about EUR 6.50 per hour. The reservation wage is higher and slightly more dispersed in the West and increases monotonically with workers' position in the PFE distribution and with the acquired skill level.

Due to the above restriction in our estimation, the differences in the reservation wages between the sub-samples are exclusively driven by differences in the frictional parameters. For instance, the difference between κ_u and κ_e is much larger in the fourth quartile than in the first quartile of the PFE distribution, which is reflected in a much higher μ_ϕ for workers with higher ability. Note that differences in κ_u and κ_e reflect differences in both job offer arrival and layoff rates. The higher the layoff rate, the smaller the expression $\beta \equiv \rho/\delta$ in Equation (2.1), and thus the smaller the incentive for the unemployed to be picky when accepting a wage offer – after all, accepting a job means giving up a higher job arrival rate. If the job has a higher probability of ending, the costs of accepting it in terms of foregone

[25]Bachmann and Frings (2017) adopt a different approach to quantify labour market frictions in Germany and estimate labour supply elasticities specific to the individual firm. Using linked employer-employee data from the IAB (LIAB), the authors document substantial differences in employers' market power across industries. Their findings indicate that retailing, hotels and restaurants and agriculture feature a larger degree of monopsonistic power than other services and manufacturing of food products. Bachmann et al. (2022) document that the degree of monopsony power that workers in Germany are exposed to differs by the tasks they perform. Furthermore, Hirsch et al. (2022) show that due to the greater density of labour markets, employers have less wage-setting power in urban than in rural areas.

[26]While this restriction makes sense for the job offer arrival and destruction rates as well as for the variance of the opportunity costs, there is no strong reason to impose it for the mean. When we abolish the restriction, we find a mean that is actually slightly negative for the whole sample and many of the sub-samples. In fact, there are issues with the separate identification of μ_b and σ_b on the one hand and κ_u on the other hand (κ_e is pinned down by observed employment-to-employment transitions), which all enter the expression for the reservation wage distribution $A(\phi)$. The latter matters for the empirical predictions and is hardly affected by the lifting of the restriction.

employment opportunities become smaller.

2.6.2. Distribution of wages, opportunity costs, markups, productivity

Figure 2.1 shows key plots summarising the steady-state equilibrium.[27] Panel (a) depicts our non-parametric estimate for g, the pdf of the wage distribution. The cdf G, which is not shown here, is similarly estimated using a kernel density estimator.

The wage offer distribution F (panel (b)) is obtained by combining the estimate for G with the maximum likelihood estimates for the frictional parameters and the opportunity cost distribution, as outlined in Section 2.5 above. The location and the shape of the wage offer distribution differ from the wage distribution. For instance, more than 70% of the wage offers, but only about 10% of observed wages are below EUR 10.

Panel (c) shows the estimated distribution of reservation wages. This is a normal distribution centred around EUR 6.50 and truncated at EUR 3.64, the lowest admissible hourly wage. Note that there is hardly any mass left beyond EUR 12.50.[28] This means that the unemployment-reducing effect of higher minimum wages operating through a lower rate of job offer rejections will be mostly limited to minimum wage levels below this amount.

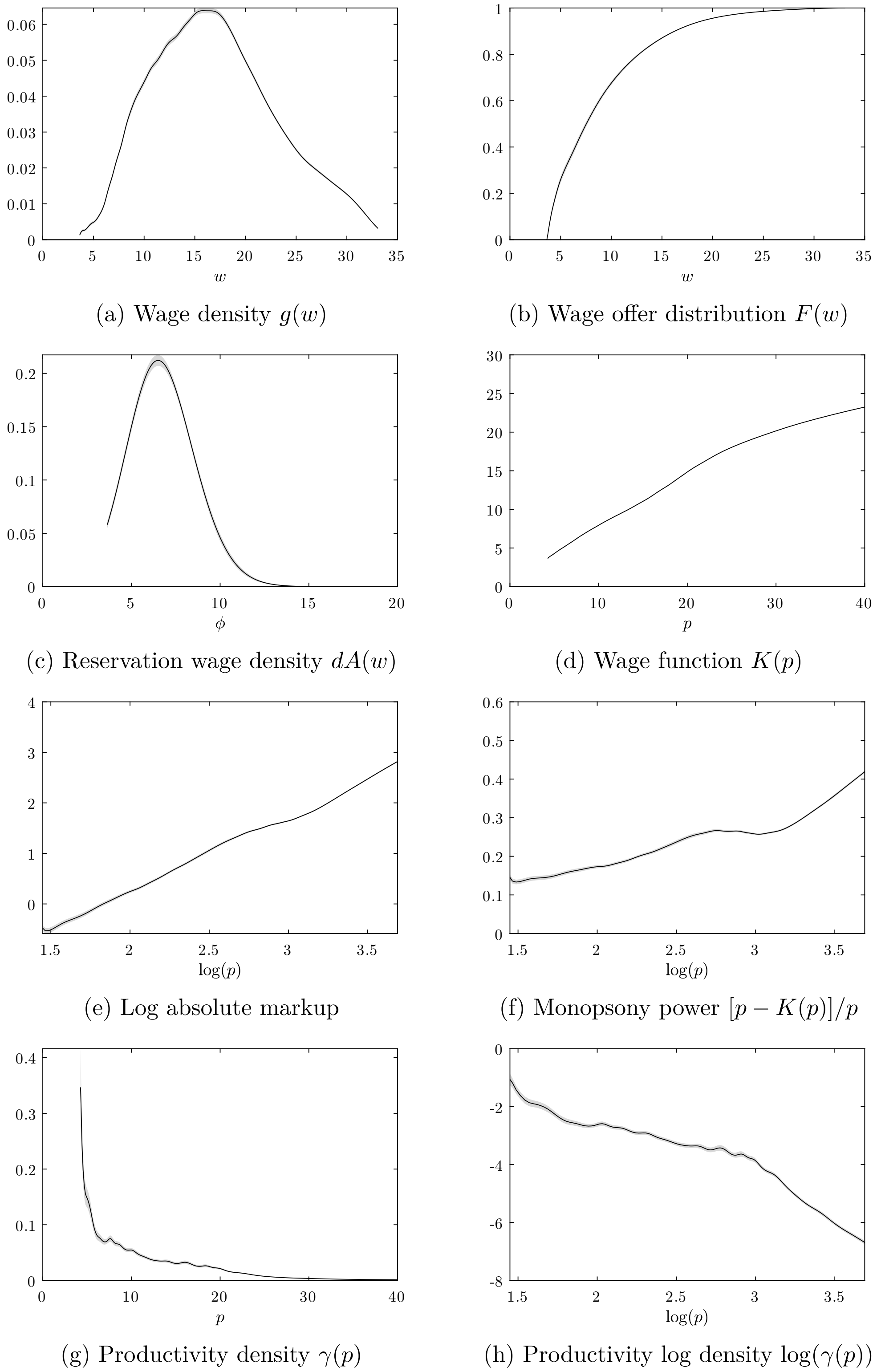
Panel (d) presents the optimal wage offer as a function of firm productivity p. For example, a firm with a value product of EUR 20 per hour will optimally set a wage of about EUR 15 per hour. The function reveals a monotonically increasing relationship between wages and productivity.[29] As the slope of wage offer function decreases with productivity, high productivity firms exhibit more monopsony power.

The absolute markup, which is shown in a log-log-scale in panel (e), grows monotonically and at a fairly constant rate with a firm's productivity. Expressed as a percentage of productivity (panel (f)), the relationship is no longer (log-)linear: there is a relatively slow increase first, a plateau at productivity levels around EUR 15–20, and a strong increase thereafter. While the lowest-productivity firm has a markup of about 15%, the markup is over 40% for the firms with the highest productivity. Put differently, workers obtain less than 60% of the value product in these high-productivity firms. However, as the estimate of the productivity density γ in panel (g) makes clear, such cases are fairly rare. Most firms have a value product of less than EUR 20 per hour, and there is hardly any mass left beyond EUR 40 per hour. Finally, panel (h) shows that our three-stage estimate of firm productivity

[27]The plots are for the whole sample. Plots by region, skill group, and permanent worker ability can be found in Figures A.9 to A.11 in Appendix A.9.

[28]The distribution of reservation wages is very close to the one estimated by Fedorets and Shupe (2021) based on a survey question from the Socio-Economic Panel.

[29]As this pattern is not guaranteed by the non-parametric estimation procedure described in Section 2.5, the monotonicity provides a check of whether the observed distribution of wages may be an equilibrium outcome from the model.



(a) Wage density $g(w)$
(b) Wage offer distribution $F(w)$
(c) Reservation wage density $dA(w)$
(d) Wage function $K(p)$
(e) Log absolute markup
(f) Monopsony power $[p - K(p)]/p$
(g) Productivity density $\gamma(p)$
(h) Productivity log density $\log(\gamma(p))$

Figure 2.1.: Main equilibrium functions, whole sample. *Note:* This figure shows the main equilibrium functions summarizing the steady-state for the estimates for the whole sample. Ordinate outcomes can be found in the subfigures' titles. Wages and productivity are measured in EUR. *Key:* Grey area indicates 95% confidence bands based on 250 bootstrap runs.

results in a (non-parametric) distribution that is not too dissimilar from a Pareto distribution in that the density γ is a straight line in log-log-coordinates over the relevant range of p.

The main equilibrium functions for the different labour markets defined by region, skill group, and permanent worker ability can be found in Appendix A.9. Both the wage density and the wage offer distribution in West Germany lie to the right of the curves for East Germany. Firms in West Germany tend to be more productive, and they also offer higher wages for any given productivity level above EUR 15-20 per hour. Below this range, the wage offer functions are almost identical in the East and in the West. This difference in wage setting is mirrored in the distribution of markups, which are higher in East Germany for productivity levels of about EUR 15 and more. The relative markup in East Germany grows monotonically with productivity, while in West Germany there is a decline over a short range; these different shapes explain the plateau that is observed for the sample as a whole.

The estimates also reveal considerable heterogeneity across skill groups and permanent worker ability. While the differences across skill groups are not that clear-cut, the differences across PFE quartiles exhibit the expected pattern, with wage and wage offer distributions in the higher permanent ability segments lying to the right to the respective distributions of their lower ability counterparts. Note that the correlation between reservation wages and permanent worker ability indicates that a great deal of unobserved heterogeneity is already captured by heterogeneity in reservation wages. There are also clear differences in wage-setting policies. Monopsony power decreases with the acquired skill level. For the low-skilled segment, the absolute markup exhibits a relatively flat increase at lower productivity levels, which results in a U-shaped pattern of the relative monopsony power. Monopsony power also generally decreases with permanent ability, even though some non-monotonicities in the relationship between productivity and monopsony power for the third and fourth PFE quartile counteract this pattern.

2.6.3. Within-sample model fit

To explore the within-sample model fit, we compare several simulated model outcomes with their empirical analogues. In a first step, we investigate the model's ability to fit the data for the whole sample. Second, because the plausibility of our model assumptions may vary across labour markets, we also explore the model fit by labour market segment.

We start by computing the steady-state unemployment rate u implied by our estimates (see Equation (2.5)). For the entire sample, we find a predicted rate of 8.4%, which is close to the rate of 8.1% observed in our stock sample (Table A.9 in Appendix A.10). The variation in the predicted rate across regions, skill groups, and permanent worker ability is consistent with the patterns observed in the sample, i.e. steady-state unemployment is higher in the

East than in the West and decreases with skills and permanent worker ability (with the exception of the predicted difference in u between the third and fourth PFE quartile). The model overpredicts unemployment for the medium-skilled and for the upper quartiles of the PFE distribution, while it underpredicts the rate in East Germany, for the low-skilled and the lower PFE quartiles. While the overall fit is less satisfactory across worker ability segments and for the low-skilled, the differences in predicted and empirical unemployment rates for the other segments are small.

In order to explore the mechanisms behind the model's ability to predict u, we next turn to the transitions between labour market states. Table A.8 in Appendix A.10 compares simulated and empirical one-year transition rates. The model does a reasonable job in predicting these transitions and, in line with what was found for the unemployment rate, replicates the variation across segments very well. Keeping in mind that these transition rates are complex functions of underlying determinants, we discuss possible explanations for imperfections in the fit. Predicted job finding rates may be affected by the assumption that employed and unemployed individuals draw from the same wage offer distribution. This could imply that wage offers to the unemployed are overestimated. How well the approximation of an identical distribution works depends on how important the returns to on-the-job experience are in a particular labour market segment. Low-skilled individuals have been found to exhibit lower returns to experience (Dustmann and Meghir, 2005).[30] The assumption of an identical wage offer distribution for the unemployed and the employed is therefore more plausible for this group than for the medium-skilled, which is reflected in a better fit for the unemployment-to-employment transitions among low-skilled workers and the bottom half of the PFE distribution. As job offer arrival rates are determined by λ_u as well as F, we also compare the wage offer distribution F that results from the model with the empirical distribution of wages accepted by individuals who are currently employed at very low wages close to $\underline{w}$.[31] Figure A.12 in Appendix A.10 shows that the closer fit for the unemployment-to-employment transitions of the low-skilled and the lower PFE quartiles goes hand in hand with a better fit for F in this direct test.

From Table A.9, we see that despite the good fit of the unemployment-to-employment transitions, the model underpredicts the unemployment rate for the low-skilled. Column (3) and (6) of Table A.8 show that part of this discrepancy may be explained by an underprediction of low-skilled workers' employment-to-unemployment transitions. A similar

[30]The authors show that low-skilled workers in Germany exhibit significant wage growth in the first two years of work, but virtually no real wage growth afterwards. The wages of (medium) skilled workers, in contrast, exhibit positive returns to experience throughout their working life.

[31]This is based on the idea that these individuals would accept any other job offer, such that the distribution of wages that low-wage individuals receive on their next job provides a direct estimate of the wage offer distribution even in the presence of reservation wage heterogeneity (see also Shephard, 2017).

pattern may be observed for workers in the lower PFE quartiles. This suggests that the assumption of exogenous job destruction rates may be less innocuous for these groups.

We now turn to the fit of the unemployment duration distribution, focusing on the duration dependence of the transition rate from unemployment to employment. Please notice that the structural equilibrium model already predicts negative duration dependence driven by heterogeneity in the workers' values of b, so we look for evidence of duration dependence in the data over and above what is captured by the structural model. Figures A.13 and A.14 in Appendix A.10 show Kaplan-Meier survival curves for the transitions over 48 months. Clearly, at low durations the duration dependence is slightly more positive than what the estimated model predicts whereas at high durations the opposite applies. It seems that the estimated model reflects a compromise between the fit at low durations and the fit at high durations and as a result it slightly underestimates the positive duration dependence at low durations and it underestimates (in absolute sense) the negative duration dependence at high durations.[32]

Finally, the model tends to overpredict employment-to-employment transitions. The fit is better for West Germany, the medium-skilled and the upper PFE quartiles (Columns (2) and (4) in Table A.8). For these groups, the differences between predicted and empirical rates are smaller than one percentage point.

2.6.4. Robustness checks

Table A.7 in Appendix A.9 reports results from a number of robustness checks for the whole sample. First, instead of disregarding individuals with wages right-censored at the upper limit for social security contributions (SSC), we use a Tobit regression to impute wages above this limit. Second, we replace the imputation of working hours with the assumption that all full-time employees work 40 hours per week. Third, we experiment with different ways of assigning a single wage to employment spells that last over several years, during which time individuals typically experience wage increases. In the theoretical model, this cannot happen as each job is characterised by a single, time-invariant wage. In our main specification, we use the average wage in the same job over the past year. In further robustness checks,

[32]We formalise this in a test by re-estimating the full model with an ad hoc extension of the likelihood in which we multiply the hazard for the unemployed by a term $\psi \cdot t^{\psi-1}$. Note that this extension is not meaningful in the context of the structural equilibrium model. Rather, it is a convenient way of checking whether the unemployment duration data fit the model. The test confirms the presence of mild positive duration dependence at durations below a year, over and beyond what is captured by the structural model through the heterogeneity in b. The model does not fit well the fraction of unemployed in the data with almost infinitely long unemployment durations. This may be because the normal distribution for b is too restrictive. Alternatively, some individuals who are classified in the data as being unemployed throughout the observation interval may actually not be in the labour force. This may be because in register data, classification into unemployment is not based on the ILO definition of unemployment but instead relies on the receipt of unemployment benefits.

we use the last observed wage only. Additionally, we use the average wage over the whole employment spell instead of the average annual wage. These measures differ from our baseline specification to the extent that individuals experience wage changes within the last year or over the whole employment spell. Fourth, we truncate the wage distribution at a different level. In our main specification, wages below EUR 3.00 per hour are discarded in an initial step. As a robustness check, we change this threshold to EUR 4.00.[33] Moreover, when replacing the right-censoring at the upper limit for SSC with an imputation procedure, we try two variants in which we truncate the imputed wages at the 95th or 99th percentile. Finally, we set ρ, which is assumed to be 0.02 in our main specification, to alternative values (0.01 or 0.04). We also combine the robustness checks along the different dimensions. While the first three dimensions have a negligible impact on the parameter estimates, the assumptions regarding the truncation level and the discount rate ρ matter slightly more. However, the impact is limited to the estimates of the job offer arrival rates, while the other parameters remain almost unchanged. The following comparative statics results remain qualitatively very similar in all these specifications.[34]

2.7. Unemployment effects of different minimum wage levels

We begin by discussing and quantifying the different mechanisms through which the minimum wage affects the unemployment rate (Section 2.7.1). We then present results on the total effect, i.e. incorporating all these pathways, of the minimum wage on the rate and duration of unemployment, first overall (Section 2.7.2) and then by region, skill group, and permanent worker ability (Section 2.7.3).

2.7.1. Pathways

Decomposition of the unemployment rate The unemployed fall into three different groups, as shown by the decomposition in Equation (2.5). Group (1) consists of individuals whose reservation wage is below $\underline{w}$, i.e., who will accept any job offer. This purely frictional unemployment decreases in κ_u, the ratio of the job arrival rate of the unemployed over the job destruction rate. For Group (2), unemployment is partly frictional (through κ_u) and partly driven by the interplay between the reservation wage and the wage offer distribution. Unemployed individuals in this group accept some job offers but reject others, depending on the wage offer. Finally, individuals in Group (3) are permanently unemployed because their

[33]The resulting lowest wage observed is a bit higher, e.g. EUR 3.64, because of a further truncation at the first and 99th percentile within each PFE quartile, see Section 2.3. This further depends on the wage and hours measure used.

[34]For the change in the unemployment rate, this is documented in the last column of Table A.7.

reservation wage is higher than the highest wage offer $\overline{w}$.

Effects through the wage offer distribution For minimum wage levels below the lowest productivity level $\underline{p}$, the model predicts that a minimum wage reduces unemployment, as long as the minimum wage shifts up firms' optimal wage offers. The reason is that in this case unemployed individuals are now more likely to receive acceptable wage offers.[35] With $\underline{w}$ = EUR 3.64 and our estimate for the wage offer function, this cutoff level is $\hat{\underline{p}} = \hat{K}^{-1}(3.64)$ = EUR 4.26 for the whole sample. The introduction of a minimum wage of, say, EUR 4.00, slightly above the lowest productivity, limits firms' power to set wages below productivity. The lowest wage is now EUR 4.00 instead of EUR 3.64 and, via Equation (2.8), this increase has repercussions throughout the wage offer distribution.[36] This is illustrated in Panel (a) of Figure 2.2 for the whole sample: the higher the minimum wage level, the smaller the workforce l that a firm attracts for a given wage offer w. Moreover, the relationship between l and w becomes less steep for higher minimum wages.

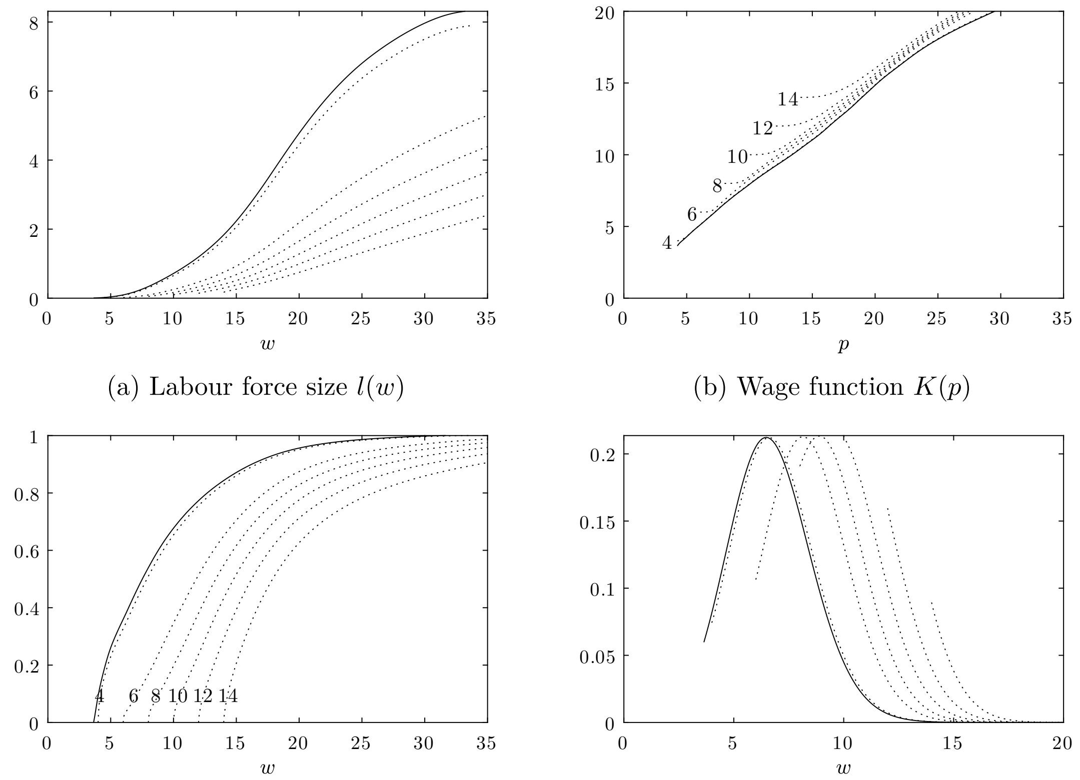
As a result of these interactions operating through $l(w)$, different minimum wage levels lead to different optimal wage offer functions $\hat{K}^{MW}$, and therefore to different wage offer distributions $\hat{F}^{MW}$. Increasing the minimum wage generally shifts $\hat{K}^{MW}$ upwards and $\hat{F}^{MW}$ to the right (cf. panels (b) and (c)). While the biggest changes occur for low wages and productivities, even high-productivity firms adjust their wage offer slightly in response to an increase in the minimum wage.

These changes in the wage offer distribution affect the steady-state unemployment rate. A minimum wage below $\underline{p}$ leads to an increase in $\underline{w}$, which in turn means that some individuals shift from Group (2) to Group (1) in Equation (2.5). As $1 + \kappa_u > 1 + \kappa_u \overline{F}(x)$ for all $x \in]\underline{w}, \overline{w}]$, this leads to a reduction in the unemployment rate. For individuals staying in Group (2), unemployment goes down as $\overline{F}(w)$ decreases for all w. Moreover, the highest wage offer $\overline{w}$ increases, which reduces the number of individuals who reject all job offers (Group 3).

Effects through the job offer arrival rates For minimum wage levels above the lowest productivity level $\underline{p}$, the minimum wage affects the job offer arrival rates, which means that the sign of the minimum wage effect on unemployment becomes ambiguous a priori. In the model by Bontemps et al. (1999, 2000), this mechanism arises because the minimum wage

[35] Note that an alternative way in which minimum wages may affect workers' search behavior would be by inducing more search effort in response to the minimum wage. See Christensen et al. (2005) for a model of endogenous search effort and a previous (working paper) version of Ahn et al. (2011), which discusses an extension of their model that allows for endogenous search effort.

[36] Several empirical studies document spillover effects of minimum wages on wages in the upper part of the wage distribution (e.g., Autor et al., 2016 or, in the context of Germany, Gregory and Zierahn, 2022).



(a) Labour force size $l(w)$ (b) Wage function $K(p)$

(c) Wage offer distribution $F(w)$ (d) Reservation wage density $dA(w)$

Figure 2.2.: Equilibrium functions for different minimum wage levels, whole sample. *Note:* This figure illustrates the effect of different minimum wages on equilibrium functions (cf. Figure 2.1). Panel (a) shows the effect on the labour force size (measured per unit intensity). Different minimum wage levels shifts the optimal wage offer function (panel b) and the wage offer distribution (panel c). Panel (d) shows the effect on the reservation wage density and its support. Wages and productivity are measured in EUR. *Key:* No minimum wage (——); minimum wage levels are EUR 4, 6, 8, 10, 12, and 14 (··········).

raises the lowest feasible wage offer $\underline{w}^{MW}$ and the productivity level $\underline{p}^{MW}$ that is associated with it. Firms with a productivity below this level leave the market, and Bontemps et al. (1999, 2000) assume that κ_u and κ_e are proportional to the fraction $\overline{\Gamma}(\underline{p}^{MW})$ of firms that remain in operation. Because the proportionality assumption is somewhat arbitrary, the present paper models firms' vacancy posting directly. As outlined in Section 2.2, firms choose the job offer arrival rates such that the return from marginally increasing the rates is just offset by the cost of doing so. An increase in the minimum wage leaves the cost unchanged but reduces the return, which leads to a reduction in the optimal job offer arrival rates. The reduction is particularly pronounced for job offers that are made to the unemployed (cf. Figure 2.3). Our simulations predict that a minimum wage of EUR 8.50 would bring down the ratio of the job offer arrival rate to the unemployed over the job destruction rate, which is 20.1 in the actual environment without a minimum wage, by almost a third.

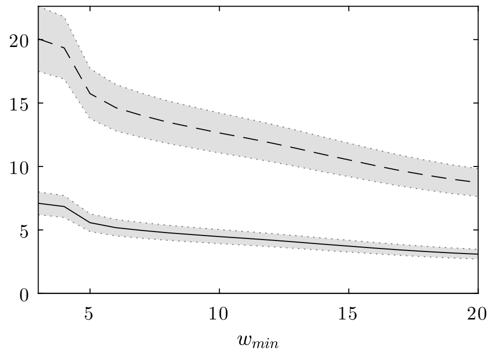


Figure 2.3.: Change in minimum wage: frictional parameters, whole sample. *Note:* This figure shows κ, the ratio of the job arrival over the job destruction rate, as a function of the minimum wage. *Key:* Employed workers κ_e (——); unemployed κ_u (– – –). Grey area indicates 95% confidence bands based on 250 bootstrap runs.

As a consequence, the unemployment effect of a minimum wage is now the result of two countervailing forces: the reduction in unemployment as higher wage offers lead to less frequent rejections of job offers, and the increase in unemployment arising from the fact that job offers now arrive at a slower rate. Formally, the second effect reduces the denominators in Equation (2.5), thereby increasing the frictional component of unemployment in Groups 1 and 2.

Effects through reservation wages So far, we have discussed the channels operating through the wage offer distribution and the job offer arrival rates. Both channels are already present in the Bontemps et al. (1999) model with homogeneous λ. In the model with $\lambda_u \neq \lambda_e$, there is an additional channel operating through A, the distribution of reservation wages ϕ. This channel is present regardless of whether the minimum wage is below or above $\underline{p}$. As shown in Equation (2.1), the reservation wage ϕ depends on κ_u, κ_e, F and $\overline{w}$, all of which are functions of the minimum wage. While an increase in $\overline{w}$ raises the reservation wage, a proportional reduction in κ_u and κ_e lowers it. F has a double effect on ϕ, operating both through the numerator and the denominator of the second term in Equation (2.1). In our simulations, the resulting net influence on A turns out to be positive, i.e. a higher minimum wage shifts the reservation wage distribution to the right (cf. panel (d) of Figure 2.2).[37] There is also a slight composition effect as a higher minimum wage draws in workers with relatively high reservation wages, while workers with lower reservation wages, who used to work at firms with low productivity that now have to leave the market, find themselves among the unemployed. In the baseline situation without a minimum wage, the distribution

[37] Note that the distribution shown in the figure is truncated at the lowest wage observed in the data because the part to the left of $\underline{w}$ is non-parametrically unidentified.

H_e of the opportunity costs of employment among the employed has a mean of EUR 0.002, while the distribution H_u for the unemployed has a slightly higher mean of EUR 0.50. (The means of the reservation wage distributions A_e and A_u are EUR 6.57 and EUR 6.86.) With a minimum wage of EUR 8.50, the mean of H_e increases to EUR 0.03, while the mean of H_u decreases to EUR 0.04. The means of A_e and A_u are very similar in this scenario, at EUR 9.17 and EUR 9.18, respectively.

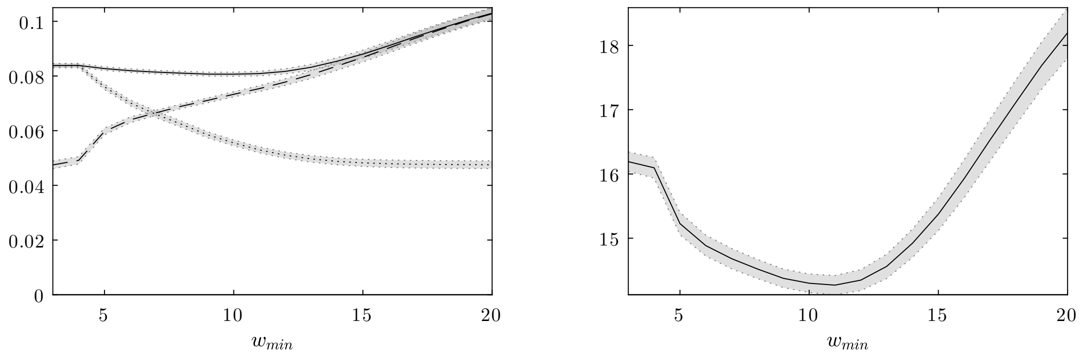
2.7.2. Whole sample

Figure 2.4 shows the effect of different minimum wage levels on the unemployment rate and the average unemployment duration, based on the estimation results for the whole sample.[38] The solid line is the effect that is actually predicted by the model. In the German context, the introduction of a statutory minimum wage leads to a reduction of the unemployment rate for low levels of the minimum wage. Unemployment is lowest for a minimum wage between EUR 9.00 and 11.00. The minimum wage of EUR 8.50 that was introduced on January 1st, 2015 leads to an unemployment rate of 8.1% in the model, down 0.3 percentage points from the baseline level (with no minimum wage) of 8.4%. At a minimum wage of EUR 13.50, the unemployment rate reaches this baseline level again.

The small effect of the minimum wage on the unemployment rate results from two countervailing forces that happen to almost exactly offset each other over a wide range of minimum wage values. The negative effect (in the sense of reducing unemployment) arises because a higher minimum wage means that unemployed individuals are now more likely to receive acceptable wage offers. This effect is illustrated by a simulation (see the dotted line in Figure 2.4) in which we allow for heterogeneity in the opportunity cost of employment b, but switch off the channel operating through the reduction in job offer arrival rates; these are held constant at their estimated status-quo levels. The unemployment-reducing effect tapers out beyond a minimum wage level of about EUR 12.50 because, as seen in Figure 2.1, there is little mass left in the reservation wage density beyond this level. Since the opportunity cost distribution H is unbounded, purely frictional unemployment (corresponding to a situation in which all unemployed individuals are in Group (1)) is reached only asymptotically. As w_{min} approaches infinity, the dotted line converges to an unemployment level of $100 \times 1/(1 + \widehat{\kappa_u}) = 4.8\%$.

This value is the starting point for the dashed line that shows the ratio $1/(1 + \widehat{\kappa_u})$. In this case, the negative effect working through the wage offer distribution is switched off, all unemployment is purely frictional from the start, and higher minimum wages unambiguously raise unemployment. Such a scenario would lead to a very different conclusion about how

[38] Selected numerical values for the change in the unemployment rate as a function of the minimum wage level are reported in Table A.12 in the Appendix.



(a) Unemployment rate u

(b) Mean unemployment duration

Figure 2.4.: Change in minimum wage: unemployment, whole sample. *Note:* The figure shows model predicted unemployment rates and unemployment durations for different minimum wage levels, based on the estimation results for the whole sample (see Section 2.6). Panel (a) shows the unemployment rate (see equation 2.5 in Section 2.2). The solid line (——) is the effect that is actually predicted by the model. To illustrate that the mininum wage effects result from two countervailing channels, we also show the unemployment rate for two alternative models: A model without changes in job offer arrival rates (··········) and a model which only covers the frictional component of u (−−−). The model represented by the dotted line allows for heterogeneity in the opportunity cost of employment b, but switches off the channel operating through the reduction in job offer arrival rates (these are held constant at their estimated status-quo levels). The model represented by the dashed line shows the unemployment rate as the ratio $1/(1+\widehat{\kappa_u})$. In this case, the model does not allow for heterogeneity in b and all unemployment is purely frictional. Panel (b) shows the mean unemployment duration in months (see equation 2.14). Grey area indicates 95% confidence bands based on 250 bootstrap runs.

the introduction of a minimum wage of EUR 8.50 in 2015 affected the unemployment rate. If all unemployment were always frictional, the rate would have gone up to 7.0%, a sizeable increase from the frictional unemployment rate of 4.8% that we find for the benchmark case without a minimum wage. The fact, however, that this benchmark rate of frictional unemployment is much lower than the predicted unemployment rate of 8.4% shows that, according to the analysis here, a substantial part of unemployment in the benchmark is not frictional but the result of wage offers that fall below the reservation wages of the unemployed. For higher values of the minimum wage, by contrast, the reduction in job offer arrival rates becomes the almost exclusive driver behind the increase in the unemployment rate. In Figure 2.4, this is reflected by the asymptotic convergence of the solid line and the dashed line.

The mean unemployment duration (panel (b) of Figure 2.4) is given by[39]

$$\frac{A_u(\underline{w})}{\lambda_u A(\overline{w})} + \int_{\underline{w}}^{\overline{w}} \frac{1}{\lambda_u \overline{F}(x) \cdot A(\overline{w})} \, dA_u(x). \tag{2.14}$$

The effects mentioned above in the context of the unemployment rate are again at play here. In fact, each item in the expression depends on the minimum wage level. The effect on the numerator A_u is ambiguous a priori and, given that A changes little, probably fairly small. The main change is likely to take place in the denominator, where λ_u decreases in the minimum wage while $\overline{F}$ increases, again giving an ambiguous effect. The influence of the change in the integral limits $\underline{w}$ and $\overline{w}$ is also an empirical question. Our simulations show that with the introduction of a minimum wage, the mean unemployment duration first decreases from its steady-state level of 16.2 weeks. The minimum of about 14 weeks is reached at a minimum wage level of around EUR 11. For higher levels of the minimum wage, the average unemployment duration increases again.

2.7.3. Heterogeneity between labour markets

The simulation results discussed so far have been based on the estimation for the whole sample. Figures 2.5, 2.6 and 2.7 show the effects when the simulations are based on a separate estimation for each labour market defined by region, skill group, or permanent worker ability. The figures show the change of the unemployment rate compared with its status-quo level in each labour market segment, as a function of the minimum wage level.[40]

[39]Note that the expected value needs to be derived based on the right truncated distribution of reservation wages, as individuals with reservation wages greater than $\overline{w}$ are characterised by infinite unemployment durations. In our application, $A(\overline{w})$ is equal to one. As a result, the mean unemployment durations based on the truncated and untruncated distribution of reservation wages do not differ from each other.

[40]Selected numerical values for these changes are again reported in Table A.12 in the Appendix. The simulations for the different labour market segments can be aggregated in order to derive the overall

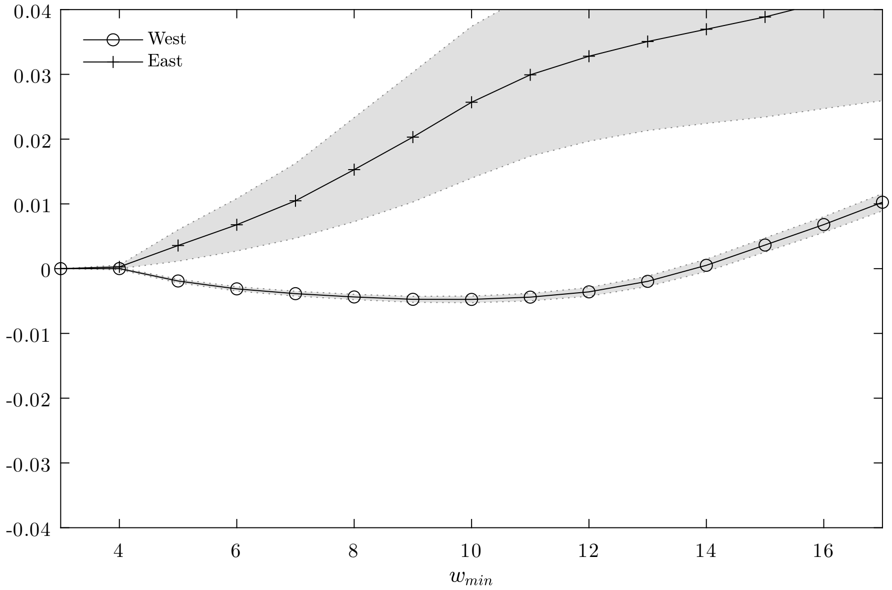


Figure 2.5.: Change in unemployment rate by region. This figure shows the change in the unemployment rate for different minimum wage levels based on separate estimations for East and West Germany relative to the status quo level. Grey area indicates 95% confidence bands based on 250 bootstrap runs.

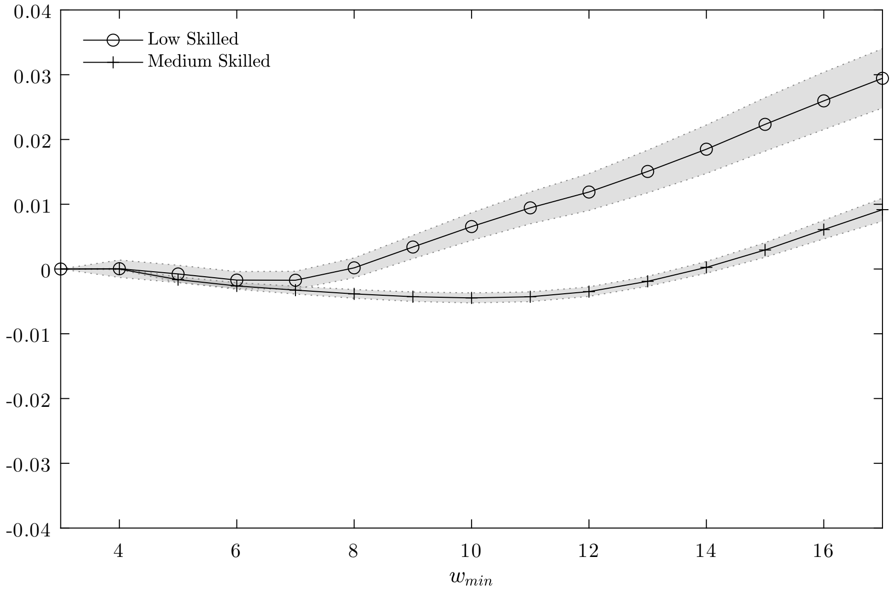


Figure 2.6.: Change in unemployment rate by skill group. This figure shows the change in the unemployment rate for different minimum wage levels based on separate estimations for low- and medium-skilled individuals relative to the status quo level. Grey area indicates 95% confidence bands based on 250 bootstrap runs.

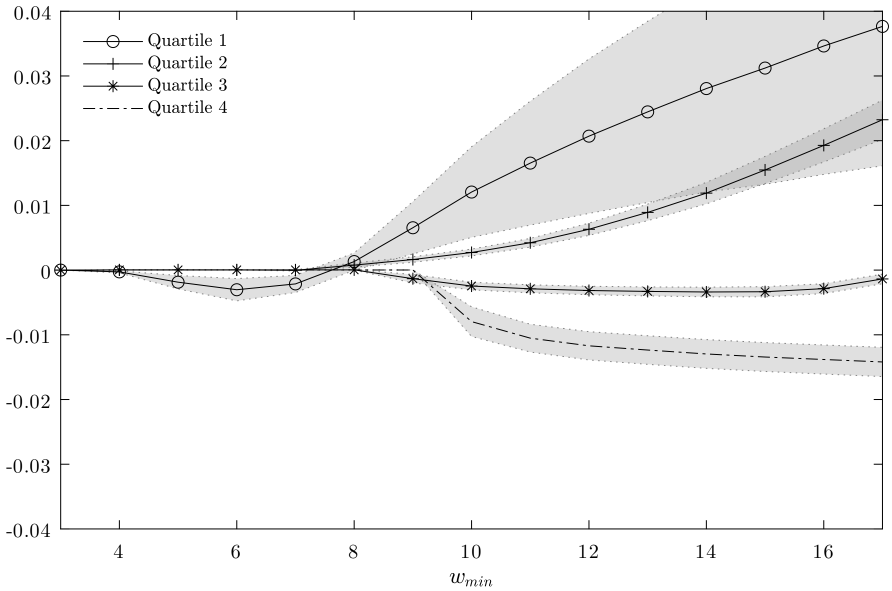


Figure 2.7.: Change in unemployment rate by PFE quartile. This figure shows the change in the unemployment rate for different minimum wage levels based on separate estimations for each quartile of the person fixed effects relative to the status quo level. Grey area indicates 95% confidence bands based on 250 bootstrap runs.

We find that the same minimum wage level can have different effects on unemployment depending on the labour market segment.

By region East and West Germany differ not only in the level of unemployment (9.0% in the East, 8.0% in the West), but also in how the unemployment rate reacts to the introduction of a minimum wage. According to our simulations, the introduction of any minimum wage – even at low levels – would increase the unemployment rate in East Germany. For the actually implemented level of EUR 8.50, the model predicts an increase of 1.8 percentage points, i.e. 20% of the status-quo level. In West Germany, by contrast, a minimum wage of EUR 8.50 reduces unemployment by 0.4 percentage points, or 5% of the rate observed before the introduction. Only for minimum wage levels of more than EUR 13.50 do we see an increase in unemployment in the West compared with the benchmark case without a minimum wage. These remain fairly moderate over the range of values considered here, while in East Germany a minimum wage of EUR 13.50 or higher would bring up the unemployment

unemployment rate as a function of the minimum wage level (Table A.12 and Figure A.15 in the Appendix). Overall, the aggregated rates show similar trends compared to the rate that results when the estimation and simulation are directly carried out for the sample as a whole. However, when looking at the aggregation by PFE, we do not find a drop in the unemployment rate for low minimum wage levels and the increase in unemployment sets in earlier.

rate by about 30% compared with its pre-introduction level.

The effect of the minimum wage on unemployment again results from the different pathways described above. The unemployment-reducing effect – other things equal, unemployed individuals are less likely to reject wage offers after the introduction of a minimum wage – is stronger in the East at lower minimum wage levels because the unemployed have lower reservation wages there. At the same time, the productivity of firms is lower and the decline in the job offer arrival rate is more pronounced there. In the East, this second effect dominates throughout, while in West Germany it leads to an increase in unemployment only for relatively high minimum wage levels.

By skill group Looking at labour market segments defined by skill group, the unemployment-reducing effect dominates up to a minimum wage level of about EUR 7 for the low-skilled. Afterwards the effect via a lower job offer arrival rate dominates. For the medium-skilled this effect dominates at much higher levels of about EUR 11.

By permanent worker ability When labour market segments are defined via permanent worker ability, the reaction of the unemployment to the introduction of a minimum wage falls into three groups. The segment defined by the first PFE quartile first experiences a reduction in the unemployment rate, which is predicted to increase again beyond a minimum wage level of about EUR 6.00. Workers in the lowest quartile are characterised by low reservation wages, such that the negative effect of the minimum wage on unemployment is already exhausted at quite low minimum wages levels. The positive effect (in the sense of raising unemployment) that operates through a reduction in the job offer arrival rate takes over from then, and the unemployment rate reaches its status-quo level at a minimum wage of about EUR 8.00. In the segment defined by the second PFE quartile, the negative and positive effect on the minimum wage offset each other up to a minimum wage level of about EUR 8.00. Beyond this level the positive effect via the job offer arrival rate dominates. Note that, due to a higher value of $\underline{w}$ in the second PFE quartile, an effect on the unemployment rate may be observed only for minimum wages larger than EUR 6.32. For the third and fourth quartiles this threshold is EUR 8.14 and EUR 9.19, respectively. For these upper quartiles, the unemployment-reducing effect dominates almost completely. For the highest quartile, the effect through the job offer rate sets in so slowly that unemployment is lower than in the status quo even for a minimum wage of EUR 17.

2.7.4. Post-reform comparison

Comparing predicted and actual unemployment We next compare our results with actual changes in unemployment between our pre-reform and post-reform period. Table A.10

shows observed changes in unemployment along with the changes predicted by our model for the whole sample and broken down by labour market segment. Over the pre- and post-reform period, the German labour market experienced a substantial decline in unemployment, despite a major inflow of unskilled migrants in the years 2015 and 2016. For our sample of full-time employed individuals, the unemployment rate fell by 3 percentage points. Thus, our model predicted change in unemployment of 0.03 percentage points accounts only for a small fraction of the observed decline in unemployment. The direction of the predicted change in unemployment across labour market segments is consistent with what is observed in the data for West Germany and the medium-skilled. For East Germany and the low-skilled the model predicts an increase in unemployment, which is counterfactual to what is observed in the data. As to permanent worker ability, workers in the upper quartiles experienced also a decrease in unemployment, which contrasts with the model predicted constant unemployment rates. For the lowest quartiles, the model predicted change in unemployment accounts only for a very small fraction of the observed substantial reduction of about 7 percentage points.

Taken together, from the lens of our model the introduction of the minimum wage can only explain a small fraction of the observed decline in unemployment. This suggests that there have been other important determinants in the German labour market that are relevant for understanding the favourable development of unemployment and that are not captured by our model. For example, a number of studies have documented an increase in matching efficiency after the German Hartz reforms, which involved a considerable change in the German welfare system and a reform of the Federal Employment Agency (Launov and Wälde, 2016; Hochmuth et al., 2021). Other factors include productivity growth coupled with general wage moderation and a considerable increase in labour hoarding due to rising labour shortages, which has led to a substantial decline in separation propensities (Klinger and Weber, 2016).[41] The latter is also visible in our data. Column (3) and (6) in Table A.11 report a substantial decline in separation rates across all segments, which is counterfactual to the predictions by our model.

Note that our model could, in principle, accommodate a change in separation (as well as job finding) rates by allowing for time variant job offer and destruction rates. Simulating a minimum wage of EUR 8.50 after estimating the model using data of the post-reform period would bring the predicted changes in unemployment probably much closer to those observed in the data. However, we wish to note that such a simulation would not reflect a counterfactual that isolates the pure minimum wage effect from other concurrent developments that have taken place during our observation period.

[41] See also the study Hutter et al. (2022), who adopt a macro-econometric approach to quantify the extent to which the above determinants contributed to the decline in unemployment during the time period 2012 to 2017.

Comparison to reduced-form studies The previous discussion has highlighted that our counterfactual predictions need to be interpreted as resulting from a policy change during which none of the other developments happened. Ex-post reduced-form evaluation studies typically aim at identifying the causal effect of the minimum wage holding everything else constant. Thus, the results from these studies provide a more appropriate reference against which to validate our model predictions.[42] In line with our simulations, much of the existing evidence finds that the minimum wage had no or at most a small negative effect on employment.[43] Using the IAB Establishment Panel, Bossler and Gerner (2020) compare establishments with employees affected by the minimum wage with a control group of establishments that are not directly affected. They find that employment remained roughly constant in the treatment group and grew in the control group. As a result, 45,000 to 68,000 jobs were lost (or rather, not created) because of the introduction of the minimum wage. This corresponds to 1.7% of the employment in the affected establishments. In line with our simulations, Bossler and Gerner find that this employment effect is mainly driven by establishments in East Germany. However, the employment effect is no longer statistically significant once the intensity of the treatment is taken into account. Using a similar difference-in-differences strategy at the establishment level, Bonin et al. (2018) find a small negative effect of about the same magnitude. The negative effect is exclusively driven by a reduction in marginal employment (below EUR 450 per month), while regular employment increased after the introduction of the minimum wage.

Several reduced-form studies rely on variation in the regional bite of the minimum wage. Bonin et al. (2020) find a negative effect on total employment of between 0.5% and 0.8%, depending on the specification. Based on the Structure of Earnings Survey, Caliendo et al. (2018) find that overall employment went down by 0.4%, which translates into 140,000 jobs. Using data from the Federal Employment Agency, Schmitz (2019) estimates a slightly larger reduction of up to 260,000 jobs. By contrast, with the same data but a different specification that also exploits variation across gender and age, Garloff (2019) finds some evidence of a positive effect on employment, but the effect is dependent on the specification and in any

[42]See the surveys by Bruttel (2019) and Caliendo et al. (2019). There is also a literature that evaluates the pre-2015 industry-specific minimum wages, typically using difference-in-differences designs with industries without a minimum wage as control groups. In what is probably the first quasi-experimental study for Germany, König and Möller (2009) analyse the introduction of a minimum wage in the construction industry. The authors find no significant employment effects in West Germany and small negative effects in the East. In 2011, the German Federal Ministry of Labour commissioned an evaluation of minimum wages in several industries. In general, these studies also tend to find limited employment effects (e.g., Boockmann et al., 2013; Frings, 2013), with the exception of the roofing industry (Aretz et al., 2013).

[43]The small employment effects are in line with firms' expectations and plans as reported in survey data in the months before the minimum wage took effect (Bossler, 2017; Link, 2019). In a more recent survey experiment by Bossler et al. (2020b), by contrast, firms do report that they would reduce employment if the minimum wage were to be increased above its current level.

case very small (11,000 jobs). Adopting a similar approach, Stechert (2018) confirms these results. Based on individual-level data aggregated at the county level and taking commuting flows into account, Ahlfeldt et al. (2018) estimate a small positive effect of the minimum wage on employment (+0.06%). They also find that a one-percentage point increase in the regional bite decreased the unemployment rate by 0.05 percentage points. Holtemöller and Pohle (2020) use variation at the state-industry level. They find a small reduction in overall employment of, depending on their measure of the regional bite, between 20,000 and 50,000 jobs. Dustmann et al. (2022) do not find a significant negative employment effect in their regional analysis.

Friedrich (2020) exploits the variation in the bite of the minimum wage across occupations. He finds a small positive effect on regular employment when the minimum wage was introduced in 2015, but the effect becomes insignificant in 2016 and 2017. The effect on marginal employment is slightly negative, but statistically insignificant in all three years. Restricting the analysis to West Germany produces the same pattern, while in East Germany the employment effects are more negative, in line with the predictions of our model.

Finally, using individual-level data, Dustmann et al. (2022) find that the introduction of the minimum wage boosted the wages of low-wage workers, but did not reduce their probability of remaining employed. Umkehrer and Berge (2020) study the effect of a minimum-wage exemption for the long-term unemployed and find no effect on transitions out of unemployment at the threshold.

Importantly, even in those studies that do find a negative overall employment effect, the decrease is almost exclusively driven by a reduction in marginal employment. Because we restrict our sample to full-time workers and thereby exclude marginal employment, the results are not directly comparable. The effect on regular employment in the reduced-form studies is at most slightly negative (Caliendo et al., 2018; Schmitz, 2019), while Bonin et al. (2020) find no significant effect and Garloff (2019), Holtemöller and Pohle (2020), and Friedrich (2020) estimate a small positive effect.

Regular employment in most of these studies also includes (non-marginal) part-time work, while our own simulation is carried out for full-time workers only. In addition, we exclude high-skilled individuals, i.e. the group of individuals who are least likely to be affected by the minimum wage. Notice also that our results refer to equilibrium changes whereas reduced-form studies capture short-term adjustments. Finally, we do not consider non-compliance, and our model assumes that prices and the productivity of firms and individuals are unaffected by the minimum wage.[44] Based on the extent to which firms can react to the minimum wage along these margins, the unemployment effects of the minimum wage will be

[44]See Coviello et al. (2022) for a recent analysis of the effect of the minimum wage on the productivity of workers.

dampened.[45]

While keeping in mind these caveats, we conclude that our simulation results for the introduction of the minimum wage are not in contradiction with the existing evidence, which increases our confidence that the counterfactual simulations are reasonably informative about what might happen to unemployment at other minimum wage levels. Note that this stands in sharp contrast to previous ex-ante studies that relied on the assumption of perfect competition, i.e. on a model that by construction does not allow for positive employment effects of a minimum wage.[46]

2.8. Conclusion

Based on an equilibrium job search model, this paper argues that the statutory uniform minimum wage of EUR 8.50 that was introduced in Germany in 2015 had a small negative effect on the unemployment rate of full-time workers. The unemployment-reducing effect is driven by West Germany, while in East Germany we do find an increase in unemployment resulting from the introduction of the minimum wage.

We use the model for a series of counterfactual policy experiments and find that unemployment is a non-monotonic function of the minimum wage level. In contrast, simple extrapolations of effects found for actually observed minimum wage levels might be misleading. Our model suggests that there would have been considerable scope for increasing the minimum wage beyond the level of EUR 8.50. We document substantial heterogeneity not only in the productivity distribution, but also in search frictions and in reservation wages across labour market segments differentiated by region, skill group, and permanent worker ability. To the extent that the minimum wage is motivated by a desire to offset firms' monopsony power, this suggests that a uniform minimum wage is perhaps too blunt a tool. While in East Germany there is basically no scope for unemployment-neutral minimum wages, in West Germany the benchmark level of unemployment is reached again at EUR 13.50. For medium-skilled workers, there would have been scope for unemployment-neutral minimum wages of up to EUR 14.00, while low-skilled workers would have experienced an increase in

[45]See Clemens (2021) for a discussion of these other margins and a review of the recent empirical evidence. In the German context, Bossler et al. (2020a) fail to detect any effects of the minimum wage on establishment-level productivity, based on data from the IAB Establishment Panel. For lack of price data at the micro level, there have been no quasi-experimental studies so far on whether prices were adjusted in response to the minimum wage. Using planned price changes as reported in several business surveys before and after the introduction of the minimum wage, Link (2019) shows that more firms planned to react via the price than via the employment channel.

[46]See, e.g., the studies by Ragnitz and Thum (2008), Bauer et al. (2009) and Knabe and Schöb (2009), which predict large negative employment effects of up to one million jobs. Braun et al. (2020) calibrate stylised macro models (both for perfect competition and monopsony) and predict a strong increase in unemployment in their baseline specifications.

unemployment with minimum wages of more than EUR 8.00. The heterogeneity in unemployment responses is particularly pronounced across permanent ability segments. While for low-ability workers, the negative effect of the minimum wage on unemployment is already exhausted at quite low minimum wages levels, the unemployment-reducing effect completely dominates for high-ability workers. For these workers, the negative labour demand effect sets in so slowly that unemployment is lower than in the status quo even at quite high minimum wages.

Comparing our model predictions with the data suggests that according to our model the introduction of the minimum wage accounts only for a small fraction of the observed decline in unemployment. This indicates that there have been other important determinants of the favourable labour market development in Germany. However, the predictions from our counterfactual simulations are consistent with the results from studies using quasi-experimental variation, most of which have found no or at most small positive effects on unemployment. The counterfactual predictions do not necessarily translate into today's situation, however, because the various changes that have occurred since then (the continuation of the labour market boom and the Covid-19 pandemic in 2020) might affect the external validity of the results.

We should also note that while the model allows us to assess the scope for unemployment-neutral minimum wage increases, we do not carry out an explicit welfare analysis and therefore refrain from drawing explicit policy conclusions.

In future research, it will be interesting to study correlates of search frictions and hence firms' market power across labour market segments. For instance, they may be related to differences in workers' characteristics across labour market segments, to firm characteristics, market structure, and union coverage.

Chapter 3.

Recent Trends in Labour Supply Elasticities in Germany[1]

3.1. Introduction

Numerous studies have documented changes in labour supply outcomes in Germany in recent decades. Female labour force participation has increased over time, which has been linked to cohort effects and changing gender norms.[2] It is now more common for males to work part-time; this was a rare phenomenon until the 2000s. For Germany, it has also been documented that the desired hours of work have decreased.[3] These changes in labour supply outcomes could be due to changes in real wages, changes in institutions or compositional changes; while fundamental preferences remained stable. In this case, these changes would reflect a movement on stable labour supply curves (Devereux, 2003). They could also be due to changes in fundamental preferences, or a mixture of the above. At the same time, there are general trends in wages, wage heterogeneity and work force composition in Germany. Furthermore, with the reduction of the income taxes 2000 to 2004 and the Hartz reforms, there have been significant changes in the German tax and transfer system affecting work incentives.[4]

[1]I am grateful to Bernd Fitzenberger and Andreas Peichl for helpful comments. I would also like to thank everybody who has been helping to develop the ifo Microsimulation Model and its sister projects and has contributed to the code base over the past years, especially Florian Buhlmann, Max Löffler, Andreas Peichl, Nico Pestel, Sebastian Siegloch, and Eric Sommer.

[2]See e.g., Balleer et al. (2013), Fitzenberger et al. (2004) and Fitzenberger and Wunderlich (2004).

[3]E.g., by Weber and Zimmert (2018) and Blömer et al. (2021b).

[4]For an overview of the changes in the income tax system, see, e.g., Beznoska and Hentze (2018). Blömer et al. (2021a) provide an analysis on how average and marginal tax burdens as well as the social security contributions have changed in Germany since 1986 and show how the wedge between gross and net wages in real terms has changed over time. The Hartz reforms were a series of four significant reforms implemented from 2003 to 2005 to restructure the German labour market policies and the transfer system. The core element of Hartz IV, implemented in 2005, was a substantial reduction in long-term unemployment benefits

Given these simultaneous trends, it is difficult to infer only from labour supply *outcomes* whether underlying preferences have in fact changed over time. A typical measure that summarises labour supply preferences, reflecting the individual consumption-leisure trade-off, is the own-wage elasticity. The labour supply wage elasticity measures the percentage change in labour supply induced by a percentage increase in the gross hourly wage. In this paper, I estimate a structural labour supply model for Germany for each cross-section 1998 to 2018, and document the evolution of implied labour supply elasticities over time. The estimations are performed using the German Socio-Economic Panel, a representative household survey, and a detailed microsimulation model for the German tax and transfer system (Blömer and Peichl, 2020).

There is extensive literature on labour supply elasticities for different subgroups, years, and time periods. By comparing results from various studies, time trends in elasticities can be found. While this can be done for some countries and subgroups (e.g., Bargain and Peichl, 2016), for Germany, there are too few methodologically comparable data points available to demonstrate robust trends, especially not for multiple subgroups.[5] Currently, there is no estimation of elasticities for Germany with a consistent methodology over a longer time span. For the US, one study can be found that estimates discrete choice labour supply models over a longer period (Elder et al., 2020).

From a meta-study on labour supply elasticities, Bargain and Peichl (2016) assess that elasticities have declined between the 1980s and the early 2000s, and that elasticities are smaller for men than women. They also document that studies find larger elasticities for Germany than for the US or the UK (see also Bargain et al., 2014). For the US, Heim (2007) finds that, until 2002, there had been a strong decline in labour supply elasticities of married women over time. Blau and Kahn (2007) also document a decrease in female wage elasticities in the US from 1980 to 2000. The study by Elder et al. (2020) for the US, which follows a similar approach to this paper for Germany, finds that labour supply elasticities have recently risen again for both men and women in the US.

The main findings of my paper are the following. Own-wage labour supply elasticities implied by the models have increased over the years 1998 to 2018. On the intensive margin, elasticities have continuously increased, especially for couples and single males. In contrast, for single females, there has only been moderate growth in their total labour supply elasticity. On the extensive margin, elasticities increased only for single males, while females became

reducing the generosity of the transfer system in Germany (see Hochmuth et al., 2021, for a short overview and an assessment on Hartz IV).

[5]Bargain and Peichl (2016, p. 24) note "Further validation of these results can be obtained at the price of an extensive estimation of discrete-choice models over the long period. [...] In particular, a change in preferences over the past four decades can be tested directly on the preference parameters revealed by discrete-choice model estimations. [...] This research avenue is tedious but clearly feasible for some countries for which comparable data are available over the long run (the USA, the UK, and Germany in particular)."

less sensitive to their own and their partner's wage. In a further decomposition analysis, using counterfactual model-data combinations, I find that compositional changes play only a minor role in the shift in elasticities, as most of the change is driven by estimated preferences.

The remainder of the paper is structured as follows: section 3.2 provides an overview of the basic discrete choice model, and the specification and extensions applied. Section 3.3 describes the data set and briefly explains the used tax and transfer microsimulation model. Section 3.4 contains the results, first showing descriptive statistics for the data used (3.4.1), the estimation results (3.4.2), the implied labour supply elasticities over time (3.4.3), followed by robustness checks (3.4.4), a counterfactual analysis (3.4.5), and a discussion (3.4.6). Section 3.5 concludes.

3.2. Model and estimation

3.2.1. Discrete choice labour supply

In this section I first present the basic general discrete choice labour supply model, which can easily be estimated using maximum likelihood methods. The basic model can be extended in various dimensions (see Löffler et al., 2018, for an overview). I then focus on the presentation of the specific baseline model used throughout the main empirical analysis in this paper. Further extensions and modelling choices, which are carried out as robustness checks, will be briefly discussed.[6]

In contrast to continuous choice models, the discrete choice model is particularly useful for analysing labour supply elasticities (for a discussion, see for instance Creedy and Kalb, 2006; Löffler et al., 2018). The main reasons are that both the intensive and the extensive margin can be analysed and the complexities of non-convex budget sets are not a problem.

The discrete choice approach models decisions as a choice between different types or categories. In the labour supply context, the possible choices are usually discrete categories of hours of work, the corresponding income to that amount of work, and the non-work time (e.g., leisure time). The model can be estimated for individuals as well as for couples. For the latter, it takes the form of a unitary household labour supply model where the labour supply decision is taken together.

For the basic model, it is assumed that the individuals[7] m, f of a household n maximise a

[6] The notation and exposition in this section closely follows Creedy and Kalb (2006), Löffler et al. (2018) and Blömer and Peichl (2020).

[7] In the following, I present the model for couple households. For single households, the formulas collapse to the utility maximisation of the decision of one household member. I follow the typical notation in the literature, where m and f correspond to male and female partners. For couples, I limit the following empirical analyses to heterosexual partners. It is not possible to empirically analyse the labour supply of non-heterosexual partners due to low sample sizes in the data.

utility function U with arguments consumption C_{nj} and leisure of all household members L^m_{nj} and L^f_{nj}:

$$U\left(C_{ni}, L^m_{ni}, L^f_{ni}, \epsilon_{ni}\right) \equiv max_{j \in J_n} U\left(f\left\{w^m_n h^m_{nj}, w^f_n h^f_{nj}\right\}, T - h^m_{nj}, T - h^f_{nj}, \epsilon_{nj}\right). \quad (3.1)$$

To maximise U, the household chooses alternative i from possible job choices $j \in J_n$. The function $f(\cdot)$ represents the tax and transfer system that transforms gross to net incomes. w^f_n, w^m_n denote the hourly wage rates and T is the total time endowment of each individual, which is assumed to be 80 for all individuals following van Soest (1995).[8] h^m_j and h^f_j denote working hours of both spouses and ϵ_{nj} captures non-observable tastes or disutility components for household n when choosing job j. Total utility for alternative j is given by

$$U_{nj} = U\left(C_{nj}, L^m_{nj}, L^f_{nj}, \epsilon_{nj}\right) = v\left(C_{nj}, L^m_{nj}, L^f_{nj}\right) + \epsilon_{nj} = v_{nj} + \epsilon_{nj}. \quad (3.2)$$

A typical specification for the error term is an extreme value distribution, which generates a convenient hours distribution and results in a multinominal logit model (Creedy and Kalb, 2006). Non-observables ϵ_{nj} are assumed to be additively separable and independently and identically extreme value type I distributed with density $\exp(-\epsilon - \exp(-\epsilon))$ and cumulative distribution function $\exp(-\exp(-\epsilon))$. Under these assumptions, the probability that household n chooses i is given by

$$p_{ni} = p(U_{ni} > U_{nj,j \neq i}) = \frac{\exp(v_{ni})}{\sum_j \exp(v_{nj})}, \quad (3.3)$$

and yields the standard conditional logit problem, as shown by McFadden (1974). The model can be estimated by maximising the log-likelihood function

$$\ln L = \sum_n \sum_j d_{nj} \ln p_{nj} = \sum_n \sum_j d_{nj} \left(v_{ni} - \ln\left(\sum_j \exp(v_{nj})\right)\right) \quad (3.4)$$

with indicator $d_{nj} = 1$ if household n chooses j and $d_{nj} = 0$ otherwise.

The assumptions on the error term, specifically the IIA assumption, can be further relaxed. A common approach is to estimate a random coefficients model allowing for unobserved heterogeneity in preferences. As this is computationally more demanding, this will be done as a robustness check only.

[8] van Soest (1995, p. 67) notes that this "could be incorporated as a parameter to be estimated. Preliminary results suggested that the estimate of this parameter is imprecise, and that setting TE equal to 80 hardly affects the other results." In a sensitivity analysis, Euwals and van Soest (1999) try different choice sets and different total time endowment per week (112 and 96 hours). They conclude that "[a]lmost all models capture participation rates and average hours worked to a similar extent. More importantly, it turns out that the wage and income support elasticities for the alternative choices are similar to those for the base case" (p. 107).

3.2.2. Baseline specification

The utility function's systematic part follows a translog form, used e.g., by van Soest (1995), Haan (2006), and Flood et al. (2007). Quadratic terms allow for decreasing marginal utility of consumption and leisure time. Typical alternative specifications take the form of quadratic utility (e.g., Keane and Moffitt, 1998) or Box-Cox specifications. For a survey and sensitivity analysis, specifically in the context of the used microsimulation model in Germany, see Löffler et al. (2018). Logs of consumption and leisure[9] enter the utility function

$$\begin{aligned} U\left(C_{nj}, L^m_{nj}, L^f_{nj}, P_{nj}, \epsilon_{nj}\right) = {} & \beta_1 \ln C_{nj} + \beta_2 (\ln C_{nj})^2 \\ & + \beta_3 \ln C_{nj} \ln L^m_{nj} + \mathbf{x^1_{nj}} \beta'_\mathbf{4} \ln L^m_{nj} + \beta_5 (\ln L^m_{nj})^2 \\ & + \beta_6 \ln C_{nj} \ln L^f_{nj} + \mathbf{x^2_{nj}} \beta'_\mathbf{7} \ln L^f_{nj} + \beta_8 (\ln L^f_{nj})^2 \\ & + \beta_9 \ln L^m_{nj} \ln L^f_{nj} \\ & + \delta P_{nj} + \mathbf{x^3_{nj}} \gamma' + \epsilon_{nj} \end{aligned} \tag{3.5}$$

for each household n and choice j. The pure utility is given by coefficients β_1 to β_9.

This utility model will be used for several types of households, which can be couples or single-person households.[10] Couple households are further differentiated between couples in which only one spouse is flexible as far as working hours are concerned[11] (this will be called a 'semi-flexible' couple), and couples with two flexible partners. This specification is simplified for single and semi-flexible households. Couples can be married or unmarried.

Table 3.1 describes the variables used in detail. The vectors $\mathbf{x^1_{nj}}$ and $\mathbf{x^2_{nj}}$ consist of individual and household characteristics and represent taste shifters. These vectors contain the following variables of all adult individuals in the household: the age of an individual, age squared, individual handicap status, an indicator for living in East Germany, and an indicator for nursing cases in the household. Each vector also consists of the number of children in the age groups zero to two, three to six, and seven to sixteen in the household and a constant. Depending on the households' composition, the characteristics in these vectors differ. For single-person households, they only consist of one individual's variables.

The utility function also includes a term (P_{nj}) to account for welfare take-up of the household (Moffitt, 1983) with $P_{nj} = 1$ if the household participates and 0 otherwise (see also Kalb, 2000).[12] The potential disutility from this is reflected by the coefficient δ and can

[9] This also includes other non-market activity, for example time for household work and child care.

[10] I refer to *households* here not in the sense of persons living together but as a core family which consists of a maximum of two adults as a couple plus their dependent children.

[11] For example, a couple in which one partner is in retirement age.

[12] For the relevance of modelling benefit take-up in the German context, see also Bruckmeier and Wiemers (2017).

Table 3.1.: Labour supply model: variable definitions

Coef.		Variable	Explanation
β_1		$\ln C$	Log consumption (defined as monthly household net income in EUR in current prices)
β_2		$(\ln C)^2$	Log consumption squared
β_3		$\ln C \ln L^m$	Log consumption interacted with log leisure (defined as 80 minus weekly hours of work) of male
$\beta_{\mathbf{4}}'$	$\mathbf{x^1}$	$\ln L^m$	Log leisure of male interacted with...
		$\times$ 1	... Constant
		$\times$ East Germany	... Indicator for region of residence: 1 if former GDR
		$\times$ Age^m	... Age of male
		$\times$ (Age^m)^2	... Age of male squared
		$\times$ Disability^m	... Indicator for disability status of male
β_5		$(\ln L^m)^2$	Log leisure of male squared
β_6		$\ln C \ln L^f$	Log consumption interacted with log leisure of female
$\beta_{\mathbf{7}}'$	$\mathbf{x^2}$	$\ln L^f$	Log leisure of female interacted with ...
		$\times$ 1	... Constant
		$\times$ East Germany	... Indicator for region of residence: 1 if former GDR
		$\times$ Age^f	... Age of female
		$\times$ (Age^f)^2	... Age of female squared
		$\times$ Disability^f	... Indicator for disability status of female
		$\times$ Nursing case in HH	... Indicator for presence of nursing case in household
		$\times$ N. child 0–2	... Number of dependent children age 0–2
		$\times$ N. child 3–6	... Number of dependent children age 3–6
		$\times$ N. child 7–16	... Number of dependent children age 7–16
β_8		$(\ln L^f)^2$	Log leisure of female squared
β_9		$\ln L^m \ln L^f$	Log leisure of male and female interacted
δ		P	Indicator for welfare participation: *Wohngeld*, *Sozialhilfe* (1998–2004); *Wohngeld*, *Arbeitslosengeld II*, *Kinderzuschlag* (2005-2018)
γ'	$\mathbf{x^3}$	$I(h^m > 0)$	1 if male is working
		$I(h^m = 20)$	1 if male is working 20 hours
		$I(h^m = 40)$	1 if male is working 40 hours
		$I(h^f > 0)$	1 if female is working
		$I(h^f = 20)$	1 if female is working 20 hours
		$I(h^f = 40)$	1 if female is working 40 hours

Note: This table shows variable definitions for the labour supply model in equation (3.5). Dependent variable: utility. Models for singles and semi-flexible couples simplify as follows: Models for single males and semi-flexible couples with only a flexible male omit terms for β_6, $\beta_{\mathbf{4}}'$, β_5, and β_9. Models for single females and semi-flexible couples with only a flexible female omit terms for β_3, $\beta_{\mathbf{4}}'$, β_8, and β_9.

be interpreted as a stigma effect.

The coefficients γ capture fixed costs of work and labour market restrictions. The specification includes indicators for employment status (being employed, and dummies for having full-time employment at 40 hours or part-time at 20 hours) for each partner ($\mathbf{x^3_{nj}}$). The direct inclusion of dummy parameters for working and for specific choices within the utility function has, for instance, been done by van Soest (1995) and Aaberge et al. (1995) and has become standard for the discrete choice methodology. van Soest (1995) argues that these labour market restrictions are a result of demand effects as employers may not hire workers preferring atypical working hours. He concludes that "[a]s a consequence, part-time jobs will be scarce and average search costs for a part-time job will be relatively high" (p. 72). To address this, a limitation of the job offers, given some data on the restrictions for specific choice categories, could in principle be added to the models (Dickens and Lundberg, 1993). However, based on indirect information inferred from observed hours, the multinomial logit framework allows for the simple ad hoc approach where specific constant terms for the choice alternatives are included as part of the utility model. van Soest (1995, p. 72) notes that "[t]hese constants reflect monetary or nonmonetary drawbacks of working part-time, for example, search costs of part-time jobs (which, in our static framework, cannot be incorporated explicitly), or unattractive job characteristics". He shows that a basic model without these additional controls leads to a very poor within-sample model fit, strongly overpredicting part-time categories of 10, 20, and 30 hours per week.[13] The inclusion of fixed costs of work improves the model fit especially by fitting the peak at 40 hours while predicted part-time is much closer to observed frequencies. Following the arguments of Aaberge et al. (2009), the inclusion of part-time dummies is important, as not all choice alternatives are equally available. Notably, this ad hoc inclusion of fixed costs of work and labour market restrictions alters the interpretation of the utility model. Fixed costs of work as well as part-time restrictions leading to a lower frequency of part-time jobs will typically show up as disutility in the estimated model. Vice versa, typical working time categories such as 40 hours per week will be associated with additional utility.

For singles, the discrete choice set regarding hours of work consists of seven alternatives: 0 or 10, 20, ..., 60 hours of work per week. For couples, this choice set encompasses the combination of these seven hour alternatives, i.e., 49 possible choices. Furthermore, the choice set is expanded to include a non-take-up option as a choice category for hour choices which results in welfare eligibility of the household.

[13] In a validation exercise, Hansen and Liu (2015) find that the inclusion of fixed costs is especially important to improve the out-of-sample model performance.

3.2.3. Identification

Identification of the parameters of the structural discrete choice model for every year relies on cross-sectional variation. A key problem faced when estimating models over a longer period covering all relevant subgroups of the population is that clearly exogenous variation in the form of (quasi-)experimental or randomised variation is not available. This is also the case for the time span analysed in this paper.

For the identification of structural models of labour supply, exogenous variation could still come from the tax and transfer system. It is often argued that this variation stems from nonlinearities, nonconvexities, and discontinuities of the tax and transfer system (for instance, by van Soest, 1995). Individuals with the same gross wage may receive different net wages due to differences in household demographics such as the marital status, number and age of children, and other income sources (Bargain et al., 2014). Furthermore, there is, to some extent, regional variation, e.g., from differences in social security contributions in Germany (see also the discussion in Bargain et al., 2014). Note that for identification, the variation from the tax and transfer system must still come from differences depending on characteristics that are not already controlled for by individual and household variables that are part of the specified utility function in the form of taste shifters (vectors $\mathbf{x_{nj}^1}$ and $\mathbf{x_{nj}^2}$).

There are also reduced-form approaches estimating labour supply elasticities in settings that can rely on quasi-experimental variation. For instance, Eissa and Hoynes (2004) exploit variation in the EITC in the US tax system to directly estimate labour supply reactions and elasticities of married couples with children. Blundell et al. (1998) exploit a longer series of group specific tax reforms in the UK to estimate female labour supply elasticities.[14] As a downside, this approach assumes that the underlying preferences do not differ over a very long time frame, which is in contrast to the literature arguing and showing that labour supply preferences did change over time.[15] Studies that can rely on exogenous variation typically need to focus on a specific population that is affected by the natural experiment, often limiting the analysis to married females.

There is a growing literature on the validation of structural models of labour supply. In particular, a structural model can be estimated and then used for the prediction of an actual reform that has been implemented. If this actual reform can be considered a natural experiment, i.e., being exogenous to labour supply, the model prediction can be compared to the observed outcomes of the reform. A comparison of the out-of-sample model fit could serve as a validation method for the estimated structural model. This has already been done

[14]For an application of this estimation strategy for Germany, see Wagenhals (2000) and Fendel (2020).

[15]Furthermore, limitations for two-way fixed effects estimators could arise when heterogeneous effects could lead to biased estimates (de Chaisemartin and D'Haultfœuille, 2020).

by McFadden et al. (1977) in the context of discrete choice models for transport choices.[16] In the context of a discrete choice labour supply model, Hansen and Liu (2015) provide a comparison of labour supply and welfare participation predictions to observed responses to a welfare reform actually implemented in Canada. They report that the predictions from the structural model replicated the reform effects obtained by a regression discontinuity approach to a satisfactory degree. However, in a sensitivity analysis they show that modelling assumptions, such as accounting for fixed costs of work did play an important role for the out-of-sample model fit. Notably, the natural experiment, and therefore the validation exercise, could only be done for a very specific subgroup[17]. Similarly, Bargain and Doorley (2016) assess a transfer reform in France in 2009 exploiting an age discontinuity. They also combine this approach with the estimation of a structural model using the same variation by excluding age from the structural labour supply model. Bargain and Doorley highlight that the combination of structural models with quasi-experimental variation can provide a stronger base for credible extrapolations, which is a shortcoming of reduced-form ex-post estimates. Thoresen and Vattø (2015) compare the predictions of a standard discrete choice labour supply model with estimates exploiting a tax reform in Norway in 2006 and find that both frameworks lead to similar results. While some studies report validation exercises encouraging the use of structural models, others find contrary results. Choi (2018) estimates changes induced by experimental variation from a welfare policy change in the US states of Minnesota and Vermont and compare them to predictions from a static discrete choice labour supply model. She finds that while the within-sample fit is good, the estimated changes in labour supply and welfare participation could not be replicated out-of-sample, i.e., by the model's prediction. Keane and Wolpin (2007) report poor model performance for a dynamic discrete choice model when compared to external data sources. For Germany, a validation exercise in a similar fashion has been done by Geyer et al. (2015). They estimate a static discrete choice labour supply model using SOEP data and find that predictions lead to the same conclusions as results from a quasi-experimental approach exploiting a parental leave reform in Germany.

To summarise, variation that is clearly exogenous to labour supply is in general rarely available for a longer period of time. In most settings a reduced-form approach is promising for specific subgroups only. Beyond serving as exogenous variation for direct estimation, reduced-form approaches can be used to validate model choices, but results are mixed and again are informative only for the sample analysed. For the research question at hand – the analysis of trends in own-wage elasticities in Germany comparing different demographic

[16]McFadden et al. (1977, Chapter 3) report a 'prediction success table' for transportation choices after the introduction of a new transportation system in the San Francisco Bay Area. See also McFadden (2001) for a discussion.

[17]Single males without children, living in Quebec.

groups – there is no credible exogenous variation that could be exploited in a reduced-form approach. I therefore rely on the estimation of structural discrete choice models. Beyond the question on the level and trends of elasticities for different groups over time, it is interesting to study to what extent changes in elasticities are driven by changes in observable characteristics, or by changes in the estimated parameters. Once a structural model is estimated it also allows for the prediction of labour supply for counterfactual compositions. Aggregate or average elasticities might have changed over time due to changes in composition, while the estimated behavioural model, which includes taste shifters, could have been the same.

3.3. Data and microsimulation

The empirical analysis in this paper is based on the German Socio-Economic Panel (SOEP), a microdata household survey.[18] The SOEP provides representative cross-sectional data on German households. Furthermore, the SOEP also includes specific oversampled subsamples for migrants or high-income households and provides survey weights based on the German Microcensus. Depending on the survey year, the cross-sectional number of cases amounts to approximately 30,000 individuals living in 15,000 households.

A calculation of a hypothetical disposable household income for each possible choice category, considering a complex set of taxes and transfers, is required. Furthermore, for the analysis of elasticities, the same variables need to be calculated for a set of 'shocked' wages (for instance, a ten percent gross wage increase). For this task, the detailed ifo Microsimulation Model will be applied. This microsimulation model covers a wide range of individual- and household-specific German taxes and transfers and the interaction of these policies. The taxable income will be calculated using various gross income variables and following the most important rules for deductibles. Both personal income taxes and capital taxes are covered by the model. Furthermore, social security contributions and rules on marginal employment are taken into account. On the benefit side, the unemployment benefit II system, social assistance, child benefits, housing benefits, additional child benefits, and the advance on alimony payment are covered by the microsimulation. A more in-depth model documentation can be found in Blömer and Peichl (2020).

The use of a detailed microsimulation model results in considerable data requirements. The SOEP serves as a rich (wide) data set covering demographic and economic variables on the personal and household level. Most importantly, these include a wide range of income and employment variables, personal and household characteristics, but also various variables required for calculating disposable household income. Households with missing relevant information, partial unit-non-response, and households surveyed for the first time will be

[18] For details, see Goebel et al. (2019). Specifically, this paper is based on the SOEP version v36.

disregarded. When reporting results, individual cross-sectional weights (omitting participants of the first wave of a subsample) consistent for analysis over time, will be used. Sample weights are not used for the estimation of the econometric models. The handling of the data set and the complex data preparation in the context of the tax and transfer model is also best described in the model documentation of the ifo Microsimulation Model (Blömer and Peichl, 2020).

For data preparation in the context of the household labour supply model, two important concepts arise. First, the concept of a 'flexible' person regarding labour supply. Labour supply decisions are only estimated for a subset of households with at least one 'flexible' person who is considered potentially elastic regarding labour participation and hours of work. A person is assumed to be flexible if he/she has completed education and is viewed as independent of parents' behaviour, is of working age, receives no old-age or disability pensions, is not self-employed, is not a civil servant, has no refugee status and has not migrated in recent years.

Second, the concept of a 'labour supply unit'. Note that the SOEP includes complex household structures such as households with persons from multiple generations, and relatives or other persons available to the labour market. When estimating the unitary household labour supply model, this household structure is adapted to the structure of a labour supply unit (potentially as part of a larger household). Labour supply units consist of the 'core family' with a maximum of two adults as a couple, and their dependent children. Couples can be married or unmarried, but only couples living together will be considered. Furthermore, individuals living with their parents are not considered.

Taking these two concepts together, the model will be estimated for the following different labour supply types: (1) singles and single parents, (2) flexible couples, and (3) semi-flexible couples, in which one partner is not considered elastic. Both the estimation of the labour supply models and the analysis of labour supply elasticities is based only on these household units.[19] Flexible and semi-flexible couples are grouped together throughout the discussion of the results.

Further data requirements arise from the imputation of non-observed hourly wages of the empirically not working. As is common in the discrete choice literature, this entails a wage equation, auxiliary to the labour supply model, following a Heckman procedure. The wage equation is estimated for each year 1998 to 2018 and separately for men and women. The wage regression will estimate the conditional mean log hourly gross wage for individuals that are working as wages are only observed when hours of work are positive. That is, the distribution of the hours of work is truncated at zero hours. This sample is

[19]Note that this restriction on flexible persons regarding the analysis is also a reason why estimated labour supply elasticities may vary across studies.

potentially selective and without further correction would lead to biased estimates because individuals that do not work for particular reasons are non-randomly excluded from the sample. Among the determinants for participation in the labour market, the offered wage rate itself will be a very plausible reason: Individuals will not only decide on the number of hours they will supply at a given wage rate (intensive margin) but also decide whether to work at all (extensive margin). Therefore, the wage equation will be estimated as a Heckman selection model with an additional stage for the selectivity of working and having an observed hourly wage using all individuals of the population (Heckman, 1979). The normality of the wage residual is assumed, and for the identification of the selectivity, instruments that can be excluded from the wage regression need to be found. As a critical remark, in the discrete choice literature, these instruments typically do not stem from clearly randomised or (quasi-)experimental variation but build on observable excluded variables such as age of children, demographics and other income variables.

Table B.1 in the appendix describes the setup and the variables used. Log hourly wages are regressed on variables reflecting work and unemployment experience, tenure, education, nationality as well as regional dummies. As discussed, the model is estimated as a Heckman selection model, correcting for selectivity of observed wages and participation. For identification, usual variables serve as exclusion restrictions:[20] A cubic age profile, educational variables, nationality, marital status, disability, number of children by age group, and variables reflecting income from other sources. Results for the wage equation for the years 1998 and 2018 can be found in Tables B.3 and B.4 in the appendix.

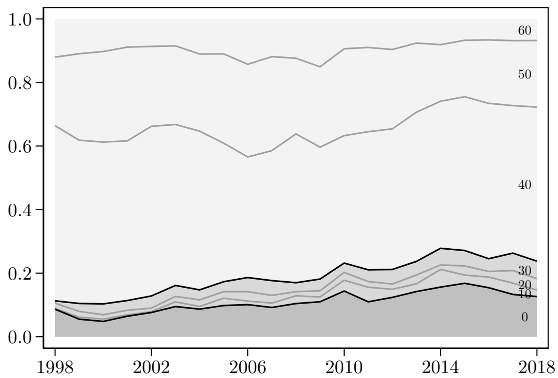
For the hypothetical choice categories it is assumed that the hourly gross wage rate is the same irrespective of the hours of work. Arguably, this typical assumption in the discrete choice literature can be problematic if a part-time wage penalty exists.

3.4. Results

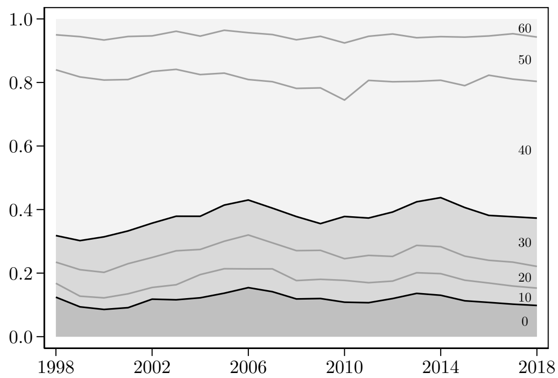
3.4.1. Descriptives

This section briefly discusses descriptive statistics for the analysed sample. The data selection is described in the previous section 3.3. The estimation sample consists only of persons considered potentially flexible on the labour market. All reported statistics are calculated using individual sample weights provided by the SOEP. Figure 3.1 shows the main outcome variable of interest, hours of work as discrete categories, over the years 1998 to 2018. Figure 3.2 shows real hourly gross wage. Table B.2 in the appendix shows descriptive statistics for the arguments of the utility function for selected years. Flexible

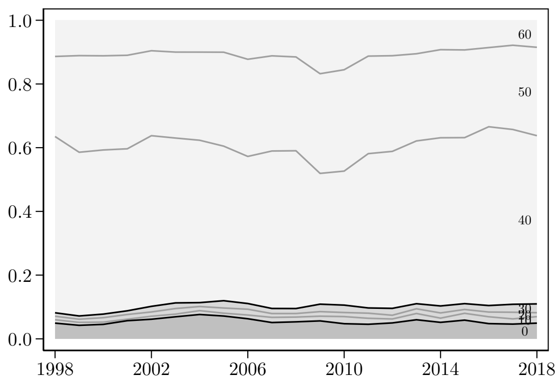
[20]Compare e.g. to van Soest (1995) and Bargain and Peichl (2016) or Mühlhan (2022) for the German context using the SOEP.



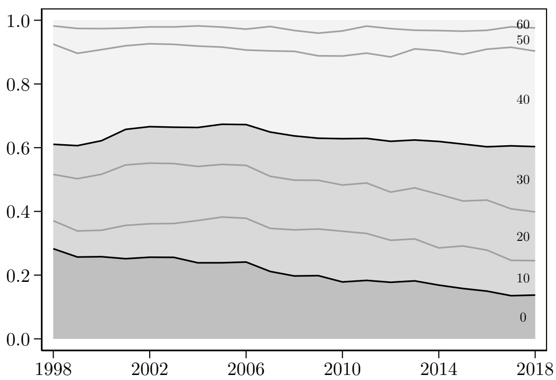
(a) Single, male



(b) Single, female



(c) Couple, male

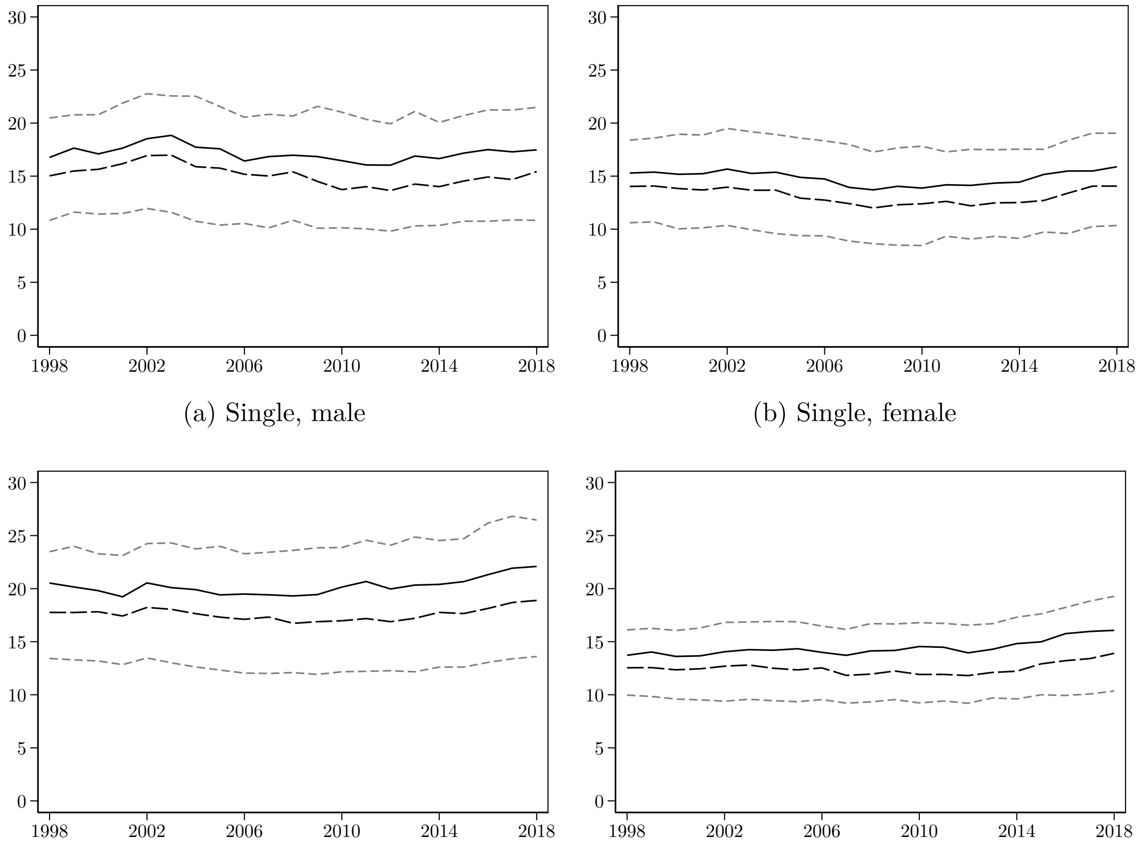


(d) Couple, female

Figure 3.1.: Hour choices, estimation sample, 1998 to 2018. *Note:* The figure shows cumulative relative frequencies of hour choices stacked over all categories $j = 0, 10, ..., 60$ hours of work per week for the estimation samples. The area between lines mark the relative frequency of the hour category denoted by the number between lines on the right axis. Sample restrictions apply (for details, see Section 3.3). *Source:* ifo Microsimulation Model; SOEP v36.

and semi-flexible couples are aggregated and summary statistics are reported for the flexible person only.

The number of observations in the SOEP increased over the years. For 1998, the estimation sample consists of 4,515 labour supply units analysed with 6,794 persons with flexible labour supply. 395 of them are single males, 568 are single females, and there are 2,279 flexible couples. Beyond that, labour supply is estimated for 559 males and 714 females with an inflexible partner. Overall, there are 6,794 flexible persons considered (8,067 persons including inflexible partners). Most of the observations are couples (78% of all units, 88% of all persons). For 2008, the sample consists of 7,674 flexible persons. For 2018, the sample consists of 10,310 flexible persons.



(a) Single, male

(b) Single, female

(c) Couple, male

(d) Couple, female

Figure 3.2.: Real hourly gross wages, estimation sample, 1998 to 2018. *Note:* The figure shows real hourly gross wages in EUR in 2018 prices for the estimation samples. The solid line shows the mean (——) and the dashed line (–––) the median. Dashed greyscale lines (----) mark the first and the third quartile. Nominal wages are deflated using the German CPI. Sample restrictions apply and the figures include the predicted wages for unemployed individuals (for details, see Section 3.3). *Source:* ifo Microsimulation Model; SOEP v36.

Looking at the chosen categories of weekly work hours, Figure 3.1 shows strong differences across gender and relationship status. Single males work mostly full-time in contrast to single females who are more often working in part-time jobs. These differences are very pronounced for couples, as around 90% of couple-males work in full-time jobs while only around 40% of females with a partner work in full-time jobs. Part-time work is a very rare phenomenon for males, especially for males with a female partner. Three main changes in labour supply outcomes during the last two decades emerge: First, employment among females with a partner increased, mainly towards part-time employment. Second, employment rates of single males in the sample decreased. And third, part-time work of males is still very uncommon in comparison to females, but has slightly increased over time.

Looking at real hourly gross wages (in 2018 prices), Figure 3.2 shows once again differences between males and females as well as between singles and couples. Note that the figures summarise the wage variable for the estimation sample and include predicted wages for the not employed in each cross-section. Therefore, this sample differs from a sample that would be used to analyse paid wages.[21] Single females have lower wages than single males, especially discernible at the third quartile of the wage distribution. This difference is more pronounced for couples. While median wages of couple-males are at around EUR 18 to 20 per hour, median wages of couple-females are around EUR 15. Furthermore, the wage distribution of males is more dispersed than the one of females leading also to much higher wages of males at the third quartile of the wage distribution. Real wages measured at the mean and the quartiles did not show a strong trend over time. To some extent, a small decrease of males' wages until 2010 can be found. Furthermore, wages of females with a partner slightly increased, especially in recent years.

Demographic variables differ across estimation samples and changed over time as shown in Table B.2. Single women are on average older than single men and are more often single parents. A larger fraction of single males live in East Germany. Trends can be seen, for instance, in the number of children and the average age over time. The mean age increases in all subgroups over time. There are two major trends driving this: First, labour force participation of younger individuals has decreased over time, because education periods are longer. Second, the labour force participation of the elderly has risen along with the typical age of retirement in the last twenty years.[22]

3.4.2. Estimation results

The estimation results for the utility function, equation (3.5), for the years 1998 and 2018 can be found in Tables B.5 and B.6 in the appendix. Column (A) refers to single males, column (B) to single females, column (C) to semi-flexible couples in which only the male has a flexible labour market attachment, column (D) to semi-flexible couples with a flexible female, and column (E) to couples in which both partners have a labour market attachment.

As previously discussed, the argument leisure time is interacted with demographics such as age, number of children or a regional indicator. As the total time endowment of each individual, T, is defined as 80 hours per week, $L_s = 80 - h_s$. C is monthly post-government[23] household income in current prices. Coefficients alone are not informative and not easily

[21] The discussed trend in employment is, through composition effects, also a driver of the wage structure when looking at paid wages (see e.g., Dustmann et al., 2009; Biewen et al., 2018; Fitzenberger and de Lazzer, 2021).

[22] Note that a person in education or in retirement age is assumed to be inflexible and not part of the sample for the descriptives. For details, see section 3.3.

[23] Without taking VAT into account.

comparable. Therefore, the main analysis of the results is carried out using additional calculations. Specifically, gross wage shocks will be simulated to calculate implied labour supply elasticities (see the following subsection 3.4.3).

To briefly illustrate the model, indifference curves can be drawn as shown in Figure B.1 for estimated model (5). Note that the model also includes indicators for some working time categories that impact on the utility function and also change the typical interpretation of utility. What looks like a strong 'distaste' for part-time work categories, especially for males, is due to the ad hoc way in which labour market restrictions are captured (Aaberge et al., 2009). The estimated models show that a disutility is associated with positive hours reflecting fixed cost of work. Furthermore, the working time category of 40 hours per week shows up as additional utility leading to this particular shape of the indifference curve.

Tables B.5 and B.6 also report pseudo R^2 for each estimated model. These coefficients of determination range from values of 0.23 to 0.42 for 1998, and 0.14 to 0.31 for 2018 which is broadly in line with other studies.[24] As the (pseudo) R^2 is meaningful when comparing different model specifications using the same data set, it has become common practice in the discrete choice literature to compare predicted and observed hour distributions (see, e.g., van Soest, 1995; Aaberge et al., 1995; Bargain et al., 2014). The within-sample model fit regarding the distribution of hours of work can be found in the appendix in Figures B.2 and B.3. As shown, the models are able to produce a fairly good fit for the different choice categories. Tables B.7 and B.8 report the absolute difference (predicted minus observed hours density) for each choice category. Overall, the discrepancy is typically below one percentage point with a slightly higher prediction error for the 30 and 50 hours category in 2018 (a discrepancy up to four percentage points). As one single outlier, non-employment is overpredicted for females in semi-flexible couples for 1998 by five percentage points.

3.4.3. Labour supply elasticities

Labour supply elasticities are a typical measure for preferences analysed in the labour economics literature and a concise behavioural parameter that is often considered when designing redistributive policies. In this paper, I illustrate Marshallian (uncompensated) wage elasticities. The labour supply elasticity is defined as $\partial h/\partial w \cdot w/h$ and measures the percentage change of labour supply, here hours worked h, induced by a percentage increase of a price variable, here the gross hourly wage w. Alternatively, the elasticity with respect to the net wage or income could be calculated. Gross wage elasticities are by far the most analysed type, especially in the discrete choice literature. In their survey of the literature on labour supply elasticities, Bargain and Peichl (2016) note that almost all papers report

[24]Bargain et al. (2014) report pseudo R^2 for similar specifications for different countries and data sets that range from 0.15 to 0.44 (0.26 to 0.31 for Germany based on data from the EUROMOD framework).

elasticities with respect to the gross wage.[25]

In contrast to continuous choice specifications, the structural basis of discrete choice models does not provide an explicit function for labour supply as a function of wages (Creedy and Kalb, 2006). Given the calculated probabilities for the estimated model, labour supply can be analysed based on expected hours. In this paper, labour supply elasticities are calculated as the response to a counterfactual 'wage shock' implied by the model estimates and comparing the predicted labour supply with the predicted in-sample labour supply. As discussed in the previous section, labour supply models will be estimated for every year 1998 to 2018, and in this way, elasticities are simulated for every year. The simulated wage shock consists of a ten percent gross wage increase of one person's wage in the household.[26] The elasticity is then calculated as the percentage change in hours ($\partial h/h$) due to the ten percent wage shock ($w/\partial w = 10$).

$\hat{p}_n(h = j) \equiv \hat{p}_{nj}$ is the predicted probability of individual n working j hours ($h_j = 0, 10, ..., 60$). As for individual n, the probability of not working is given by $\hat{p}_{n0}$, the probability of working is $1 - \hat{p}_{n0}$. For individual n, the expected hours over all choices can be calculated by $\sum_j h_{nj}\hat{p}_{nj}$. For the counterfactual scenario, the predicted probability is denoted as $\hat{p}'_{nj}$.

Elasticities can be calculated as changes in aggregates of expected hours across all individuals or by analysing location parameters of changes in individual expected hours, e.g., the mean or the median. The aggregate expected hours are calculated as a sum over all individuals, by $\sum_n \sum_j h_{nj}\hat{p}_{nj}$. The average individual elasticity may differ from the elasticity of aggregate labour supply. In this paper, the main results are presented for elasticities calculated from aggregate expected hours across all individuals and the aggregate participation probabilities.

This aggregate elasticity is calculated as the relative change in the aggregate over all individuals' expected hours:

$$\varepsilon = \frac{\sum_n \sum_j h_{nj}\hat{p}'_{nj} - \sum_n \sum_j h_{nj}\hat{p}_{nj}}{\sum_n \sum_j h_{nj}\hat{p}_{nj}} \frac{1}{0.1}. \tag{3.6}$$

[25] Bargain et al. (2014, p. 751) argue that the "size of hour elasticities might be influenced by differences in tax-benefit systems across countries" and calculate net wage elasticities as a robustness check. "Precisely, baseline elasticities are calculated by incrementing gross wages by 1 percent, as is common in the literature. Accordingly, the fact that high-tax countries are characterized by smaller net wage increments could explain smaller elasticities." (Bargain et al., 2014, p. 751) In their robustness checks, the authors find that net wage elasticities are slightly larger than gross wage elasticities. The net wage could ultimately be more relevant for labour supply as the gross wage, reflecting the individual consumption-leisure trade-off. However, analysing net wage elasticities requires careful consideration which taxes are taken into account. Transfers, deductions, other income sources, joint taxation, and complex interactions within the household complicate this. In most cases in Germany an individual net wage is simply not defined for couples.

[26] Different levels of these wage shocks are possible, e.g., a one percent increase. A robustness check in section 3.4.4 will show that the results are robust to differences in this regard.

This total elasticity can be broken down into the extensive and the intensive component ($\varepsilon = \varepsilon^{\text{ext}} + \varepsilon^{\text{int}}$). The extensive elasticity is simply the relative change in aggregate participation probabilities:

$$\varepsilon^{\text{ext}} = \frac{\sum_n (1 - \hat{p}'_{n0}) - \sum_n (1 - \hat{p}_{n0})}{\sum_n (1 - \hat{p}_{n0})} \frac{1}{0.1}. \tag{3.7}$$

The calculation of the change in expected hours can be adjusted by the change in aggregate participation, $\frac{\sum_n (1-\hat{p}'_{n0})}{\sum_n (1-\hat{p}_{n0})}$. Rescaling the baseline aggregate hours by the participation change gives the aggregate expected hours conditional on the same participation probability as in the shocked scenario. This results in the intensive elasticity, defined as

$$\varepsilon^{\text{int}} = \frac{\sum_n \sum_j h_{nj} \hat{p}'_{nj} - \frac{\sum_n (1-\hat{p}'_{n0})}{\sum_n (1-\hat{p}_{n0})} \sum_n \sum_j h_{nj} \hat{p}_{nj}}{\sum_n \sum_j h_{nj} \hat{p}_{nj}} \frac{1}{0.1}, \tag{3.8}$$

which can be interpreted as the relative change in aggregate expected hours conditional on working.

As an alternative to aggregate labour supply, I briefly analyse individual elasticities.[27] A robustness check shows that the results are essentially the same when comparing aggregate elasticities and mean individual elasticities. However, as individuals with higher hours have a higher impact in the analysis of aggregate or mean individual elasticities, I add a short analysis of the distribution of the individual elasticities.

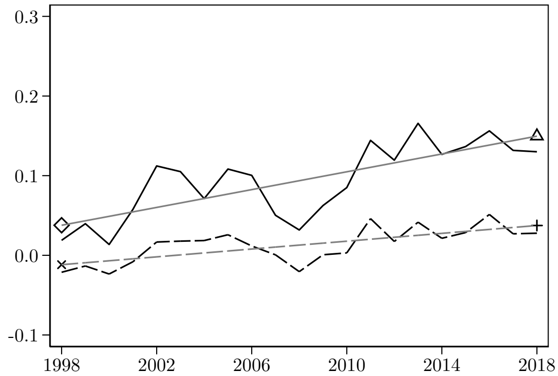
The main results for the aggregate elasticities are graphically illustrated in Figure 3.3.[28] The solid lines show the implied total elasticity ε and the dashed lines show the intensive elasticity ε^{int} over the years 1998 to 2018. The difference between total and intensive elasticity is the extensive elasticity, ε^{ext}, shown in the appendix in Figure B.4. As typically found in the literature, the extensive margin accounts for a big part of the total elasticity, roughly two thirds of the total elasticity (Heckman, 1993).

While subfigures (a) to (d) show elasticities with respect to the own wage, subfigures (e) and (f) show elasticities with respect to the partner's wage.[29] As the elasticities are uncompensated for income changes, they comprise the substitution effect (which increases labour supply) and the income effect (which reduces labour supply). The estimated total own-wage elasticities are positive for all subgroups. In other words, an increase in the own wage increases labour supply. That is to say, the substitution effect outweighs the income effect. Cross-wage elasticities, i.e., the change in labour supply due to a change in the

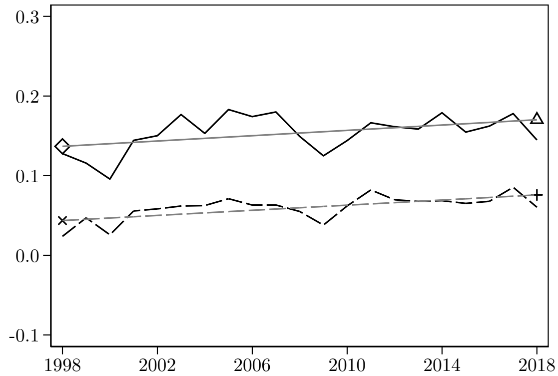
[27] See the corresponding equations (B.1) to (B.3) in the appendix for the individual elasticities.

[28] The values for each year 1998 to 2018, including bootstrapped standard errors (150 draws) can be found in the appendix in Tables B.9 to B.11.

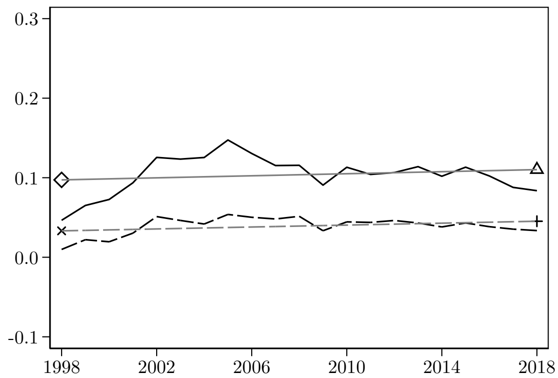
[29] In all cases, the elasticities are calculated only for individuals who are part of the estimation sample, i.e., considered 'flexible' on the labour market. For couples, the partner can be 'flexible' or 'inflexible'.



(a) Single, male, own wage

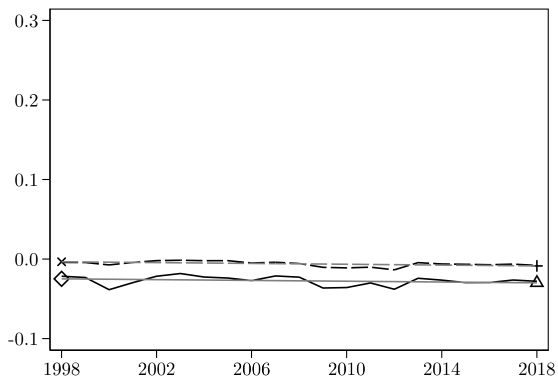


(b) Single, female, own wage

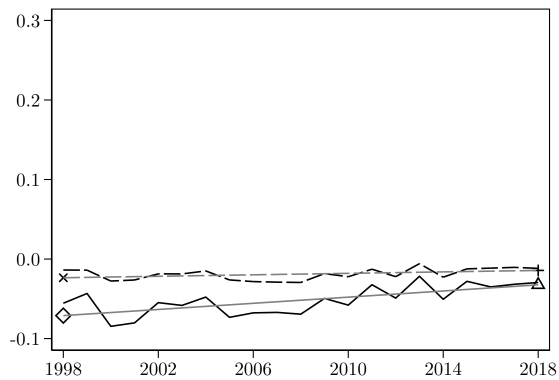


(c) Couple, male, own wage

(d) Couple, female, own wage



(e) Couple, male, partner's wage



(f) Couple, female, partner's wage

Figure 3.3.: Wage elasticity, 1998 to 2018. *Note:* The figure shows the total elasticity (——) and intensive elasticity (– – –) calculated as the aggregate expected hour change due to a simulated ten percent increase in own or the partner's gross wage. Linear trend regression lines are shown and symbols mark the fitted value for the beginning and the end of the observational period. *Source:* ifo Microsimulation Model; SOEP v36.

Table 3.2.: Change in wage elasticity, linear trend, 1998 to 2018

	Singles		Couples			
	M w^m	F w^f	M w^m	F w^f	M w^f	F w^m
Total elasticity						
1998	0.038	0.137	0.097	0.196	-0.025	-0.071
2018	0.150	0.170	0.110	0.251	-0.030	-0.032
Change	0.112	0.033	0.013	0.055	-0.005	0.039
Intensive elasticity						
1998	-0.012	0.044	0.033	0.075	-0.003	-0.024
2018	0.037	0.076	0.045	0.153	-0.009	-0.014
Change	0.049	0.032	0.012	0.079	-0.005	0.009
Extensive elasticity						
1998	0.050	0.093	0.064	0.122	-0.021	-0.048
2018	0.112	0.094	0.065	0.098	-0.021	-0.018
Change	0.063	0.001	0.001	-0.024	0.000	0.030
Fraction intensive of total elasticity						
1998	-0.312	0.319	0.341	0.380	0.138	0.330
2018	0.250	0.446	0.411	0.610	0.288	0.441

Note: This table shows the change in wage elasticities 1998 to 2018. Trend values are calculated using the fitted value for 2018 and for 1998 from a linear regression over the entire time span for each subgroup.

partner's wage, are negative, meaning that the non-work time of males and females are substitutes. Overall, elasticities are higher for females than for males. The effect that females react stronger to wage changes than men can also be found for the cross-wage elasticities which are close to zero for men.

Levels The estimated elasticities are mostly in line with the literature for Germany. Most studies for Germany have also found higher elasticities for females than for males. For the period from 1998 to 2005, other studies have estimated hours elasticities for couple-males ranging from 0.05 to 0.3 with most estimates around 0.2, while couple-female elasticities are found to be typically around two times higher in each study during that period (Bargain and Peichl, 2016, Table 1). For the years 1998 to 2005, I find smaller elasticities for couples (around 0.20 for females and 0.05 to 0.12 for males, see Figure 3.3 c and d). Note that the definition of couples varies across studies resulting in a different demographic and presumably different elasticities. In this study, married and unmarried couples are considered, while some studies explicitly focus on married females.

For 2015, Bruckmeier et al. (2021) report hours elasticities from estimations of a very similar specified discrete choice model, also using SOEP Data.[30] The authors report elasticities of couples which are very much in line with the elasticities I find for 2015. Bruckmeier et al. estimate female hours elasticities of around 0.25 and around 0.10 for males. For 2015 couples, I find elasticities of 0.25 for females and 0.11 for males. However, for singles, the elasticities I find are lower (0.14 for males and 0.16 for females versus elasticities slightly higher than 0.2 in Bruckmeier et al.).

Trends Although there is some variation across years, especially for single males, a general upward trend in elasticities can easily be identified, with the slope depending on the subgroup analysed. To remove the impact of outliers when comparing start and end points of the observational window, linear trend lines are shown.[31] Fitted values for the beginning and end of the observational period are summarised in Table 3.2 and shown as symbols in Figure 3.3. The absolute change for the actual values for start and end points 1998 and 2018 can be found in the appendix in Table B.13.

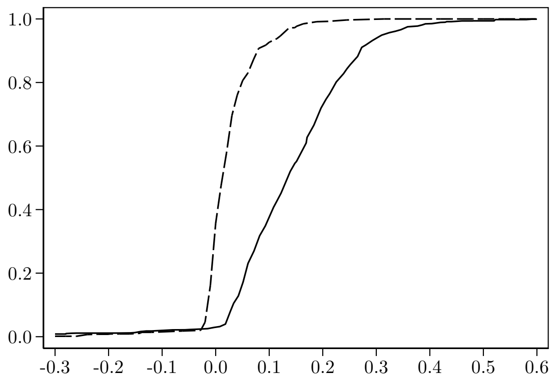
Looking at the linear trend, own-wage elasticities were in general relatively small at the beginning of the observational period but varied strongly, especially by gender. As commonly found in the literature, males reacted less sensitively to wage changes than females, especially in the 1990s and early 2000s. For males in 1998, total own-wage elasticities were around 0.038 for single males and 0.097 for males with a partner (based on the linear trend, Table 3.2). In 1998, females already had higher elasticities than males (0.137 for single females, and 0.196 for females with a partner). For all subgroups, own-wage elasticities increased with the strongest changes for single males and couple-females. While for single females, the total elasticity stayed almost constant over 20 years (only increased by 0.033 points to around 0.170), single males' elasticities demonstrated a substantial increase to 0.150 (by 0.112 points) but still remain a bit less sensitive than those of single females.

For couples, the total elasticities increased most strikingly during the 2000s and since then have developed in a similar manner while female elasticities are on a much higher level than those of males. Table 3.2 also shows that the fraction $\varepsilon^{\text{int}}/\varepsilon$ increases for couples, especially for females (from 0.38 to 0.61). Therefore, this strong shift mainly occurs on the intensive margin, meaning that individuals are more responsive predominantly via hours reactions than via participation.

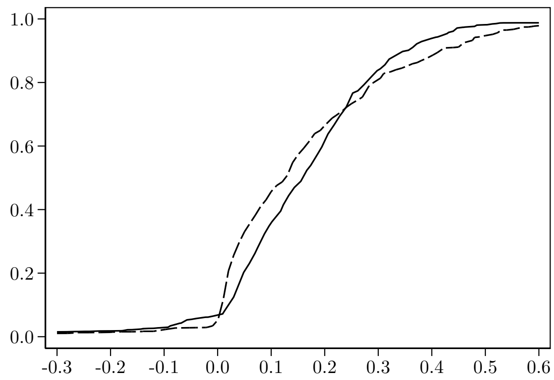
Cross-wage elasticities for couples are small, yet trend lines show that, for males, the cross elasticities became more negative. That is, that the responsiveness to the partner's wage increased. In contrast, females became less sensitive to their partner's wage.

[30] A direct comparison for 2015 is reported in the appendix in Table B.12.

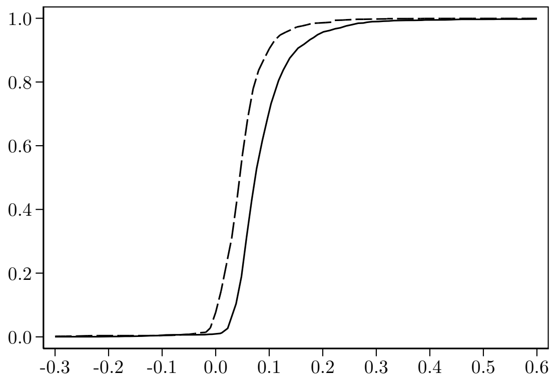
[31] This has also been done, e.g., by Heim (2007).



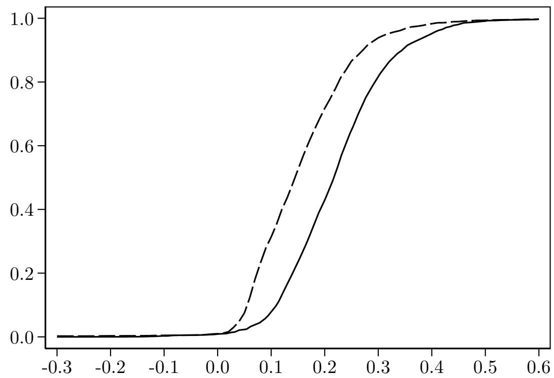
(a) Single, male, own wage



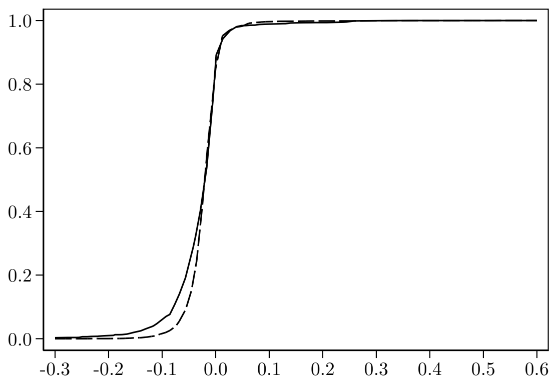
(b) Single, female, own wage



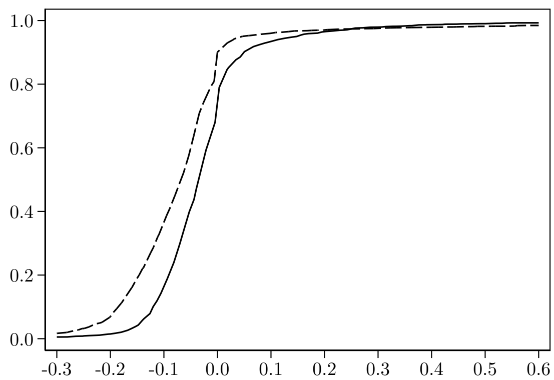
(c) Couple, male, own wage



(d) Couple, female, own wage



(e) Couple, male, partner's wage



(f) Couple, female, partner's wage

Figure 3.4.: Distribution of individual wage elasticity, 2018. *Note:* The figure shows the cumulative distribution of the individual hours elasticities due to a simulated ten percent increase in own or the partner's gross wage for the years 1998 (–––) and 2018 (——). *Source:* ifo Microsimulation Model; SOEP v36.

Distribution of individual elasticities As an alternative to aggregate labour supply, individual elasticities can be analysed. Calculating elasticities as the mean or the median of individual elasticities essentially confirms the baseline results for aggregate elasticities (see also Figure B.5 and Table B.14 in the appendix).

Figure 3.4 shows the cumulative distribution of the individual hours elasticities for the years 1998 and 2018. In general, individual own-wage elasticities are concentrated around values of -0.05 and 0.4 with differences mainly across gender. There is almost no mass of outliers with elasticities lower than -0.1 or higher than 0.6. Looking at differences from 1998 to 2018, again a clear shift to higher elasticities can be found along the whole distribution for couples and single males.

While for couples, the changes in elasticities appear mainly as a uniform shift, the distribution of single males' elasticities becomes also more dispersed. For single females, the distribution of individual elasticities becomes slightly more concentrated. The distribution of individual cross-wage elasticities again show the result that males become more sensitive and females less sensitive to the partner's wage. This comes with a noticeable change in the concentration. Males' elasticities are slightly more dispersed and females' elasticities tend to show a higher concentration in 2018.

Similar to Figure 3.3, Figure B.6 in the appendix shows the evolution of the three quartiles of the individual hours elasticities from 1998 to 2018.

3.4.4. Robustness checks

As shown by Löffler et al. (2018), the estimation of discrete choice labour supply models is sensitive to differences in modelling assumptions and data handling. As a result, the *level* of the implied elasticities may vary depending on model specifications. To assess the sensitivity of the results presented above, I carry out various robustness checks.[32] I find that the different modelling assumptions do not substantially impact the *changes* in implied elasticities over time. The conclusions remain essentially the same as for the preferred baseline specification, i.e., that labour supply elasticities have risen over time, especially for couples and single males.

The evolution of the implied elasticities is reported in the appendix in Figure B.5. As before, a linear trend is fitted, and the change in wage elasticity from the fitted values 1998 to 2018 is calculated for each robustness check, reported in Table B.14. A general message from Figure B.5 is that estimated elasticities are very similar for most robustness checks. In particular, all alternative specifications show a general upward trend in elasticities. For a

[32]In each robustness check, one element will be varied relative to the baseline specification. A full interaction of all elements, as done by Löffler et al. (2018), cannot be done in the scope of this paper, as this paper includes 21 years, instead of only one year.

few subgroups, some alternative specifications lead to slightly different elasticities.

For instance, when specifying a quadratic utility function, the elasticities of singles tend to be slightly higher than for the baseline translog specification. This is mainly apparent for single men over the last decade, resulting in a greater change when looking at trend lines (a plus of 0.151 in lieu of 0.112 in the baseline, see Table B.14). For single females, the change from 1998 to 2018 would amount to a plus of 0.059 points instead of 0.033. For couple-females, the increase in elasticities is smaller as elasticities tend to be higher in earlier years than for the baseline specification.

Simulating elasticities by 'shocking' gross wage using a one percent wage increase instead of a ten percent wage increase would result in a bigger change in elasticities for single males and a smaller change for couple-females. For all other subgroups, the change in elasticities is essentially the same as in the baseline. However, due to complexities of the budget set, a wage increase of only one percent could sometimes lead to strong relative net income changes which are not economically meaningful.

Turning to robustness checks on the model specification accounting for unobserved heterogeneity, I estimate the model as a random coefficients model with heterogeneity in preferences for consumption and leisure. This relaxes the assumption on the error term, specifically overcoming the property of independence of irrelevant alternatives (IIA), and has become standard in the discrete choice labour supply literature. However, various studies have found no significant differences in elasticities estimated by random coefficient models in contrast to conditional logit models (for Germany, see Haan, 2006; Löffler et al., 2018). I also find that the results do not differ qualitatively nor quantitatively.

3.4.5. Decomposition

On the one hand, the documented changes in implied elasticities over time may result from changes in fundamental preferences. On the other hand, they may simply arise from composition changes within each subgroup, or both. Demographic variables, such as the number of children or the age structure of each sample, have changed over time. As shown in section 3.4.1, the mean age increased in all subgroups and the number of children slightly decreased over time. Since these demographic variables are arguments of the utility function, a change in these would in itself lead to different labour supply outcomes, even if preferences remained the same. Beyond that, it could lead to different implied labour supply elasticities, depending on the changed demographics. Furthermore, educational variables have also changed during the last two decades, resulting in a different wage structure. Heim (2007) also notes that composition changes may play an important role in explaining changes in elasticities. Specifically, lower birth rates after the baby boomer generation, higher educated cohorts, fewer families, more families without children and later time of birth produce

Table 3.3.: Wage elasticity, counterfactual data composition

		Singles		Couples			
Model	Data	M w^m	F w^f	M w^m	F w^f	M w^f	F w^m
Total elasticity							
1998	1998	0.019	0.128	0.046	0.134	-0.022	-0.056
2018	2018	0.130	0.145	0.084	0.212	-0.028	-0.029
1998	$2018^{\text{CPI}=1998}$	0.068	0.181	0.063	0.185	-0.028	-0.072
2018	$1998^{\text{CPI}=2018}$	0.102	0.127	0.083	0.195	-0.029	-0.026
Intensive elasticity							
1998	1998	-0.021	0.024	0.010	0.040	-0.004	-0.014
2018	2018	0.028	0.060	0.034	0.123	-0.008	-0.012
1998	$2018^{\text{CPI}=1998}$	-0.014	0.040	0.009	0.056	-0.006	-0.019
2018	$1998^{\text{CPI}=2018}$	0.014	0.050	0.034	0.105	-0.006	-0.007
Extensive elasticity							
1998	1998	0.040	0.104	0.037	0.094	-0.017	-0.042
2018	2018	0.102	0.084	0.050	0.089	-0.020	-0.018
1998	$2018^{\text{CPI}=1998}$	0.082	0.141	0.053	0.129	-0.022	-0.053
2018	$1998^{\text{CPI}=2018}$	0.088	0.078	0.050	0.089	-0.023	-0.019

Note: This table shows the wage elasticities for 1998 and 2018 and for counterfactual model-data combinations. The first and the second row of each panel show the results using the estimated behavioural model for the actual years. The third row of each panel shows the simulated elasticities for the 2018 data using the estimated model of 1998. The fourth row of each panel shows the simulated elasticities for the 2018 data using the estimated model of 2018. Monetary variables for each counterfactual model-data combination are deflated using the German CPI.

different samples and different elasticities.

In order to check the relevance of composition changes over time, I conduct an analysis using counterfactual model-data combinations. To that end, I predict labour supply using the estimated preferences from 2018 using the data, i.e., the demographic composition, from 1998 and simulate the elasticities again. In a cross-check, I also predict labour supply for the 2018 data using the 1998 preferences. So that models can be compared, monetary variables for the counterfactual combinations are deflated using the German consumer price index.

The results are shown in Table 3.3. The first and the second row of each panel repeat the results using an estimated behavioural model for the actual years from Table B.13. The third row of each panel shows the simulated elasticities for 2018 data using the estimated model of 1998. The fourth row of each panel shows the simulated elasticities for the 1998 data using the estimated model of 2018.

The overall conclusions differ for singles and couples and also by gender. For males, the result is that elasticities are generally small when using the 1998 model (preferences and restrictions), and larger when imposing the 2018 model for both the 1998 and 2018 data.

However, for males, it is also clear that elasticities are slightly higher when using the 2018 data and holding preferences constant at the 1998 model.

For instance, for couple-males, the actual elasticities for 1998 data and 1998 preferences result in an own-wage elasticity of 0.046. Holding the model constant at 1998 preferences, but using the 2018 composition, results in a small rise in the elasticity to 0.063. The actual elasticity implied by the 2018 preferences and 2018 data amounts to 0.084. This means that the compositional change did play a role for elasticities, but that the effect of changes in preferences is larger. Similarly, the counterfactual combination of 2018 preferences with 1998 data would already lead to a relatively high elasticity (0.083), close to the actual elasticity in 2018. This pattern is also apparent for single males, and holds for the intensive and the extensive elasticity.

For females, the counterfactuals show a different picture. For couple-females, the change in preferences, holding the data constant, would lead to a relatively big increase in elasticities (from 0.134 to 0.185), closer to the actual elasticity in 2018 (0.212). The change in composition, holding the behaviour constant, would result in an elasticity of 0.195 indicating that the composition effect also plays a noticeable role. One interesting outlier are the counterfactuals for single females whose elasticities stayed rather constant on a high level over the last 20 years. However, for them, the change in preferences and restrictions, holding the data constant, would result in a slightly lower elasticity (0.127 in lieu of 0.128). In contrast, the change in composition, holding the behaviour constant, would result in a much greater elasticity (0.181) than the actual elasticity in 2018 (0.145).

As discussed, these counterfactual model-data combinations allow two ways of potentially decomposing the total change in elasticities. Note that a decomposition holding the model constant does not lead to the exact same fractions of each component as when holding the data constant. Therefore, it is convenient to calculate combined effects averaging both ways (the Shapley value) to summarise the effects.[33] Figure 3.5 shows this decomposition for the above discussed findings graphically.

To summarise, the counterfactual model-data combinations reveal that compositional changes only play a minor role in the shift in elasticities for males, since most of the change in elasticities is driven by estimated preferences or labour market restrictions. Cross-wage elasticities of females are getting closer to zero, mainly due to a strong model effect. For couple-females, changes in composition play an equally strong role in the rise of elasticities

[33]More formally, denote $\varepsilon_{M,D}$ as the elasticity simulated with the model estimated in period M using data of period D with values 0 for 1998 and 1 for 2018. One way would be to decompose $\varepsilon_{1,1} - \varepsilon_{0,0}$ (the total change) into $\varepsilon_{1,1} - \varepsilon_{0,0}$ (model contribution I) plus $\varepsilon_{1,1} - \varepsilon_{1,0}$ (data contribution I). The alternative decomposition order of the total change is into $\varepsilon_{0,1} - \varepsilon_{0,0}$ (data contribution II) plus $\varepsilon_{1,1} - \varepsilon_{0,1}$ (model contribution II). The Shapley values are simply the averages of contribution I and II for each component and add up to the total change.

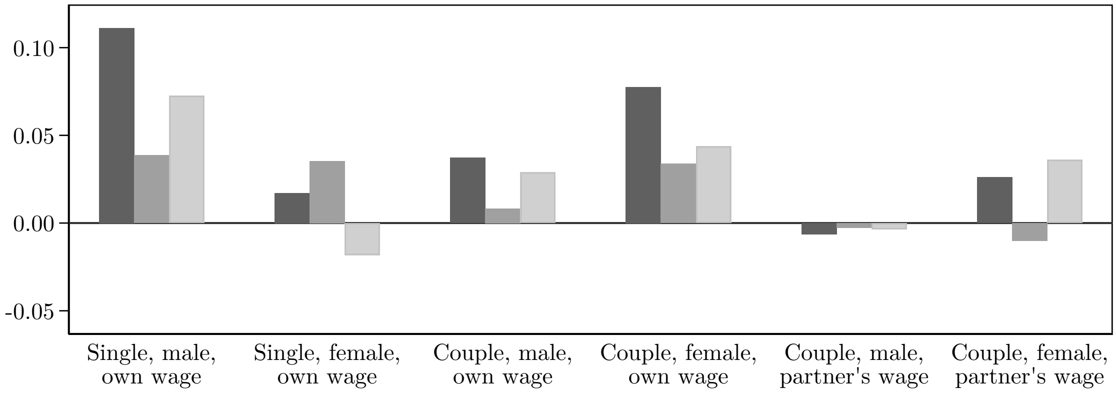


Figure 3.5.: Change in elasticitiy 1998 to 2018, decomposition. *Note:* The figure shows the total change in wage elasticities (▬), decomposed into a data component (▬) and a model component (▬) calculated as the Shapley value for each component.

as the changes in the model component. Notably, for single females, changes in behaviour and restrictions would have led to further shrinking elasticities over the last 20 years and would have continued the trends of elasticities found in the literature. However, changes in composition propose an opposing effect which counterbalances this. The following subsection 3.4.6 discusses potential explanations for the documented changes.

Note that the shift in elasticities could also be attributed to changes in labour market restrictions. For instance, it might well be that those part-time restrictions – especially for males – became more relaxed over time. This would also be revealed in the model component due to the way labour market restrictions are modelled.

3.4.6. Discussion

The finding that labour supply elasticities have recently increased in Germany is a new one. This subsection discusses the size of the changes and potential explanations.

Magnitude of changes The changes in this paper for Germany amount to an increase in the total elasticity by 0.0056 per year for single males, and by 0.0028 for couple-females over 20 years. Changes are smaller for couple-males (by 0.0007 per year) and for single females (by 0.0017 per year). However, most prominent are the changes for couples over the years 1998 to 2008 (meaning a plus of almost 0.01 points per year over ten years). Changes of this magnitude over a relatively short time are well documented by other authors, for example by Heim (2007) and Bargain and Peichl (2016), who document a decrease in elasticities 1980 to 2000 in the US and in the EU, or Elder et al. (2020) documenting the increase in elasticities in the US since 2000. Furthermore, labour supply elasticities are estimated to be generally higher in Germany than in the US (Bargain and Peichl, 2016). Therefore, a change from or to higher elasticities might be higher in Germany than in the US.

Focusing on married females in the US, Heim (2007) determines that hours elasticities decreased until 2000 from 0.36 to 0.14 over 25 years (an annual change of -0.0088). In a meta-regression analysis, Bargain and Peichl (2016) summarised that married female elasticities estimated by discrete choice models[34] decreased by 0.31 over 24 years (an annual change of -0.013).

Looking at the time since the mid-1990s, Elder et al. (2020) find that for single males, the total elasticity has increased from 0.046 to 0.113, a change of 0.003 per year, which is comparable to what I find for single males in Germany. The change in single females' elasticities mainly took place between 2003 and 2014 and is stronger in the US (a plus of 0.0079 per year). In contrast, according to Elder et al., the changes for couples in the US are smaller than in Germany, and the absolute increase in males' elasticities are similar to the increase for females' (around 0.00113 points per year).

Potential explanations What could explain the increase in labour supply elasticity, in particular the model component? While not providing a formal analysis, I illustrate four major points that could explain the results. 1. Change in norms, especially the fatherhood role, 2. more time-intensive possibilities of consumption, 3. a reduction in labour market restrictions, and 4. changes in the tax and transfer system.

The elasticities of males in general increased, but especially the elasticities of males with a female partner are not zero or close to zero any more. An initial explanation is a change in gender and parenting norms. The increasing wage elasticity for fathers could be associated with an emergence of what is sometimes described as the 'new fatherhood' role. The idea is that there has been a shift in norms, i.e., the definition of the role of fatherhood. That is, fathers are less committed to the traditional role of male breadwinner, and shift towards a more intensive parenting role. This role is based less on the male breadwinner as a fulfilling role, but more on active involvement with children.

Using SOEP data on desired hours of work, Pollmann-Schult and Reynolds (2017) study how fatherhood in Germany has changed over time. The results are only indicative, but suggest that the younger cohorts in Germany are more open to reducing their working hours in order to take care of their family. Still, change here seems to be slow.

Interestingly, Blau and Kahn (2007) contend that females became more like males in their labour supply behaviour, and that this could explain the *decrease* in labour supply elasticities of married females until 2000. Blau and Kahn, p. 397 write that as "the traditional division of labor is breaking down and men and women more equally share home and market

[34]In their survey, Bargain and Peichl also note that continuous choice models prominent in the 1980s following the Hausman approach led to very high elasticities up to one.

responsibilities, we expect women's labor supply elasticities to approach men's over time". The results of my paper for German couples also show that males and females have become more alike – but the other way round, as males' labour supply elasticities have now become more similar to women's.

Changing policies in Germany, e.g., the parental leave reform, may be the result, but also a driver, of changing norms. Aaberge and Colombino (2018, p. 178) note on the evolution of labour supply elasticities in Norway that a "greater degree of equality in education among women and men and generous parental leave plans have also contributed to the fact that the fathers have taken parental leave from work and become more involved in the service production at home, which might have contributed to more equal labour supply behaviour for females and males over time."

Furthermore, it could also be that changes in female characteristics over time have an impact on male elasticities. In particular, higher education and a higher labour force participation of married females, possibly in combination with fewer children, could reduce the 'need' for a male breadwinner role. This explanation is related to income effects. If females' wages and labour force participation increased over time, this might represent an overall shift in the partners' labour supply curve.

These changes in norms are likely to be a cohort effect and might explain, to some extent, the increase in labour supply elasticities of males with a female partner. However, this does not explain the trends for singles without children.

A second explanation that could be relevant for singles is the evolution of consumption possibilities in recent decades, which could have resulted in a greater value of leisure time. In particular, video games, home video and the internet media have provided new means of consumption. While new media is affordable in monetary terms, it is relatively 'costly' in terms of time use. The argument is that screen time in general grows, resulting in the increasing importance of leisure over work time. For the US, Aguiar et al. (2021) show that leisure time use of younger men has strongly shifted toward video gaming and recreational computing, and that, in turn, market hours have decreased. Aguiar et al. also estimate that the new consumption possibilities at declining relative prices strongly increased the reservation wages of younger men by 2.5 percent while the effect on women is only small (one percent).

The third line of arguments regards the evolution of labour market restrictions. Note that labour market restrictions are modelled ad hoc as part of the utility function to reflect that not all choice categories are equally available and that there are fixed costs of work. A shift in labour market restrictions could explain the changes in the documented 'model component'. In the last two decades in Germany, labour demand and occupation types have changed, too.[35] If this is associated with a shift from fixed working hours towards more flexible hour agreements and more jobs with flexible schedules, this could be consistent with an increase in labour supply elasticities, since it is easier to switch between hours. My finding that the intensive margin plays a much greater role, especially for women who are still more often in part-time than men, is consistent with that argument. The fact that part-time jobs become more easily available, also to men, could drive the elasticities and serve as a potential explanation. What could still be relevant regarding labour market restrictions are fixed costs of work, which are also modelled as part of the empirical model and might be revealed as an increased elasticity.

Finally, changes in the tax and transfer system could also have played a role in the documented changes, as elasticities with respect to gross wages are reported. Depending on the tax rate and progressivity, an increment in the gross wage mechanically translates to net wage changes. Lower tax rates lead to higher gross wage elasticities.[36] As gross wage elasticities are influenced by differences in taxation over time, the documented changes in elasticities might be driven by tax reforms in Germany. As elasticities did rise mainly in the first decade of the observational period (1998 to 2008), this could actually be the result of the big income tax reform in Germany from 2000 to 2004 when the top income taxes were reduced. Furthermore, this effect might also explain part of the variation of the gross wage elasticity of single males that might be considered as cyclicality, e.g., during the 2009 recession. This could be the result of automatic stabilisers, i.e., mechanically lower taxes due to progressivity of the tax and transfer system.

3.5. Conclusion

In the last decades, female labour force participation has increased in Germany, mainly in favour of part-time work. Part-time work of males also increased but remains still on a much lower level than part-time work of females. These changes in labour supply outcomes could be the result of changes in institutions, compositional changes, changes in fundamental preferences, or a mixture of these factors. A typical measure that summarises labour supply preferences is the wage elasticity of labour supply.

In order to analyse trends in labour supply elasticities for the years 1998 to 2018, I estimate a static discrete choice model of unitary household labour supply for each year. I find that

[35] This resulted in job polarization, as the share of medium-paid occupations has declined in favour of more low- and high-paid occupations (Dustmann et al., 2009; Antonczyk et al., 2018). Peichl and Popp (2022) analyse static labour demand models over a longer period in Germany and find that polarization of jobs since the 1990s and 2000s is not only driven by shifts in labour demand, like routinization or offshoring, but is also driven by changes in labour supply.

[36] Bargain et al. (2014, p. 751) report "Elasticities after a 1 percent increase in net wage are generally larger; indeed, a 1 percent change in gross wages corresponds to smaller increments due to taxation."

the own wage labour supply elasticities implied by the models have increased over the last two decades. Total own wage hours elasticities have increased, especially for couples around the turn of the century and for single males. Looking at cross-wage elasticities, I find that the responsiveness of males to the partner's wage slightly increased. In contrast, females became less sensitive to their partner's wage. The shift in elasticities could also be attributed to changes in labour demand, reflecting a relaxation of market restrictions over time.

These findings contrast some trends found for earlier periods. For the US and for Germany, a decrease in elasticities of married females has been documented for 1970 to 2000 (Bargain and Peichl, 2016; Heim, 2007; Blau and Kahn, 2007). Currently, there is no estimation of elasticities for Germany with a consistent methodology over a longer time span and most studies focus on married females only. However, the finding that elasticities of females as well as males have recently increased (again) in the last decades can also be found for the US (Elder et al., 2020).

Using counterfactual model-data combinations, I decompose the changes into changes in composition and changes in preferences and labour market restrictions. I find that compositional changes in demographics play only a minor role in the shift in males' own- and cross-wage elasticities, since most of the change in elasticities is driven by preferences or by labour market restrictions. For females, changes in composition play a bigger role in the rise of elasticities.

These trends in work and consumption preferences could also result in changes in income inequality. In a recent paper, Mühlhan (2022), using a similar approach, decomposes changes in income inequality between 2004 and 2015 in Germany and finds that inequality was impacted by employment changes. Mühlhan attributes part of the increase in female employment to preference changes. For the US, Bergstrom and Dodds (2021) find that productivity plays a much bigger role than preferences in this regard.

Finally, the documented changes in preferences and labour market restrictions impact the design of tax policy. This paper shows that the labour supply elasticity changes over time due to various factors such as preferences but also individual and household characteristics. Therefore, tax and transfer policies impacting work incentives may change over time, reflecting the documented changes. The labour supply elasticity is not a 'natural constant' and for (optimal) taxation we need to look at current developments when designing policies.

Chapter 4.

German Public Finances through the Financial Crisis[1]

4.1. Introduction

The German experience of the financial crisis differs from that of most other countries in Europe. In Germany, the crisis entailed a very strong shock, but one that was relatively concentrated in the exporting, manufacturing industries. In 2009, real GDP fell by more than 5 percent. To a large extent, this was driven by a massive decline in exports (14 percent). Due to earlier labour market reforms that increased flexibility and kept unit labour costs low, and thanks to policy instruments that facilitated labour hoarding (in particular, the 'short-time working scheme'[2]), the German labour market survived the crisis without a lasting effect on unemployment rates. In fact, unemployment decreased further to new record lows after 2010.

The German banking sector was severely adversely affected by the crisis. The German government mobilised significant resources to support banks. As a result of both the decline in GDP and the bank stabilisation operations, the German public debt to GDP ratio increased from 67 percent in 2008 to nearly 83 percent in 2010. Yet the interventions in the banking sector were essentially one-off expenses, and the increase in the debt ratio overstates the true cost of banking sector stabilisation because the public sector also acquired significant

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[1]This is the peer reviewed version of the following article: Blömer, M. J., M. Dolls, C. Fuest, M. Löffler and A. Peichl (2015). 'German Public Finances through the Financial Crisis'. *Fiscal Studies* 36.4, pp. 453–474, which has been published in final form at `https://doi.org/10.1111/j.1475-5890.2015.12073`. A previous version has been published as ZEW Discussion Paper 15-041. We would like to thank the editors, referees and participants at the workshop on 'European Public Finances through the Financial Crisis' (ZEW, Mannheim, 10–11 June 2014) for useful advice and comments. We would also like to thank Julius Koll and Klara Schade for excellent research assistance.

[2]Bargain et al., 2012.

assets.[3] The overall fiscal burden of the financial crisis will only be known when these assets are liquidated.

A third important factor is that the public sector budget in Germany was almost balanced before the crisis, so there was room to allow the automatic stabilisers to play their part.[4] Since Germany quickly recovered from the initial decline in GDP, the need for fiscal consolidation was limited. Therefore no significant tax reforms or spending cuts were made in the years after the crisis.

This paper presents the German experience of the financial crisis. It starts by describing the macroeconomic situation and how the crisis unfolded in Germany (Section 4.2), before focusing on the situation of the public finances (Section 4.3). Section 4.4 is dedicated to the policy responses to the financial crisis and Section 4.5 concludes.

4.2. Impact of the financial crisis: the macro picture

4.2.1. National income

With the exceptions of 1993 and 1996, the 1990s were characterised by stable real GDP growth rates of around 2 percent per year. Real GDP growth flattened in the early 2000s, being close to zero in 2002 and negative in 2003, but became stronger from 2004 onwards, with real GDP reaching its pre-crisis peak in 2008. Germany was hit by a severe output shock in 2009 when real GDP fell by more than 5 percent. This was to a large extent driven by a significant reduction in exports (14 percent) contributing roughly 6 percentage points to the GDP drop. However, output recovered quickly in the following years and exceeded its pre-crisis peak in 2011.

Real GDP forecasts from May 2008 and May 2009 from the Working Party on Tax Revenue Forecasting, an advisory council at the Federal Ministry of Finance, show clearly that the negative GDP shock in 2009 was not anticipated in 2008. The projection from Spring 2008 still foresaw a growth rate of 1.2 percent for 2009 and it was only in Spring 2009 that the forecast was significantly corrected downwards to -6 percent.[5] Interestingly, forecasts from 2008 and 2009 did not foresee GDP growth to be as strong as observed in 2010 and 2011, whereas forecasts were too optimistic for 2012 and 2013.

[3]The direct costs of financial sector intervention from 2008 to 2010 amounted to 10.8 percent of 2010 GDP (International Monetary Fund, 2011). Note, however, that this includes recoverable assets of EUR 240 billion purchased in 2010. Excluding asset purchases, the debt would have increased to 71 percent of GDP in 2010. Which parts of these assets will in fact be recovered is, however, yet unknown. In 2014, the impact of financial sector interventions on gross public debt was still 7.9 percent of 2014 GDP (International Monetary Fund, 2015).

[4]Dolls et al., 2012.

[5]Even in November 2008, real GDP was projected to grow by 0.2 percent.

Figure 4.1.: Evolution of share of population unemployed (%). *Note:* Unemployment definition follows International Labour Organisation (ILO) concept. *Source:* German Council of Economic Experts (2013, p. 87); German Council of Economic Experts website, data sheets 'Bevölkerung und Bevölkerungsvorausberechnung für Deutschland' (`http://www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/download/zeitreihen/ZR018.xlsx`, 4 December 2013) and 'Erwerbstätige und Erwerbslose' (`http://www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/download/zeitreihen/ZR089.xlsx`, 14 March 2013).

4.2.2. Labour markets

Figure 4.1 shows that the share of the German population who were unemployed increased sharply after reunification, with the number of unemployed rising from 2.1 million in 1991 to 3.8 million in 1997. Between 1997 and 2000, the unemployment rate decreased, but it then rose again in the early 2000s and reached its peak in 2005 when 4.5 million people were seeking work. Around that time, Germany was often called the 'sick man of Europe'. The surge in unemployment put the centre-left coalition of Chancellor Gerhard Schröder under enormous pressure. The government enacted labour market reforms known as the 'Hartz reforms' from 2003 to 2005 with the aim of making the German labour market more dynamic and reducing long-term unemployment. Since then, the unemployment rate has been declining and – to the surprise of many observers – it did not soar up in 2009 when real GDP declined by 5.6 percent. Unemployment increased only very moderately in 2009,

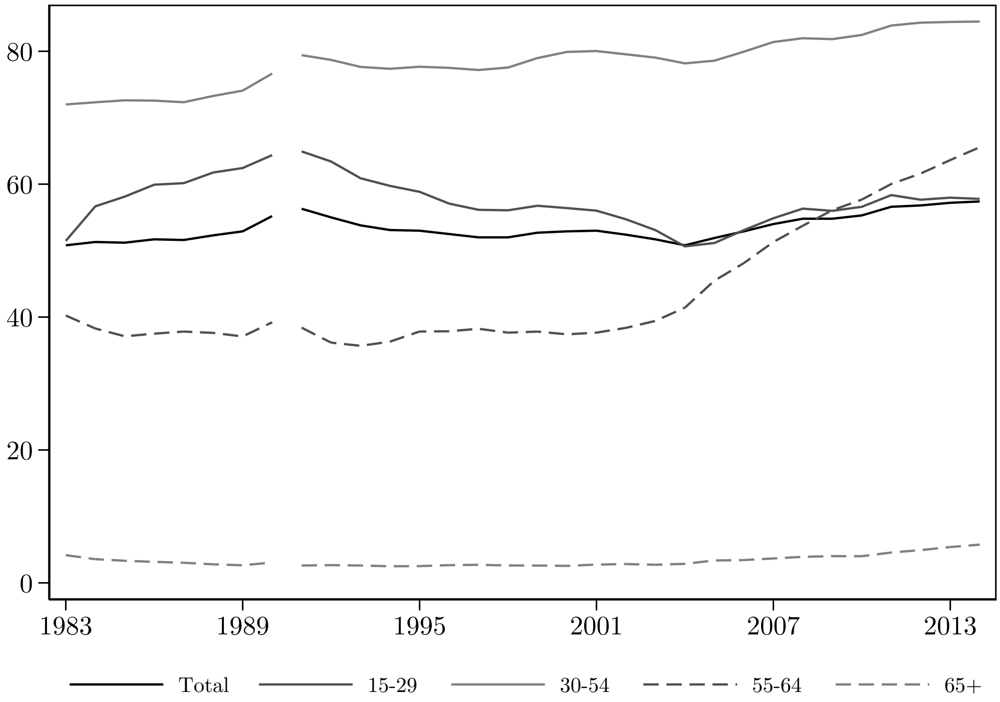

Figure 4.2.: Employment to population ratio (%). *Note:* Employment rate defined as number of people who are employed as a percentage of the total working-age population. Until 1990, data are for West Germany only. *Source:* ILOSTAT database, EU-LFS, the EU labour force survey.

but has fallen in the years since. There are different views on which factors contributed to the impressive labour market developments since 2005. Some observers argue that the Hartz reforms played an important role in making the labour market more flexible and in strengthening job-search incentives, while others point to the German system of industrial relations, which helped German industry to improve its competitiveness.[6]

Figure 4.2 shows the evolution of the employment rate since the early 1980s. In line with the reduction of the unemployment rate since 2005 shown in Figure 4.1, the employment rate has steadily increased since 2004. For the total population, it rose from 50.8 percent in 2004 to 57.2 percent in 2013. The employment rate rose fastest – by 22 percentage points in that period – for those in the 55–64 age group, and moderately for all other age groups. The retirement entry age will increase stepwise to the age of 67 in the period 2012–23, which might further strengthen this trend.

Figure 4.3 shows the evolution of real and nominal growth rates for gross wages and labour compensation. It stands out that real wage growth stagnated between 2001 and

[6]See Rinne and Zimmermann (2012, 2013) and Dustmann et al. (2014).

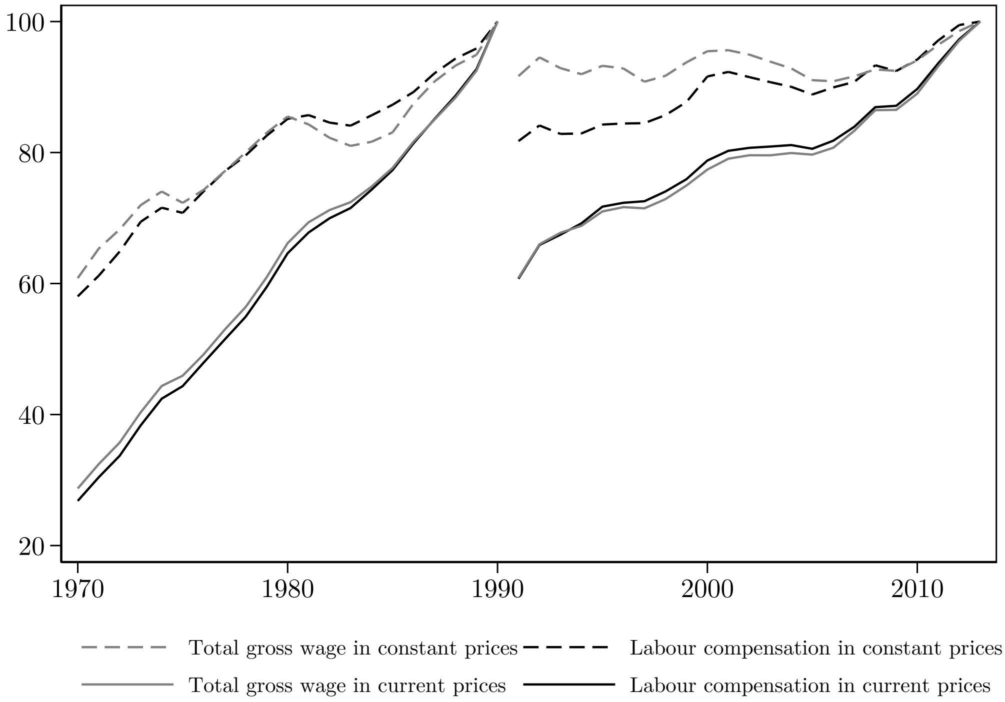

Figure 4.3.: Change in real and nominal wage growth (index series). *Note:* The base year for the period before (after) reunification is 1990 (2013). The time series until 1990 includes West Germany only. Real wages are based on the CPI (base year for West Germany: 1995; base year for the period after reunification: 2013). Labour compensation is deflated using the GDP deflator (base year for West Germany: 1991; base year for the period after reunification: 2013). *Source:* Federal Statistical Office, National Accounts.

2006, in a period with rising unemployment (see Figure 4.1). As argued by Dustmann et al. (2014), stronger bargaining power of employer federations – due to new opportunities to move production to central and eastern Europe – forced unions to agree to wage restraint in that period, which has helped German industry to regain competitiveness.

4.3. Public finance responses

4.3.1. Fiscal stance before the crisis

Tables 4.1 and 4.2 show the composition of public spending and revenue in Germany before the crisis. Social security and retirement expenditure make up a large fraction (46 percent) of total government expenditure in Germany. Among the OECD countries, only a few countries (Austria, France, Greece, Italy and Portugal) have public retirement expenditure as high as

Table 4.1.: Composition of public spending in 2007

	EUR billion	% of GDP
Social Security (incl. Unemployment Benefits)	228	9.4
Retirement expenditure	259	10.7
Health	149	6.1
Public Administration	144	5.9
Education	96	4.0
Economic Affairs	77	3.2
Public Order and Security	37	1.5
Defense	26	1.1
Housing	21	0.9
Recreation, Sport, and Culture	15	0.6
Environment	12	0.5

Note: Shares add up to 43.9 per cent of GDP. Total public spending in 2007: EUR 1,064 billion. *Source:* Institut der deutschen Wirtschaft Köln (2008); `https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/OeffentlicheFinanzenSteuern/OeffentlicheFinanzen/AusgabenEinnahmen/Tabellen/AusgabenausgewaehlteAufgabenbereiche.html`; OECD (2012).

Table 4.2.: Composition of public revenue in 2007

	EUR billion	% of GDP
Taxes on income and profits of individuals	219	9.0
Taxes on corporate profits	55	2.3
Social security contributions	321	13.3
Taxes on property	22	0.9
Value added taxes	170	7.0
Taxes on specific goods and services	76	3.2
Taxes on use of motor vehicles and other goods	9	0.4

Note: Shares add up to 36.1 per cent of GDP. Total revenue in 2007: EUR 872.7 billion. *Source:* OECD (2011).

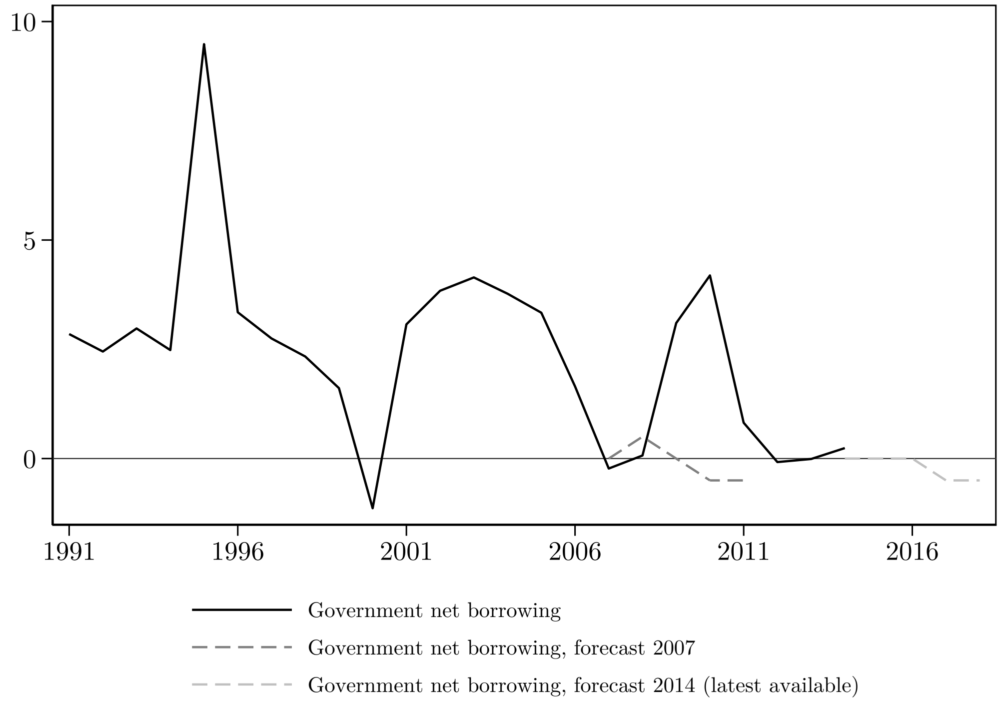

Figure 4.4.: Government net borrowing (% of GDP). *Source:* OECD.Stat, Economic Outlook No. 95, May 2014, OECD annual projections; European Commission, European Economic Forecasts, Autumn 2007 and 2014.

Germany (10.7 percent of GDP in 2007).[7] Given the unfavourable demographic trends in Germany, the burden of old-age expenditure on public budgets can be expected to grow even further. According to the 2012 Ageing Report of the European Commission,[8] it is projected to increase to more than 13 percent by 2060. On the revenue side, income tax, value added tax and social security contributions are the largest sources of revenue in Germany.

Prior to the crisis, the federal government had been engaging in fiscal consolidation efforts to improve the sustainability of Germany's public finances. As can be seen in Figure 4.4, the government cut the overall budget deficit to 1.7 percent of GDP in 2006 – one year earlier than postulated by the ECOFIN Council in March 2006. Consequently, the Excessive Deficit Procedure against Germany was terminated in June 2007. European Commission forecasts in Autumn 2007 foresaw a balanced budget for 2008 and 2009, which, according to the German Stability Programme in 2007, was due to cyclical and structural factors. Indeed, the 2007 autumn forecast projected a structurally balanced budget for that year and only

[7] OECD, 2012.

[8] European Commission, 2012.

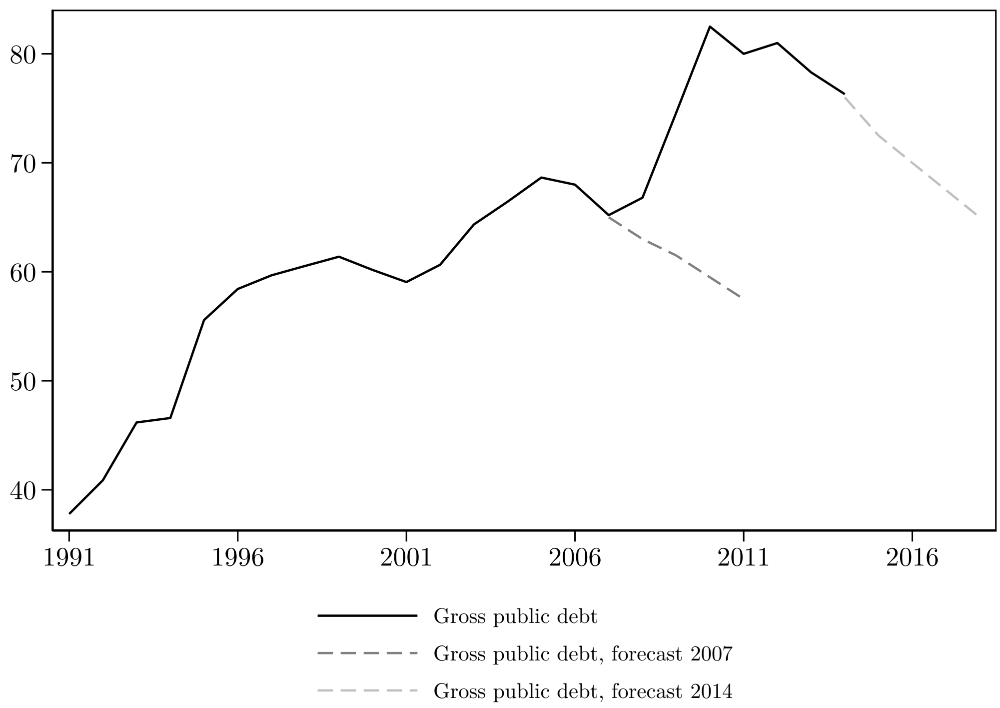

Figure 4.5.: Gross public debt (% of GDP). *Note:* 1991–94 – general government gross financial liabilities. Since 1995 – gross public debt according to Maastricht criterion. *Source:* OECD.Stat, Economic Outlook No. 95, May 2014, OECD annual projections; Federal Ministry of Finance, *German Stability Programme December 2007 Update* (http://ec.europa.eu/economy_finance/economic_governance/sgp/pdf/20_scps/2007-08/01_programme/2007-12-05_de_sp_en.eps); Federal Ministry of Finance, *German Stability Programme 2014 Update* (http://ec.europa.eu/europe2020/pdf/csr2014/sp2014_germany_en.eps).

small structural deficits (-0.4, -0.2) for 2008 and 2009. Figure 4.5 shows that the German government projected the debt to GDP ratio to fall below 60 percent – the reference value of the Maastricht Treaty – in 2010. The actual debt to GDP ratio in 2011 (80 percent) was more than 20 percentage points higher than this pre-crisis forecast for 2011 (see Section C.1 in the Appendix for some institutional information on the budgetary process).

4.3.2. How did the crisis affect the public finances?

Since 2008, the German government has enacted three packages[9] of expansionary fiscal measures in response to the recession, mainly aimed at stimulating production demand. ‘Economic Stability Plans 1 and 2’ (*Konjunkturpaket* 1 and 2), enacted in 2008 and 2009 respectively, and the ‘Growth Acceleration Law’ (*Wachstumsbeschleunigungsgesetz*), enacted

[9]It is an open question whether all of these measures (which are officially branded as responses to the crisis by the German government) would actually not have happened in the absence of the crisis.

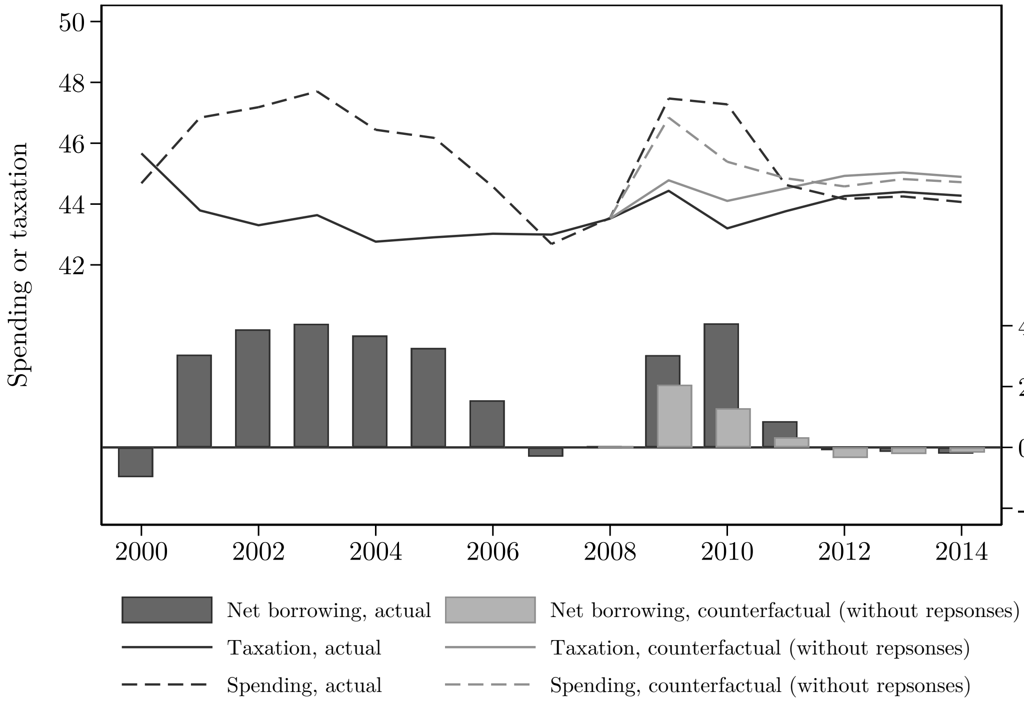

Figure 4.6.: Taxation, spending and borrowing: actual and counterfactual (% of GDP). *Source:* Authors' calculations. The counterfactual series relate to the calculations on the additional fiscal burden of the reactions to the crisis that are represented in Table 4.3. Counterfactual taxation subtracts the net effect of changes to category i from actual taxation. Counterfactual spending subtracts the additional fiscal burden of changes to categories ii, iii and iv from actual spending. Sources for GDP and government receipts and disbursements – OECD.Stat, Economic Outlook No. 96, November 2014, OECD annual projections. Sources for counterfactual analysis – German Council of Economic Experts (2009, 2010), Hübner (2010) and International Monetary Fund (2011).

in 2009, all became effective (at the earliest) in 2009 and can be seen as a response to declining export demand. In contrast to these expansionary measures, the government introduced the 'Future Package' (*Zukunftspaket*) in 2010, which included policy measures to reduce public spending and increase taxes to address the rise in Germany's national debt and the European national debt crisis.

A comparison of actual taxation and spending and a counterfactual in the absence of any policy responses is shown in Figure 4.6.[10] The dark lines show the actual out-turns for total

[10]*Data sources for Figures 4.6, 4.7 and 4.10 and Table 4.3*: We use data from OECD.Stat, Economic Outlook No. 96, November 2014, OECD annual projections. Spending is defined as total disbursements of the general government, and taxation as the total receipts of the general government, all as a percentage of GDP. To calculate the additional fiscal burden of the particular policy reactions, we use data from the Federal Ministry of Finance and estimations made by the German Council of Economic Experts (GCEE; *Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung*). For 'Economic Stability

government receipts and disbursements and the lighter lines show the counterfactual.

As can be seen in Figure 4.6, the changes in taxation that can be attributed to responses to the crisis had the effect of reducing government receipts. Therefore, the counterfactual taxation would have been higher if these reforms had not taken place. GDP reached its pre-crisis peak in 2008. In 2009, nominal GDP fell by around 4 percent while nominal government receipts decreased by around 2 percent even with the tax-decreasing reforms in place. Relative to GDP, government receipts increased in 2009; without policy responses, tax receipts would have been a bit higher.

The short-term response to the crisis was to increase spending because the government wanted to stimulate consumption and dampen the effect of the downturn in exports. Later, the German government had to react to the increasing debt and (from 2011 on) reforms that decreased spending compared with the counterfactual became effective. However, the quick return to the precrisis GDP level and positive growth rates afterwards were the main drivers that allowed spending to decline as a share of GDP.

In comparison with other European countries, these responses to the crisis were relatively small. The combined effect of all policy reactions to the crisis mainly showed up in 2009 and 2010 when the stimulus packages were effective and before the counteracting fiscal tightening took place. In contrast to other countries, the fiscal contraction due to reforms was very small in Germany and only just counterbalanced the (permanent) expansionary measures.

The additional fiscal burden of the policy reactions increased national debt by EUR 24 billion (1 percent of GDP) in 2009 and EUR 72 billion (2.8 percent of GDP) in 2010. Subsequently, the reversal of some of these policies coupled with other expansionary packages (the Growth Acceleration Law) and the counteracting policy measures of the Future Package resulted in an additional increase in government debt of around EUR 14 billion (2011), EUR 7 billion (2012) and EUR 2 billion (2013) and a small reduction in government debt of EUR 1 billion in 2014, each of which was below 1 percent of GDP.

Most of the additional fiscal burden in 2009 and 2010 was due to increases in spending (around EUR 64 billion in both years combined), while taxation fell by EUR 32 billion in both years combined. A significant part (EUR 33 billion) of the additional spending in 2010 was financial sector support in the form of direct capital injections by the federal states.[11]

As can be seen in Figure 4.6 though, without policy responses government spending would have still been higher than taxation during the crisis. Therefore, counterfactual net

Plans 1 and 2', see German Council of Economic Experts (2009, p. 65); for the 'Growth Acceleration Law', see Hübner (2010, p. 240); for the 'Future Package', see German Council of Economic Experts (2010, p. 209). Financial sector support includes only direct capital injections from the federal states and KfW, a German government-owned development bank; we use estimates from International Monetary Fund (2011, p. 8).

[11]Financial sector support in the form of asset purchases (EUR 240 billion) is not considered for the counterfactual.

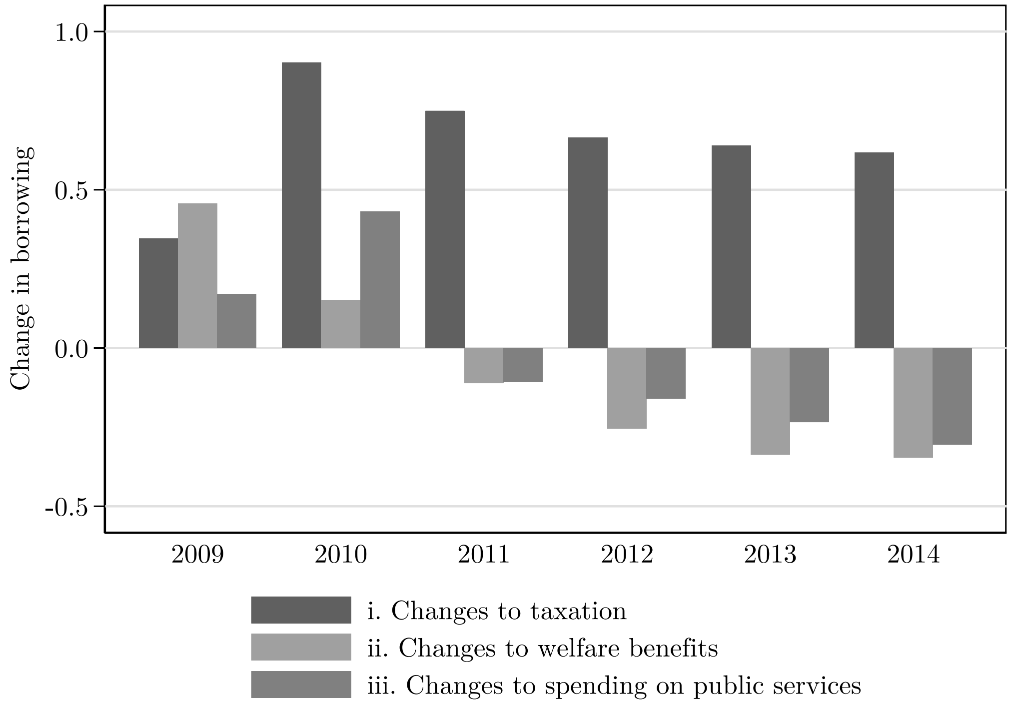

Figure 4.7.: Composition of the public finance responses (% of GDP). *Note:* Policy responses are effective since 2009. Financial sector interventions are excluded. *Source:* German Council of Economic Experts (2010); Hübner (2010); OECD.Stat, Economic Outlook No. 96, November 2014, OECD annual projections.

borrowing during this period would have still been positive. In contrast to earlier recessions, the counterfactual figures on net borrowing during the crisis of 2008–10 indicate a fairly cyclical pattern. The policy responses during the crisis did increase government debt beyond the cyclical deficit, but by quite a small amount.

4.3.3. What was the fiscal response to the crisis?

Figure 4.7 decomposes the public finance responses, as a percentage of GDP, into changes to taxation, changes to welfare benefits and changes to spending on public services. For a further decomposition into single measures, see Table 4.3 later.

The earliest policy reactions were included in Economic Stability Plans 1 and 2, which contained budgetary costs of EUR 56 billion in 2009 and 2010, of which EUR 26 billion were due to changes in taxation. Economic Stability Plans 1 and 2 included permanent changes to taxation of around EUR 17.1 billion per year from 2011.

With Economic Stability Plan 1, the fiscal burden on enterprises and households decreased. By improving depreciation allowances for small and medium enterprises (SMEs), and the limited tax exemption for new cars and other facilitating measures, the state had additional costs of around EUR 8.3 billion in 2009 and 2010 and around EUR 5.7 billion each year afterwards. As part of Economic Stability Plan 2, the income tax basic allowance was increased by EUR 170 and the lowest marginal tax rate was decreased from 15 percent to 14 percent. Another important factor has been the reduction of the average premium for public health insurance. The costs of the measures amounted to EUR 5.9 billion in 2009 and around EUR 11.4 billion each year afterwards. The Growth Acceleration Law further improved the situation for enterprises due to specific deductions. In addition, inheritance tax decreased, reducing taxes by around EUR 400 million per year. The reduced taxation is estimated by the German Council of Economic Experts (GCEE) to be EUR 6.1 billion in 2010 and EUR 8.4 billion in later years.[12] The changes in taxation that are laid down in the Future Package had an opposite effect to that of the other measures. It introduced new air traffic taxes, lower energy tax breaks, and a nuclear fuel tax (*Kernbrennstoffsteuer*) for nuclear power plants.[13] The tax changes of the Future Package sum to around EUR 7.5 billion per year of additional taxation.

Economic Stability Plans 1 and 2 temporarily increased spending on public services, welfare benefits and other spending areas in 2009 and 2010 by a total of around EUR 15 billion each year. In particular, Economic Stability Plan 1 announced a traffic investment programme worth EUR 2 billion, and the duration of short-time work has been increased to 18 months (see Section C.2 in the Appendix). Economic Stability Plan 2 provided EUR 13.3 billion for investment in infrastructure and the education system. There has also been a special programme to support the automotive industry, readjustments in the vehicle tax to enforce environmentally-friendly technologies and a further increase in short-time work subsidisation. The Growth Acceleration Law included a relief for families of around EUR 4.6 billion each year, by increasing child benefits and raising the tax-exempt amount for families with children. Lastly, the Future Package contained measures contrary to the other new regulations. Through cuts to spending on the public and military sectors and a readjustment of social laws, the state cut spending by around EUR 6 billion in 2011, EUR 12 billion in 2012, EUR 16 billion in 2013 and EUR 19 billion in 2014.

Financial sector support during the crisis (not shown in Figure 4.7) consisted of asset purchases (EUR 240 billion, 9.5 percent of GDP) and direct capital injections (EUR 33 billion in 2010) by the federal states and KfW, the government owned development bank. The direct capital injections amounted to a significant part of the increase in government expenditures in 2010 (1.3 percent of GDP).

[12] Hübner, 2010.

[13] The nuclear fuel tax is also part of the 'Ecological Readjustment' changes in nuclear energy policy.

4.4. Policy responses: an opportunity for reform?

4.4.1. Changes to tax and benefits

This section presents a micro analysis of the changes to the tax and benefit system introduced after the crisis. First, the additional fiscal burden of the policy responses will be further disaggregated into individual measures and yearly changes and, second, the redistributive impacts of these changes will be presented.

Table 4.3 shows the additional fiscal burden (as a percentage of GDP) of the tax changes in the four policy packages discussed in Sections 4.3.2 and 4.3.3. Economic Stability Plan 1 introduced changes in taxation that mainly affected small and medium enterprises rather than households. The biggest changes in household taxation happened through Economic Stability Plan 2. The German Council of Economic Experts estimated the additional fiscal burden of the reduction in income tax to be EUR 5.4 billion in each year from 2010.

It can also be seen that the additional fiscal burden of the benefit changes and one-off benefits was quite small. Economic Stability Plan 1 accounted for less than EUR 1 billion additional spending in 2009 and 2010, due to the increase of short-time work duration during the crisis. Economic Stability Plan 2 included a one-off benefit of EUR 100 per child, and a permanent increase of monthly payments for children aged 6–13, which amounted to EUR 1.8 billion additional spending in 2009. Another one-off benefit to households was a premium of EUR 2,500 to promote the replacement of old cars (‘cash for clunkers’). The GCEE estimated the impact of the programme on the budget to be EUR 5 billion. With further costs of EUR 4.2 billion in 2009 and EUR 3.1 billion in 2010 for the additional subsidisation of short-time work during the crisis, Economic Stability Plan 2 accounted for most of the increases in spending on benefits.

As mentioned in the previous discussion, the German government’s fiscal responses to the crisis included only minor permanent changes to the tax and benefit system. The most prominent among these actions entailed increases in the basic allowance of the federal income tax and more generous child benefits and child allowances (see Section 4.3.3). Besides such direct fiscal responses announced with the Economic Stability Plans, the federal government has also enacted a series of other policy reforms since the beginning of the crisis in late 2008. Most of these tax and benefit changes were not designed as a reaction to the economic downturn but had already been planned months or even years before the crisis, or were implemented as a consequence of judgements by the Federal Constitutional Court that had been pending for several years. Although these changes in the tax and benefit system were not meant officially as responses to the crisis, they still affected household incomes, especially at both extremes of the income distribution. We therefore include them in the following discussion of the tax-benefit reforms since 2008.

Table 4.3.: Additional fiscal burden by reform package, categories and measures (% of GDP)

	2009	2010	2011	2012	2013	2014
Economic Stability Plan 1 (2008)	0.15	0.29	0.21	0.21	0.20	0.20
i. Taxation						
Improved depreciation allowances for SMEs; limited tax exemption for new cars; other facilitating measures	0.11	0.22	0.21	0.21	0.20	0.20
ii. Welfare benefits						
Increase in STW duration	0.01	0.03				
iii. Spending on public services						
Public investment	0.04	0.04				
Economic Stability Plan 2 (2009)	0.82	0.96	0.42	0.41	0.41	0.39
i. Taxation						
Income tax basic allowance increased by EUR 170; lowest marginal tax rate decreased from 15% to 14%	0.11	0.21	0.20	0.20	0.19	0.19
Reduction of the average premium of the public health insurance	0.13	0.23	0.22	0.22	0.21	0.21
ii. Welfare benefits						
One-time benefit of EUR 100 per child and a small permanent increase of monthly payments for 6–13 year old children	0.07					
One-time benefit to households: ‘cash for clunkers’	0.20					
Additional subsidisation of short-time work during the crisis	0.17	0.12				
iii. Spending on public services						
Public investment in infrastructure and education	0.13	0.39				
Growth Acceleration Law (2009)		0.24	0.31	0.31	0.30	0.29
i. Taxation						
Increase in tax allowance for children and increase in child benefits by EUR 20 per child		0.11	0.17	0.17	0.16	0.16
Tax reductions for SME and changes in corporate taxation		0.13	0.13	0.12	0.12	0.12
Changes to inheritance taxation			0.01	0.01	0.01	0.01
Future package (2010)			-0.42	-0.68	-0.84	-0.91
i. Taxation						
Reduction of subsidies and changes to ecological taxes (Reductions of energy tax allowances, air flight taxes)			-0.09	-0.08	-0.09	-0.09
Corporate Taxes: tax compensation from the nuclear energy industry, railway dividend, financial market transaction taxes (since 2012), insolvency code			-0.11	-0.18	-0.18	-0.17
ii. Welfare benefits						
Changes to housing allowance (reduction in heating costs), additional subsidy to public health insurance (only 2011)			-0.11	-0.25	-0.34	-0.35
iii. Spending on public services						
Military reform					-0.04	-0.10
Changes in public administration			-0.09	-0.12	-0.14	-0.13
Reductions in interest payments			-0.02	-0.04	-0.06	-0.07
Fiscal market stabilisation law (2010)		1.30				
iv. Financial sector interventions						
Direct capital injections by the federal states and KfW		1.30				
Gross domestic Product, EUR billion	2,455	2,570	2,695	2,751	2,814	2,912

Note: Negative numbers indicate fiscal contraction. *Source:* OECD.Stat, Economic Outlook No. 96, November 2014, OECD annual projections; German Council of Economic Experts (2009, 2010), Hübner (2010) and International Monetary Fund (2011).

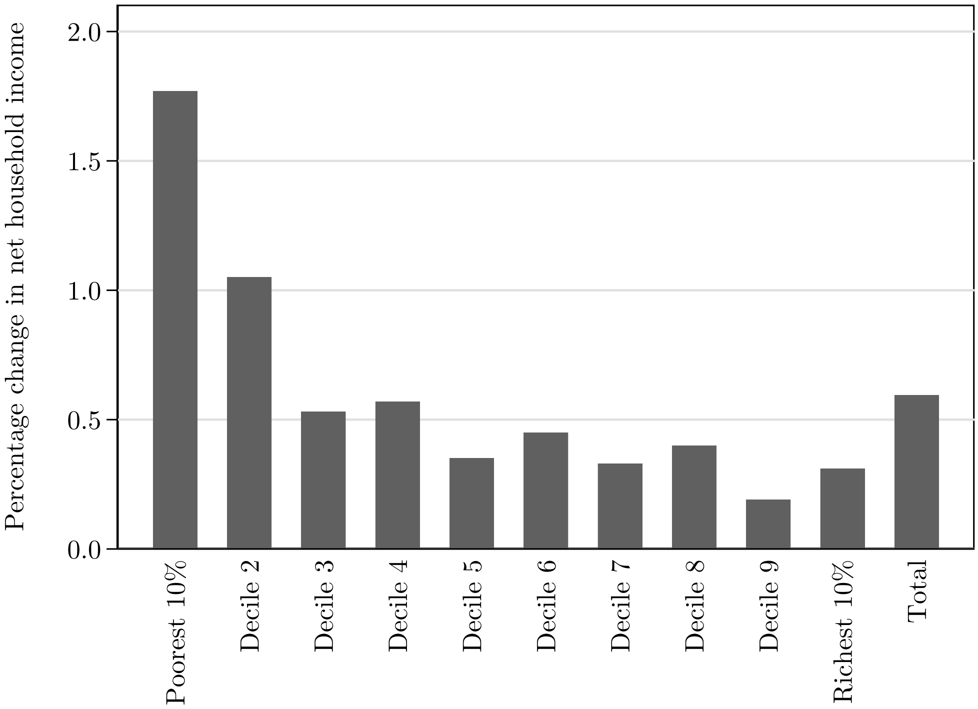

Figure 4.8.: Redistributive impact of tax and benefit changes between 2008 and 2014, by decile, expressed as the percentage change in real net household income. *Source:* Authors' calculations using IZAΨMOD v3.0.0 and SOEP wave 2009.

Figure 4.8 provides an overview of how the tax and benefit changes between 2008 and 2014 affected real equivalised household net incomes. For each decile, we compare mean net incomes after taxes and benefits under the 2008 policy system and under the tax-benefit system of 2014.[14] As can be seen from the last bar, the policy changes increased disposable net household incomes modestly on average, by 0.6 percent. That is, in stark contrast to the experience of other European countries, the net direct effect of tax and benefit changes after the crisis in Germany was to boost household incomes.

The reforms can be grouped into two categories. First, the income tax system was adjusted to reduce the effect of bracket creep and stabilise net incomes during the crisis. This entailed an increase in the basic allowance as well as slight increases in higher tax brackets. Since 2012, the basic allowance has been regularly adjusted to account for rising prices and the subsistence level, which has had the effect of lowering the tax burden especially for low income households. All other tax brackets have remained constant in nominal terms. After a political debate for over two years, the federal government also introduced a withholding

[14]The redistributive effects are simulated using the static microsimulation model IZAΨMOD v3.0.0 (Löffler et al., 2014) and the German Socio-Economic Panel Study (SOEP), wave 2009.

tax (*Abgeltungsteuer*) in 2009, which effectively limits the top marginal tax rate on capital income and capital gains to 25 percent instead of taxing them according to the regular tax rate (with marginal tax rates up to 45 percent). This reform lowered the tax burden especially for high-income households and most importantly for households with high capital incomes, which explains the slight gains for the richest 10 percent compared with the ninth decile in Figure 4.8.[15] Besides these changes to the income tax schedule, there were minor changes to the deduction of special expenses for pension and health insurance contributions.

Second, there were adjustments to social assistance (*Arbeitslosengeld II*) and housing assistance. Both became slightly more generous in the period 2008–14. In reaction to a judgement by the Federal Constitutional Court, social assistance is now linked more closely to the growth of wages and prices. Benefit payments are regularly adjusted to account for inflation and recalculated according to the living standard of low-income households. The monthly payments for single households (excluding benefits for housing and heating) increased from EUR 351 in 2008 to EUR 391 in 2014. As mentioned earlier, child benefits became more generous as well and monthly payments were raised from EUR 154 in 2008 to EUR 184 since 2010. As can be seen in Figure 4.8, this helped households in the lower deciles and increased their disposable income by 1.0–1.8 percent. Compared with the overall gain of 0.6 percent on average, this shows the progressive nature of the reforms. However, even a 1.8 percent increase for the bottom 10 percent amounts to only EUR 13 per month.

Figure 4.9 shows the effect of the tax-benefit changes since the crisis on real equivalised household net incomes for different types of families. It is clear that especially households with only one adult benefited from these reforms. Given that single households, and particularly lone parents, often belong to the low income deciles, which benefited most from reforms to the benefit system, the numbers are well in line with Figure 4.8.

The overall real effects of tax-benefit changes since the crisis were quite limited – averaging less than 1 percent of equivalised household net incomes. However, there is a progressive pattern in these (small) reforms. While the incomes of the lowest 10 percent of households were raised by 1.8 percent and the incomes of the second decile increased by 1.0 percent due to the policy reforms, the remaining 80 percent of the population saw their incomes grow by only 0.2–0.6 percent.

4.4.2. Changes to spending on public goods and services

Reductions in spending on public goods and services were mainly part of the Future Package, which was announced in June 2010, and were part of the public budget since 2011. As

[15] High-income households and capital incomes in general are known to be under-represented in the SOEP, which builds the underlying database of IZAΨMOD. Our results should thus be interpreted as a lower-bound estimate of the gain in net household incomes for the richest 10 percent of the income distribution.

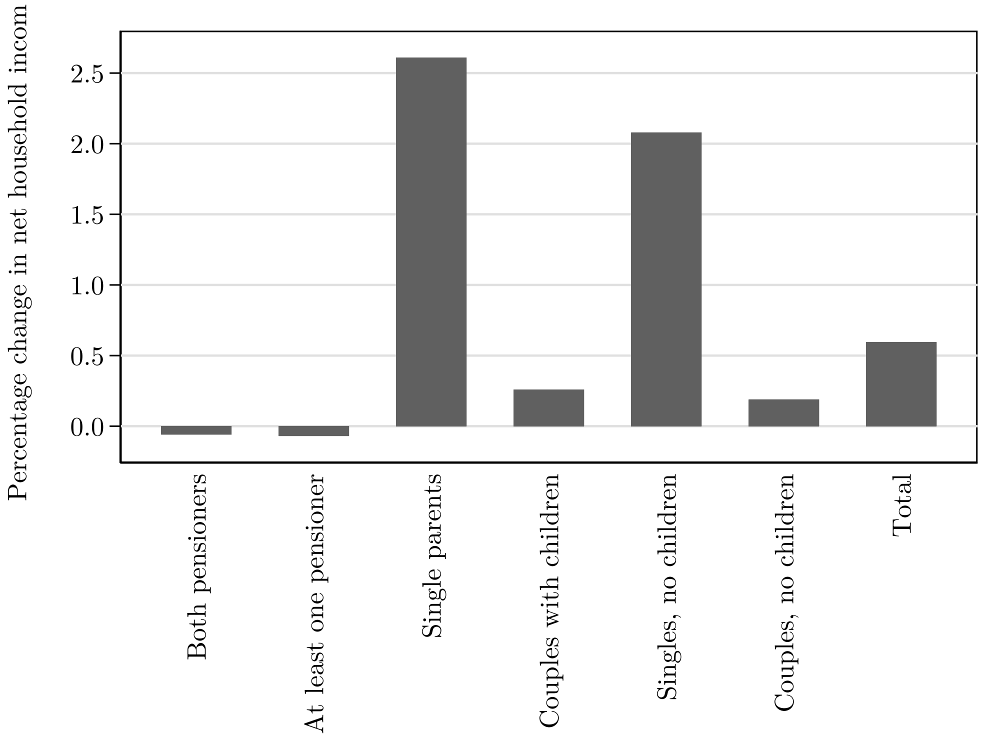

Figure 4.9.: Redistributive impact of tax and benefit changes between 2008 and 2014, by family type, expressed as the percentage change in real net household income. *Source:* Authors' calculations using IZAΨMOD v3.0.0 and SOEP wave 2009.

discussed in Section 4.3.3, these changes in spending were very small and amounted to a reduction in the fiscal burden of a cumulative EUR 22.8 billion during the years 2011 to 2014 (see Figure 4.10).

Cuts have been made in particular to public administration, and a military reform has been effective since 2013. These spending cuts range from only 0.11 percent of GDP in 2011 to 0.31 percent of GDP in 2014 (see Table 4.3), meaning that they played only a minor role. This is another way in which Germany's experience of the crisis differs significantly from that of other European countries.

4.4.3. Other structural reforms

In 2009, a balanced budget rule ('debt brake') was introduced as part of the German Constitution, which sets strict limits for net borrowing. The 'debt brake' was a direct response to the increasing public debt (see Figure 4.5), which has been significantly above the Maastricht threshold of 60 percent of GDP since 2002 and peaked during the crisis in 2010. The new balanced budget rule limits structural net borrowing to 0.35 percent of GDP for the federal government from 2016 and to 0 percent for the federal states from 2020

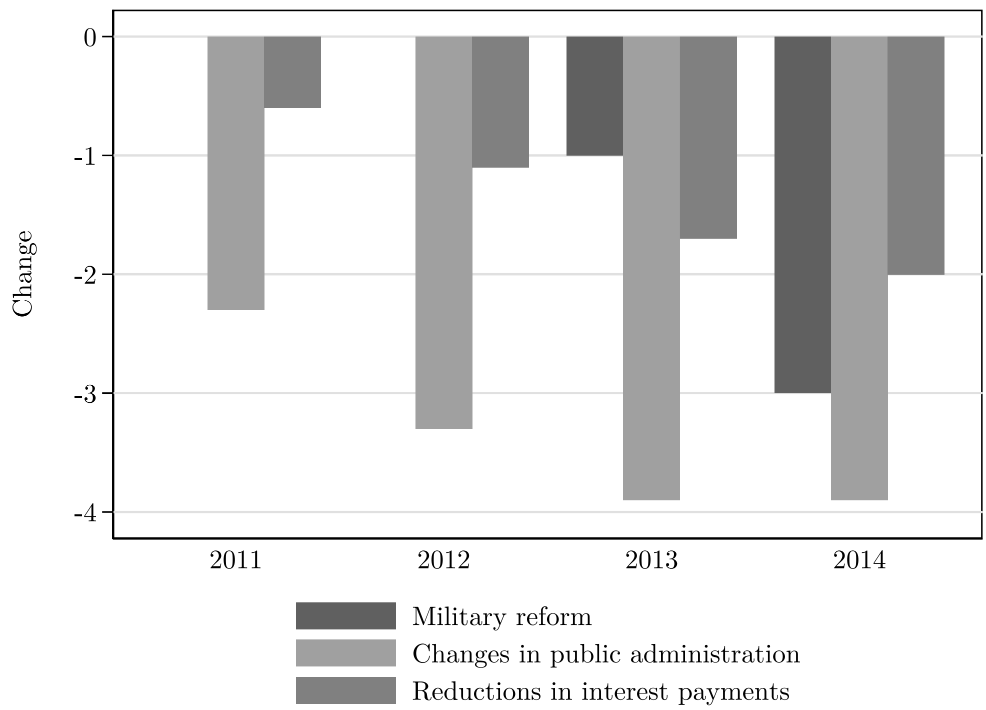

Figure 4.10.: Distribution of changes in spending on public goods and services, category iii (EUR billion). *Note:* Negative numbers indicate fiscal contraction. *Source:* German Council of Economic Experts (2010).

onwards. Before 2009 though, the level of net borrowing was already limited but subject to a general escape clause, which allowed the government to violate the limit when there was a macroeconomic disequilibrium. With the new balanced budget rule, exemptions are defined more strictly and refer to emergency cases that are not under the state's control. The debt brake also creates a direct link between new debt and an explicit repayment regulation. Furthermore, the new 'Stability Council' was created to monitor whether the structural deficit restrictions are being respected.

Beside the reactions to the crisis, other structural reforms have been implemented: most notably, a statutory uniform minimum wage of EUR 8.50 per hour. Prior to its introduction in 2015, minimum wages had been implemented only in selected industries. The effect on the labour market is still heavily debated and the impact on the public budget (for example, on payments for unemployment assistance) is unclear.

In 2007, the German government introduced a major reform of the statutory pension system. This involved a gradual increase of the standard retirement age from 65 to 67 between 2012 and 2029. In 2014, however, the government introduced two counteracting reforms – one that allows retirement at the age of 63 for employees who have been insured at least 45 years and one that increased pension entitlements for parents with children born before 1992.

4.5. Conclusions

The German experience of the crisis was very different from that of most other countries in Europe. Germany was hit by a very strong shock that was relatively concentrated in the exporting, manufacturing industries. In addition, the German labour market was very resilient during the crisis due to earlier labour market reforms and policy instruments facilitating labour hoarding (the 'short-time working scheme'). As a consequence, public finances were only moderately affected. Moreover, Germany had a balanced public sector budget when the crisis broke out, so that enough fiscal space was available to let automatic stabilisers work. Therefore, fundamental tax and expenditure reforms, which were driven by fiscal consolidation pressures in other countries, did not take place in Germany.

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Appendix A.

Appendix to Chapter 2

A.1. Data preparation: data cleaning and imputation

Imputation of missing information To maximise the available information, we fill in missing values using the full dataset, i.e. prior to imposing our sample selection criteria. When imputing missing information for the variable nationality, we first use information from parallel spells for the same individual, then information from previous spells and, if there are still missing values, with information from later spells. Similarly, we fill in missing information on region, sector, job title, position and employment status with information of previous and following spells but only if individuals stay at the same workplace.

Skill groups (educational status) Missing and inconsistent data on education are corrected according to the imputation procedure IP1 described in Fitzenberger et al. (2006). This procedure relies, roughly speaking, on the assumption that individuals cannot lose their educational degrees. Information on educational status will be aggregated in three values:

- Low-skilled: High school diploma or no qualifications.
- Medium-skilled: Completed vocational training.
- High-skilled: Technical college degree or university degree.

The final sample used in the analysis consists only of low- and medium-skilled individuals.

A.2. Definition of labour market states

Employment Employment spells include continuous periods of employment (allowing gaps of up to four weeks) subject to social security contributions and (after 1998) marginal employment. For parallel spells of employment and unemployment (e.g. for those individuals who in addition to their earnings receive supplementary benefits), we treat employment as the dominant labour market state. We disregard employment spells where individuals receive Hartz IV benefits while working (*Aufstocker*), because for this group the wage alone is not a useful metric for work incentives. Furthermore, we disregard individuals in apprenticeships and interns. It is possible that individuals have multiple employment spells at the same time. In this case, only the predominant employment spell is kept. The predominant spell is determined as follows: full-time spells outrank part-time spells. When choosing between two full-time or two part-time spells, the spell with the longest duration is kept. To break any remaining ties, the spell with the highest wage wins.

Unemployment Unemployment spells include periods of registered job searching as well as periods of receiving benefits. Prior to 2005, the latter include benefits such as unemployment insurance and means-tested unemployment assistance benefits. Those (employable) individuals who were not entitled to unemployment insurance or assistance benefits could claim means-tested social assistance benefits. However, prior to 2005, spells of receiving social assistance can only be observed in the data if the job seekers' history records social assistance recipients as searching for a job. After 2004, means-tested unemployment and social assistance benefits were merged into one unified benefit, known as 'unemployment benefit II' (ALG II). Unemployment spells during which individuals receive ALG II are recorded in the data from 2007 onwards. For the period 2010–2013 that is used, the data provides a consistent definition of unemployment.

Distinction between un- and non-employment Extending the procedure proposed by Lee and Wilke (2009), involuntary unemployment is defined as comprising all continuous periods of registered job searching and/or receipt of benefits. Gaps between such unemployment periods or gaps between receiving benefits or job searching and a new employment spell may not exceed four weeks, otherwise these periods are considered as non-employment spells (involving voluntary unemployment or leaving the social security labour force). Similarly, gaps between periods of employment and receiving benefits or job searching are treated as involuntary unemployment as long as the gap does not exceed six weeks, otherwise the gap is treated as non-employment.

A.3. Data preparation: weekly hours of work

While we observe whether an individual works full-time or part-time (defined as working less than 30 hours per week), the data lack explicit information on the number of hours worked. We only look at full-time employees and assign hours of work in the following way:

Main specification: imputation We complement the administrative data using the German Microcensus. To calculate hourly wages for full-time employment spells, we impute hours of work based on information from the German Microcensus. The imputation is done separately by region, sex, sector, job classification, and educational degree.

Alternative specification: 40 hours In a variant, we assume 40 hours of work per week for all individuals in full-time employment.

A.4. Data preparation: assignment of wages

Wages are deflated by the Consumer Price Index of the Federal Statistical Office Germany, normalised to 1 in 2015. In our data, continuous employment spells may consist of a sequence of different spells with time-varying information of daily wages. To address this issue, we adopt two different variants to assign wages to one continuous employment spell. We also assign part- and full-time status consistent with these rules.

Main specification: average over one year We assign the duration-weighted average wage confined to the last observed year for employment spell before and without a transition. For subsequent employment spells, the wage information used is an average daily wage in the first year after the transition. An individual is considered mainly full-time employed, if the weighted average duration of full-time spells over one year exceeds 50%.

Alternative specification: last and first observations For employment spells before a transition and employment spells without a transition, the last observed wage is assigned. For subsequent employment spells, the first observed wage is assigned. The last part-/full-time status is assigned to the previous employment spell, whereas the first part-/full-time status is assigned to any subsequent employment spell.

A.5. Data preparation: SSC threshold

Gross daily wages are right-censored at the upper limit for social security contributions.

Main specification: exclusion of censored observations We do not include observations with censored wages.

Alternative specification: imputation To analyse this problem, we construct cells based on gender, year, region (East and West Germany), and educational degree. For each cell, a Tobit regression is estimated with log daily wages as the dependent variable and age,

age squared, nationality, experience, experience squared, tenure in the current employment, tenure in the current employment squared, two skill dummies, occupational, sectoral as well as regional (Federal State) dummies and dummies for part-time and full-time employment as explanatory variables. As described in Gartner (2005), right-censored observations are replaced by wages randomly drawn from a truncated normal distribution whose moments are constructed by the predicted values from the Tobit regressions and whose (lower) truncation point is given by the contribution limit to the social security system.

A.6. Definition of sub-samples

Region

- East Germany: Former GDR, excluding Berlin
- West Germany, including Berlin

The labour market region of an employed individual is given by the location of the workplace. For the unemployed, we use the region where an individual searches for a job. Where this information is missing, we assign the region of the previous workplace.

Skill groups (educational degree)

- Low-skilled: High school diploma or no qualifications
- Medium-skilled: Completed vocational training

Permanent worker ability

- Four categories based on quartiles of AKM person fixed effects (PFE) distribution (see Appendix A.7)

Table A.1.: Employment-to-employment transitions across region, percent

	After transition	
Before transition	West	East
West	97.6	2.4
East	14.3	85.7

Note: Of 38,398 individuals experiencing an employment-to-employment transition, 95.9% remain in the same region.

Table A.2.: Unemployment-to-employment transitions across region, percent

	After transition	
Before transition	West	East
West	96.9	3.1
East	11.2	88.8

Note: Of 8,079 individuals experiencing an unemployment-to-employment transition, 95.2% remain in the same region.

Table A.3.: Employment-to-employment transitions across skill group, percent

	After transition	
Before transition	Low	Medium
Low	79.8	20.2
Medium	0.0	100.0

Note: Of 38,398 individuals experiencing an employment-to-employment transition, 98.6% remain in the same skill group.

Table A.4.: Unemployment-to-employment transitions across skill group, percent

	After transition	
Before transition	Low	Medium
Low	72.6	27.4
Medium	0.0	100.0

Note: Of 8,079 individuals experiencing an unemployment-to-employment transition, 96.8% remain in the same skill group.

A.7. AKM fixed effects

To measure permanent worker ability, we use person fixed effects from a two-way fixed effects model of log wages (see Abowd et al. (1999)). This model involves the estimation of the following equation

$$\log w_{it} = \alpha + \mathbf{X}_{it} \cdot \beta + \theta_i + \psi_{J(i,t)} + \epsilon_{it}, \tag{A.1}$$

where $\mathbf{X}_{it}$ is a vector of time varying observables with coefficient vector β, θ_i is a worker fixed effect that includes time-invariant observables and unobservables of individual i and $\psi_{J(i,t)}$ denotes an establishment fixed effect of establishment J, which employs worker i at time t. ϵ_{it} denotes a time-varying error term.

Estimation of Equation (A.1) follows the procedure described in Card et al. (2013) (henceforth referred to as CHK). In their two-step procedure, CHK first estimate firm fixed effects from the subgroup of workers who switch employers and control for year effects and age polynomials interacted with educational attainment. Based on these estimates, CHK compute the person fixed effects for stayers in a second step. While the original estimates used data up to 2009, the estimation procedure has been updated at the Research Data Centre of the IAB for the five periods 1985–1992, 1993–1999, 1998–2004, 2003–2010 and 2010–2017, using the universe of the Employment Histories (BeH) of full-time workers who are subject to social security contributions (Bellmann et al., 2020). Unlike in Card et al. (2013) and Card et al. (2015), the estimates for the latter four periods now also cover East Germany. The estimated person and firm fixed effects can be merged to several data sets, such as the Sample of Integrated Labour Market Biographies (SIAB) that is used in our analysis. For our analysis, we use the estimated effects for the years 2003–2010, as this time window defines the last period prior to the introduction of the minimum wage. Note that using an observation period somewhat farther away from the policy change also implies that anticipation effects are less of a concern. Merging the person fixed effect was possible for 94% of individuals in our sample. Unemployed individuals receive their person effect from their last employment spell prior to entering unemployment.

A crucial assumption underlying the AKM decomposition is that the error term in Equation (A.1) is uncorrelated to the sequence of worker i's employers. This assumption has been frequently criticised in the context of job search theory, as it does not allow for mobility based on the match-specific component of pay. Even though the fixed effects do not have a structural interpretation in our model, we wish to note that CHK demonstrate for the German case that the match-specific log wage components are quantitatively unimportant and unrelated to the direction of worker flows across employers. A further assumption of the AKM model is that firm fixed effects are additive and homogeneous across all workers employed at the same employer. To confirm this additive separability assumption, CHK further show that workers' (log) wage premiums are unrelated to their skill levels.

A.8. Descriptives

Table A.5.: Number of observations

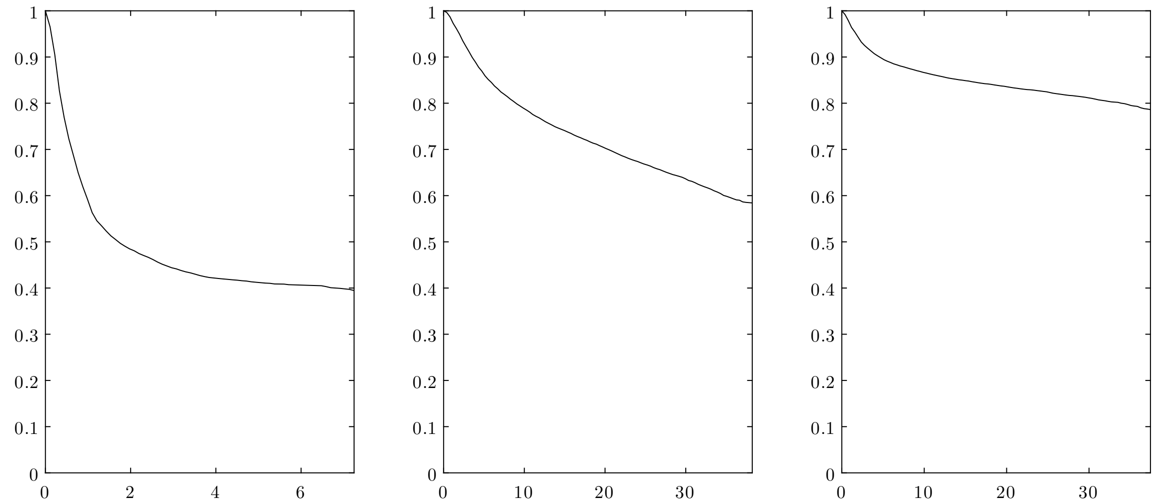
Sample	Total	Unemployment spells				Employment spells				
		Total	u → e	rc	lc	Total	e → e	e → u	rc	lc
Whole sample	208,626	16,916	8,079	8,837	27	191,710	38,398	20,818	132,494	2,219
Region										
West	176,205	13,480	6,398	7,082	23	162,725	32,720	17,003	113,002	578
East	32,421	3,436	1,681	1,755	4	28,985	5,678	3,815	19,492	1,641
Skill group										
Low-skilled	15,542	2,394	954	1,440	14	13,148	2,701	2,155	8,292	89
Medium-skilled	193,084	14,522	7,125	7,397	13	178,562	35,697	18,663	124,202	2,130
PFE quartile										
Quartile 1	37,049	7,003	2,715	4,288	21	30,046	6,391	6,712	16,943	140
Quartile 2	67,970	6,322	3,601	2,721	4	61,648	13,645	7,912	40,091	472
Quartile 3	69,438	2,581	1,431	1,150	1	66,857	12,709	4,399	49,749	902
Quartile 4	34,169	1,010	332	678	1	33,159	5,653	1,795	25,711	705

Note: Arrows (→) indicate that spells end in transitions to another employment spell (e) or to unemployment (u). Spells without an observed transition are right-censored (rc). Additionally, spells might-be left censored (lc). The column entries *Total Unemployment Spells* and *Total Employment Spells* sum up to column *Total* as 100%. The column entries $u \rightarrow e$, *rc* and *lc* sum up to column *Total Unemployment Spells*. The column entries $e \rightarrow e$, $e \rightarrow u$, *rc* and *lc* sum-up to column *Total Employment Spells*.

Table A.6.: Percentage of spell types

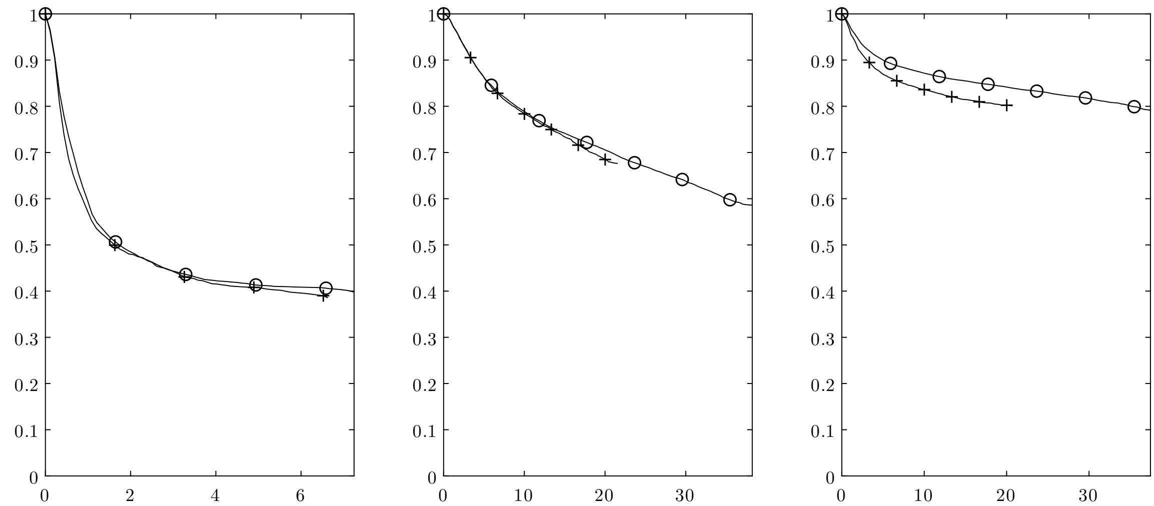
		Unemployment spells				Employment spells				
Sample	Total	Total	u → e	rc	lc	Total	e → e	e → u	rc	lc
Whole sample	100.0%	8.1%	47.8%	52.2%	0.2%	91.9%	20.0%	10.9%	69.1%	1.2%
Region										
West	100.0%	7.7%	47.5%	52.5%	0.2%	92.3%	20.1%	10.4%	69.4%	0.4%
East	100.0%	10.6%	48.9%	51.1%	0.1%	89.4%	19.6%	13.2%	67.2%	5.7%
Skill group										
Low-skilled	100.0%	15.4%	39.8%	60.2%	0.6%	84.6%	20.5%	16.4%	63.1%	0.7%
Medium-skilled	100.0%	7.5%	49.1%	50.9%	0.1%	92.5%	20.0%	10.5%	69.6%	1.2%
PFE quartile										
Quartile 1	100.0%	18.9%	38.8%	61.2%	0.3%	81.1%	21.3%	22.3%	56.4%	0.5%
Quartile 2	100.0%	9.3%	57.0%	43.0%	0.1%	90.7%	22.1%	12.8%	65.0%	0.8%
Quartile 3	100.0%	3.7%	55.4%	44.6%	0.0%	96.3%	19.0%	6.6%	74.4%	1.3%
Quartile 4	100.0%	3.0%	32.9%	67.1%	0.1%	97.0%	17.0%	5.4%	77.5%	2.1%

Note: Arrows (→) indicate that spells end in transitions to another employment spell (e) or to unemployment (u). Spells without an observed transition are right-censored (rc). Additionally, spells might be left-censored (lc). The column entries *Total Unemployment Spells* and *Total Employment Spells* sum up to column *Total* as 100%. The column entries $u \to e$, *rc* and *lc* sum up to column *Total Unemployment Spells* as 100%. The column entries $e \to e$, $e \to u$, *rc* and *lc* sum-up to column *Total Employment Spells* as 100%.



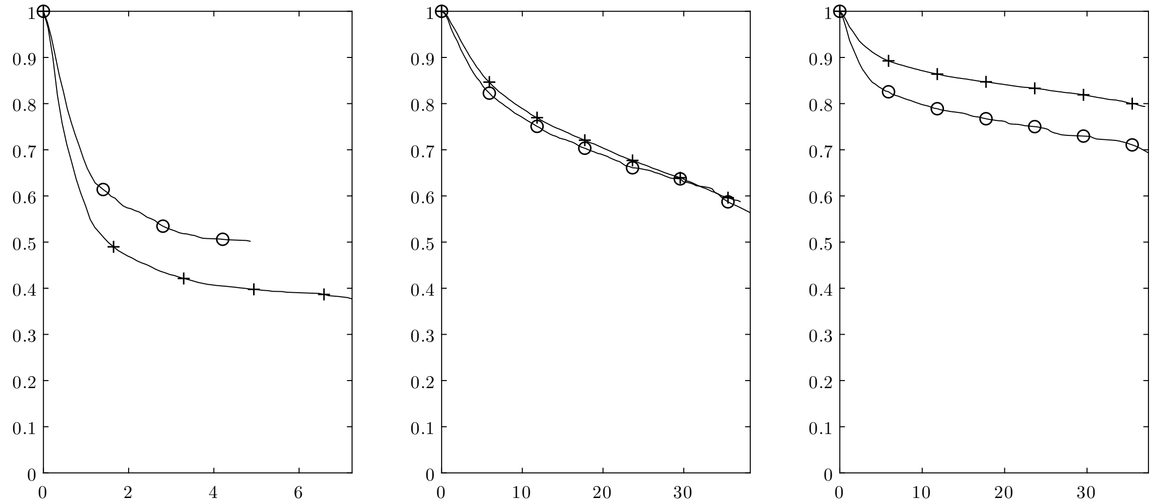
(a) u → e (b) e → e (c) e → u

Figure A.1.: Survival probabilities, whole sample. *Note:* Plots show Kaplan-Meier survival estimate for durations in years. Arrows (→) indicate that spells end in another employment spell (e) or unemployment (u).



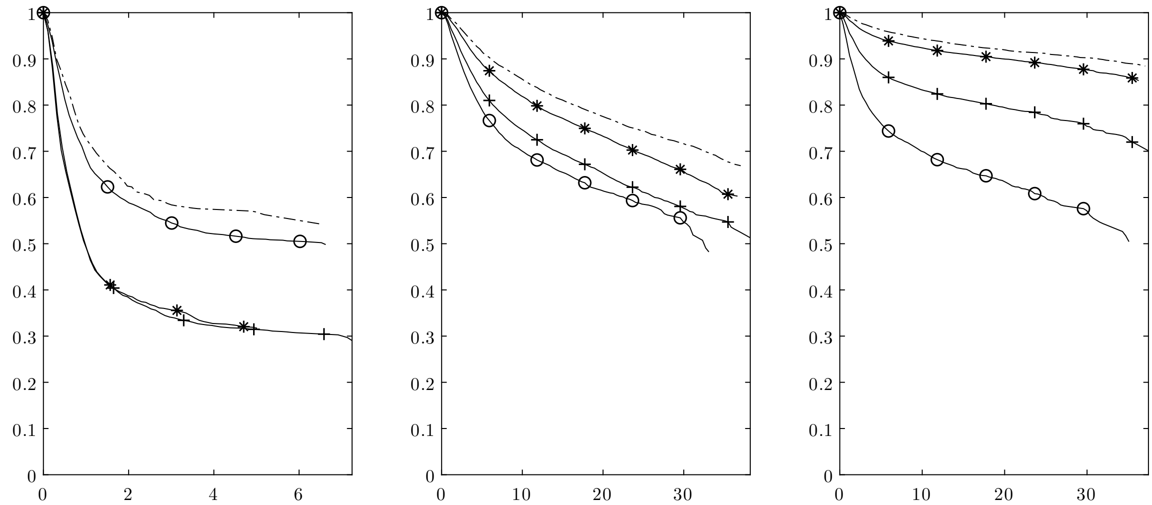
(a) u → e (b) e → e (c) e → u

Figure A.2.: Survival probabilities, by region. *Note:* Plots show Kaplan-Meier survival estimate for durations in years. Arrows (→) indicate that spells end in another employment spell (e) or unemployment (u). *Key:* West (—o—); East (—+—).



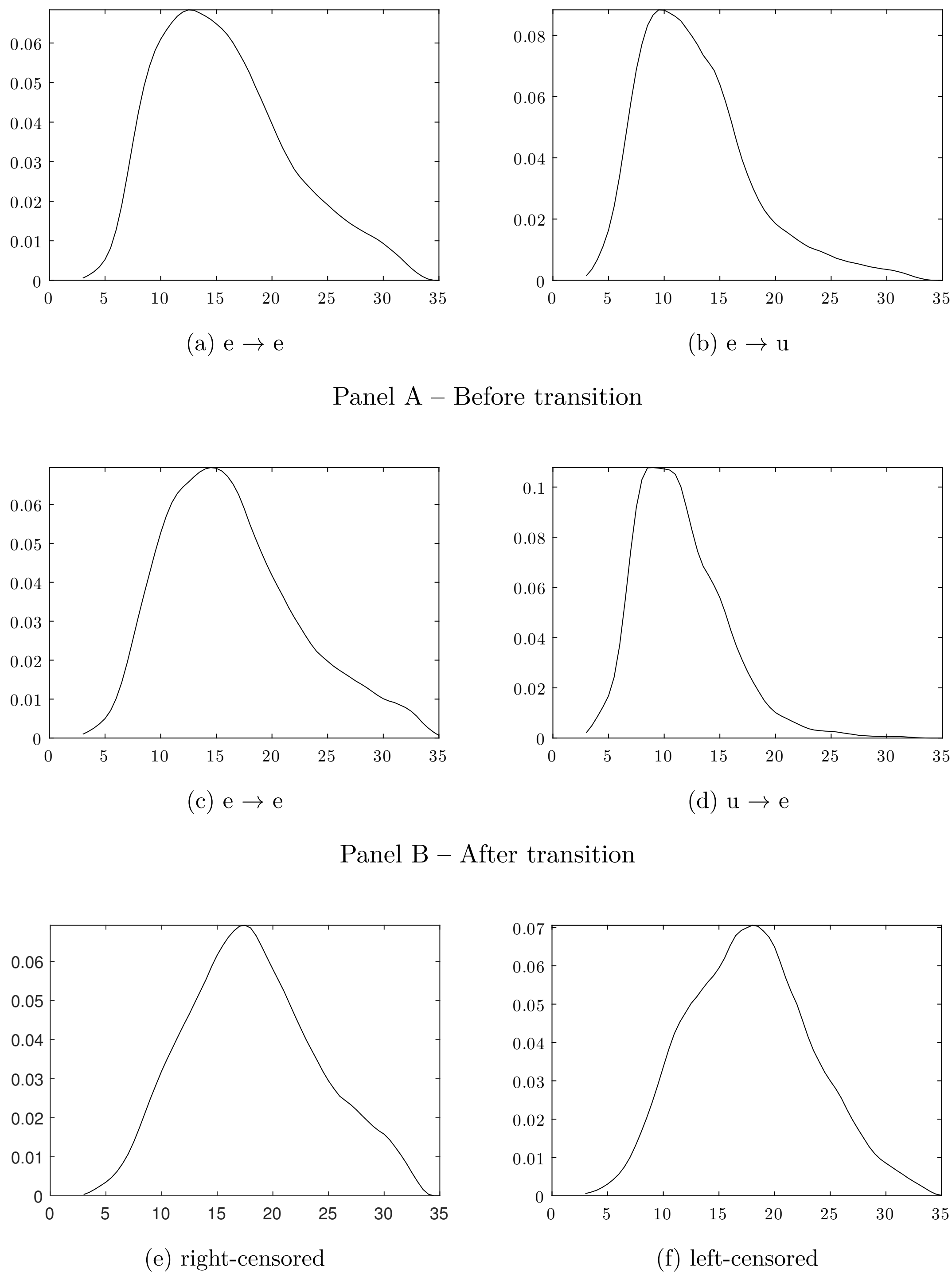
(a) u → e (b) e → e (c) e → u

Figure A.3.: Survival probabilities, by skill group. *Note:* Plots show Kaplan-Meier survival estimate for durations in years. Arrows (→) indicate that spells end in another employment spell (e) or unemployment (u). *Key:* Low-Skilled (—o—); Medium-Skilled (—+—).



(a) u → e (b) e → e (c) e → u

Figure A.4.: Survival probabilities, by PFE quartile. *Note:* Plots show Kaplan-Meier survival estimate for durations in years. Arrows (→) indicate that spells end in another employment spell (e) or unemployment (u). *Key:* Quartile 1 (—o—); Quartile 2 (—+—); Quartile 3 (—*—); Quartile 4 (—·—).



(a) e → e

(b) e → u

Panel A – Before transition

(c) e → e

(d) u → e

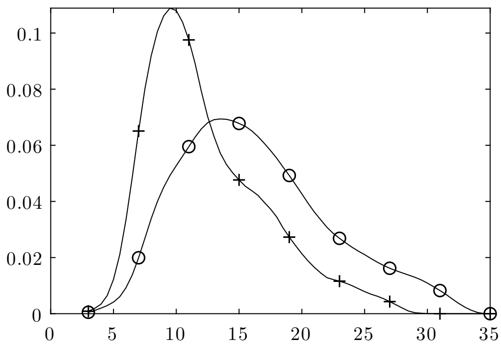
Panel B – After transition

(e) right-censored

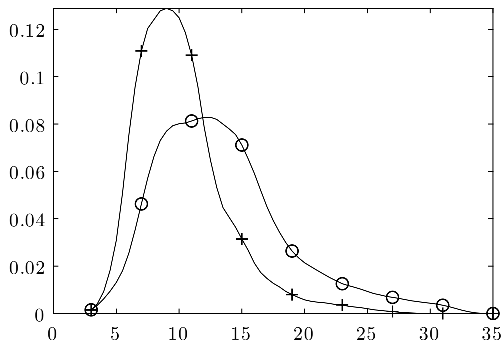
(f) left-censored

Panel C – Censored spells

Figure A.5.: Density of hourly wages, whole sample. *Note:* Epanechnikov kernel density estimate. Arrows (→) indicate that spells end in another employment spell (e) or unemployment (u). Spells without an observed transition are right-censored. Additionally, spells might be left-censored.

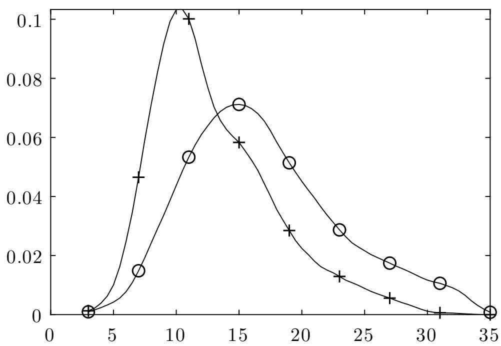


(a) e → e

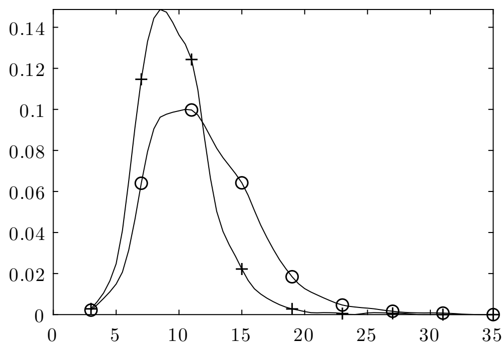


(b) e → u

Panel A – Before transition

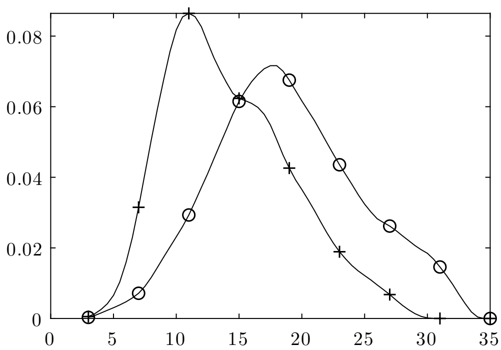


(c) e → e

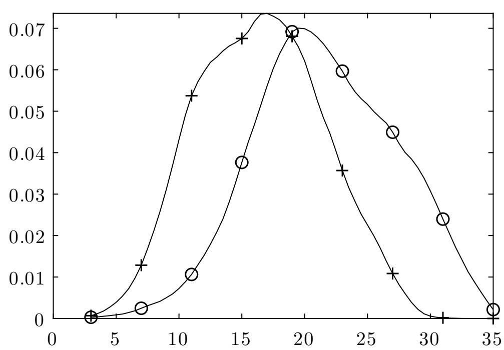


(d) u → e

Panel B – After transition



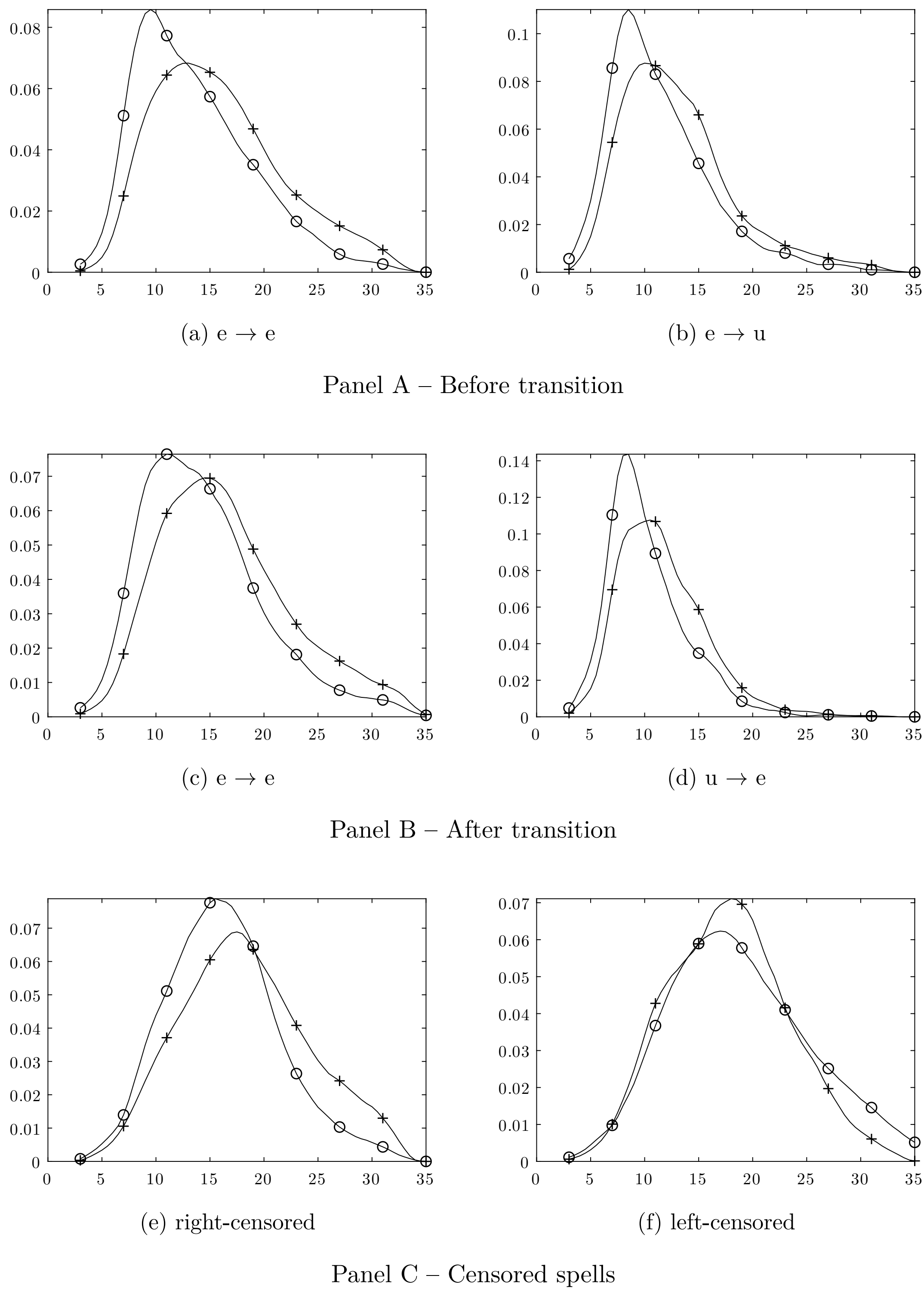
(e) right-censored



(f) left-censored

Panel C – Censored spells

Figure A.6.: Density of hourly wages, by region. *Note:* Epanechnikov kernel density estimate. Arrows (→) indicate that spells end in another employment spell (e) or unemployment (u). Spells without an observed transition are right-censored. Additionally, spells might be left-censored. *Key:* West (—○—);East (—+—).



(a) e → e

(b) e → u

Panel A – Before transition

(c) e → e

(d) u → e

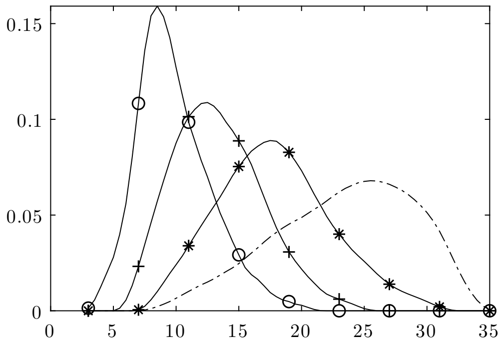
Panel B – After transition

(e) right-censored

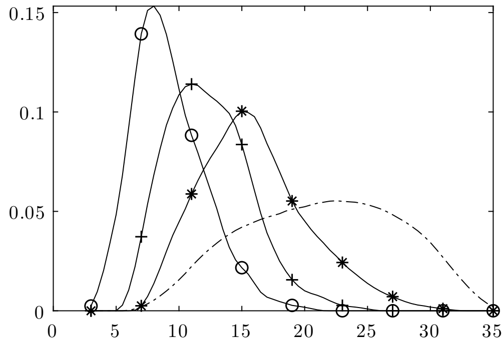
(f) left-censored

Panel C – Censored spells

Figure A.7.: Density of hourly wages, by skill group. *Note:* Epanechnikov kernel density estimate. Arrows (→) indicate that spells end in another employment spell (e) or unemployment (u). Spells without an observed transition are right-censored. Additionally, spells might be left-censored. *Key:* Low-Skilled (—o—); Medium-Skilled (—+—).

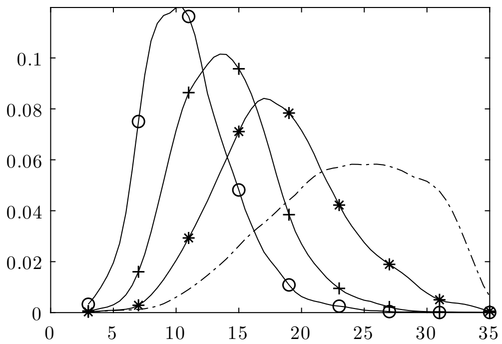


(a) e → e

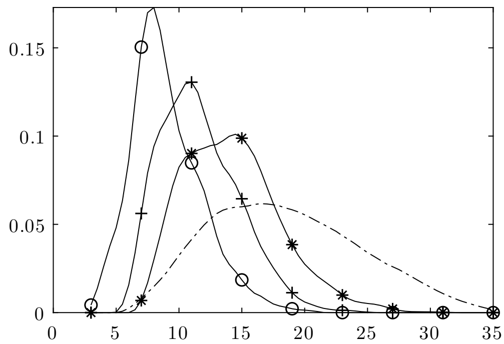


(b) e → u

Panel A – Before transition

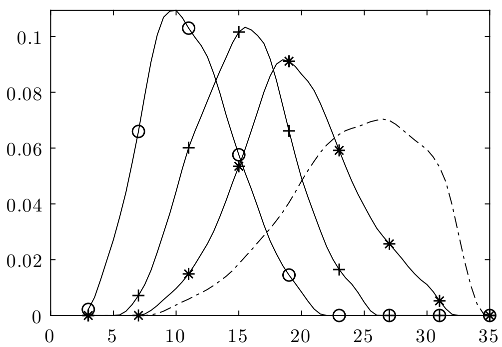


(c) e → e

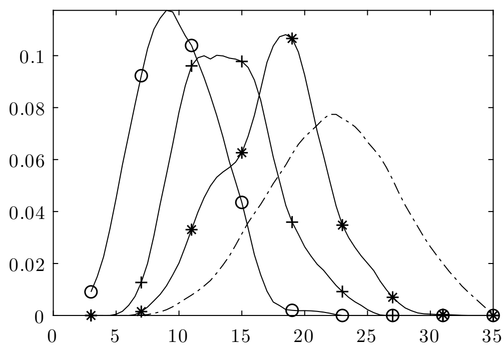


(d) u → e

Panel B – After transition



(e) right-censored



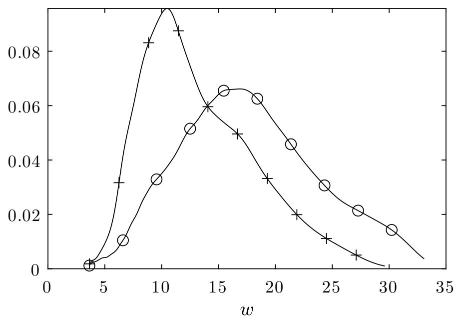
(f) left-censored

Panel C – Censored Spells

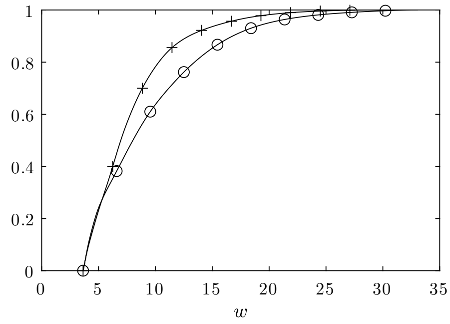
Figure A.8.: Density of hourly wages, by PFE quartile. *Note:* Epanechnikov kernel density estimate. Arrows (→) indicate that spells end in another employment spell (e) or unemployment (u). Spells without an observed transition are right-censored. Additionally, spells might be left-censored. *Key:* Quartile 1 (—○—);Quartile 2 (—+—);Quartile 3 (—∗—);Quartile 4 (—·—).

A.9. Estimation results

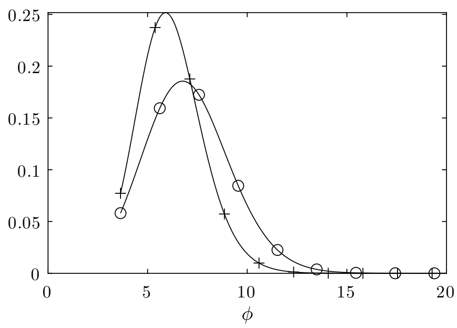
Bootstrapping We report bootstrapped standard errors with 250 draws. In very rare cases we exclude bootstrap runs if the likelihood does not converge: occurs in 1 of 251 bootstrap runs in Whole sample, in 10 of 260 bootstrap runs in East, in 1 of 251 bootstrap runs for Medium-skilled, in 1 of 251 bootstrap runs in PFE quartile 1, in 1 of 251 bootstrap runs in PFE quartile 2, in 1 of 251 bootstrap runs in PFE quartile 3, in 1 of 251 bootstrap runs in PFE quartile 4, in 2 of 252 bootstrap runs in the robustness check with 40 hours per week, in 3 of 253 bootstrap runs in the robustness check with truncation of wages at the 99th percentile, in 2 of 252 bootstrap runs in the robustness check that use wages from the last spell and the first spell only, in 2 of 252 bootstrap runs in the robustness check that use wages from average last spell and average first spell, 40 hours per week, in 2 of 252 bootstrap runs in the robustness check with truncation at EUR 4.00, in 16 of 266 bootstrap runs in the robustness check with $\rho = 0.01$.



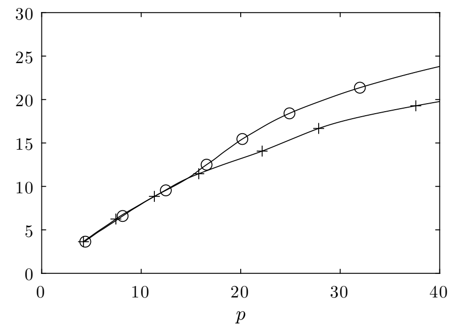
(a) Wage density $g(w)$



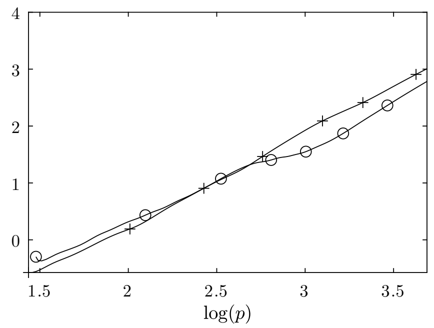
(b) Wage offer distribution $F(w)$



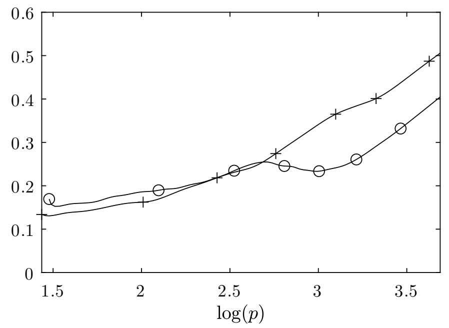
(c) Reservation wage density $dA(w)$



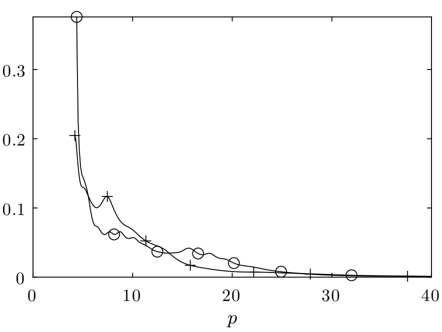
(d) Wage function $K(p)$



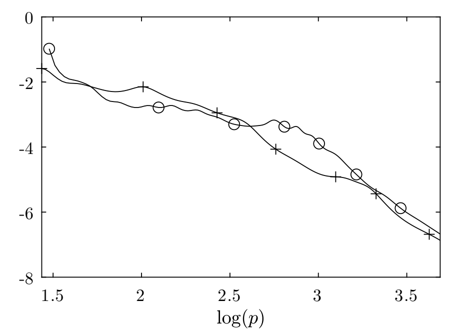
(e) Log absolute markup



(f) Monopsony power $[p - K(p)]/p$

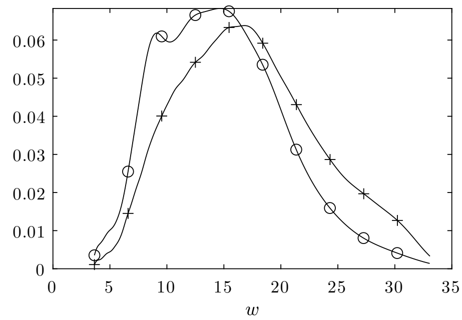


(g) Productivity density $\gamma(p)$

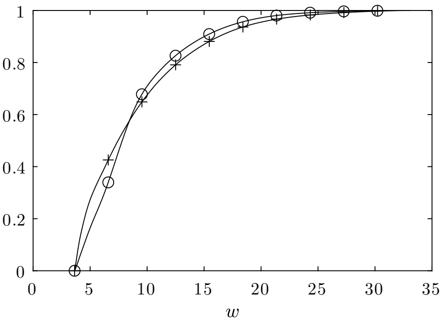


(h) Productivity log density $\log(\gamma(p))$

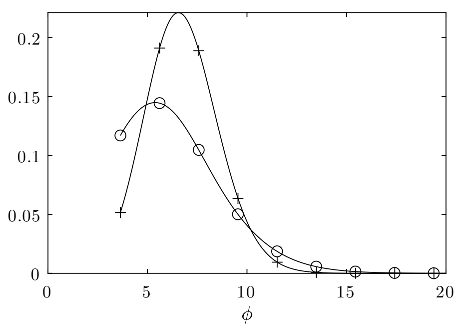
Figure A.9.: Main equilibrium functions, by region. *Note:* This figure shows the main equilibrium functions summarizing the steady-state for the estimates by region. Ordinate outcomes can be found in the subfigures' titles. Wages and productivity are measured in EUR. *Key:* West (—○—); East (—+—).



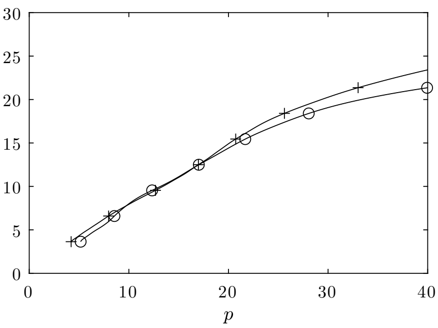
(a) Wage density $g(w)$



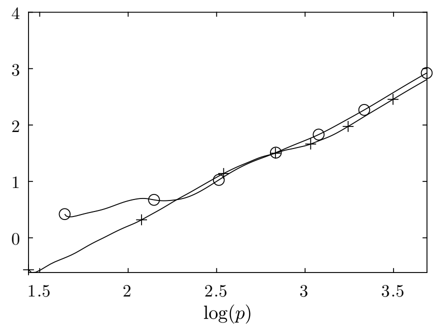
(b) Wage offer distribution $F(w)$



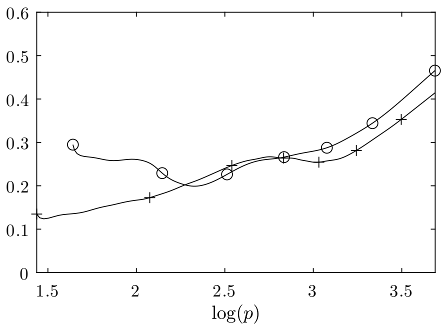
(c) Reservation wage density $dA(w)$



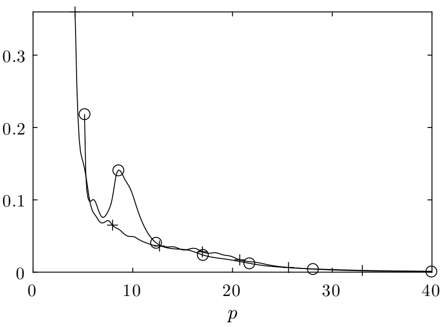
(d) Wage function $K(p)$



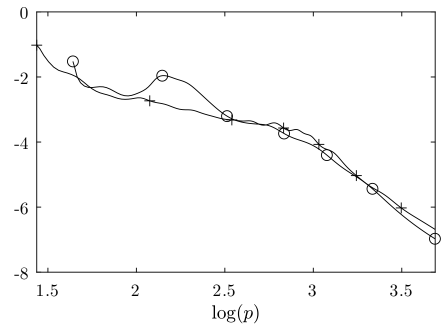
(e) Log absolute markup



(f) Monopsony power $[p - K(p)]/p$

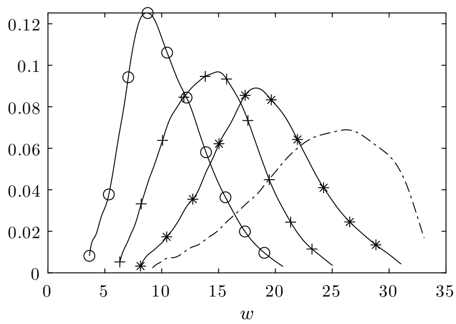


(g) Productivity density $\gamma(p)$

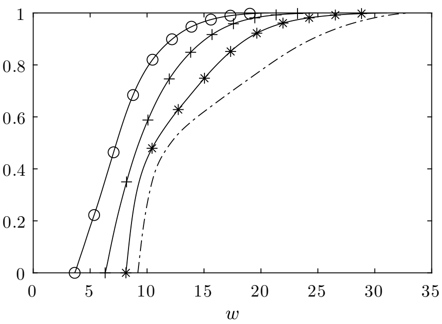


(h) Productivity log density $\log(\gamma(p))$

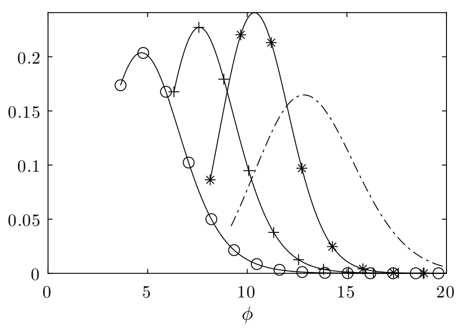
Figure A.10.: Main equilibrium functions, by skill group. *Note:* This figure shows the main equilibrium functions summarizing the steady-state for the estimates by skill group. Ordinate outcomes can be found in the subfigures' titles. Wages and productivity are measured in EUR. *Key:* Low-Skilled (—o—); Medium-Skilled (—+—).



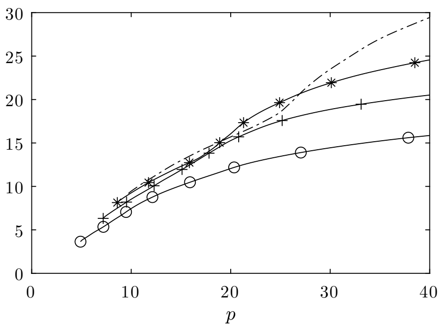
(a) Wage density $g(w)$



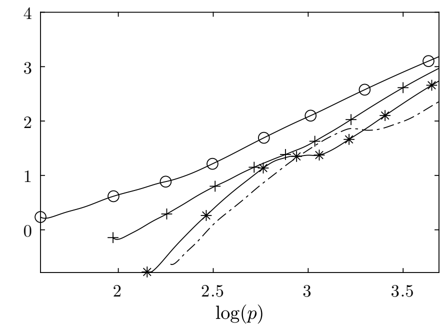
(b) Wage offer distribution $F(w)$



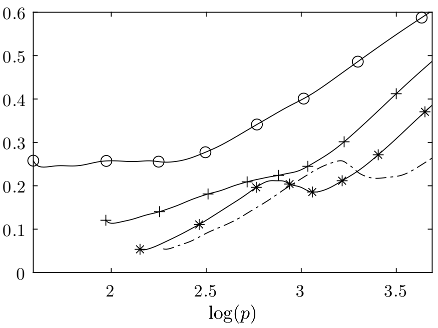
(c) Reservation wage density $dA(w)$



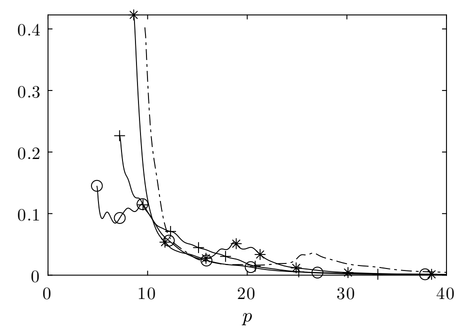
(d) Wage function $K(p)$



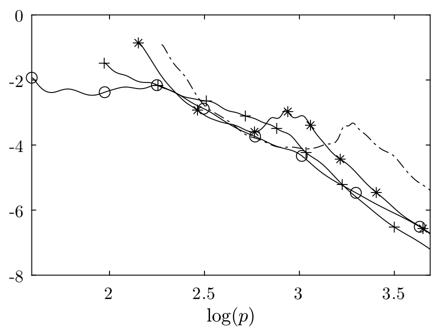
(e) Log absolute markup



(f) Monopsony power $[p - K(p)]/p$



(g) Productivity density $\gamma(p)$



(h) Productivity log density $\log(\gamma(p))$

Figure A.11.: Main equilibrium functions, by PFE quartile. *Note:* This figure shows the main equilibrium functions summarizing the steady-state for the estimates by quartile of the person fixed effect. Ordinate outcomes can be found in the subfigures' titles. Wages and productivity are measured in EUR. *Key:* Quartile 1 (—o—); Quartile 2 (—+—); Quartile 3 (—∗—); Quartile 4 (—·—).

Table A.7.: Robustness checks, whole sample

SSC	Hours	Wage measure	Truncation	ρ	N	$\underline{w}$	$\overline{w}$	δ	κ_e	κ_u	μ_ϕ	σ_ϕ	u	$u^{8.50}$	$\Delta u^{8.50}$
Cens.	Imp.	Avg. one year	EUR 3	0.02	208626	3.64	33.08	0.0063	7.10	20.06	6.50	3.60	0.0840	0.0808	-0.0031
								(0.0000)	(0.10)	(0.32)	(0.02)	(0.05)	(0.0004)	(0.0003)	(0.0003)
Cens.	40	Avg. one year	EUR 3	0.02	208837	3.61	32.96	0.0063	7.20	20.41	6.55	3.65	0.0842	0.0808	-0.0031
								(0.0000)	(0.09)	(0.30)	(0.03)	(0.05)	(0.0004)	(0.0003)	(0.0003)
Imp.	Imp.	Avg. one year	EUR 3; 95%	0.02	209012	3.64	33.45	0.0063	7.14	20.15	6.53	3.60	0.0838	0.0808	-0.0031
								(0.0000)	(0.10)	(0.33)	(0.04)	(0.05)	(0.0004)	(0.0003)	(0.0003)
Imp.	Imp.	Avg. one year	EUR 3; 99%	0.02	218373	3.64	48.27	0.0061	7.58	20.43	6.48	3.42	0.0832	0.0808	-0.0031
								(0.0000)	(0.09)	(0.30)	(0.04)	(0.05)	(0.0004)	(0.0003)	(0.0003)
Cens.	Imp.	Last/first obs.	EUR 3	0.02	207103	3.60	33.08	0.0063	7.09	19.92	6.46	3.55	0.0850	0.0808	-0.0031
								(0.0000)	(0.10)	(0.32)	(0.02)	(0.05)	(0.0004)	(0.0003)	(0.0003)
Cens.	Imp.	Avg. full spell	EUR 3	0.02	220257	3.56	33.55	0.0061	6.92	18.76	6.17	3.05	0.0859	0.0801	-0.0058
								(0.0000)	(0.08)	(0.24)	(0.03)	(0.04)	(0.0004)	(0.0003)	(0.0002)
Cens.	40	Avg. full spell	EUR 3	0.02	224006	3.58	32.18	0.0059	6.92	19.63	6.26	3.22	0.0848	0.0808	-0.0031
								(0.0000)	(0.08)	(0.28)	(0.03)	(0.05)	(0.0004)	(0.0003)	(0.0003)
Cens.	Imp.	Avg. one year	EUR 4	0.02	207928	4.51	33.08	0.0063	6.42	19.02	6.71	3.54	0.0821	0.0808	-0.0031
								(0.0000)	(0.07)	(0.25)	(0.05)	(0.06)	(0.0003)	(0.0003)	(0.0003)
Cens.	Imp.	Avg. one year	EUR 3	0.01	208626	3.64	33.08	0.0061	8.34	18.42	6.40	2.86	0.0912	0.0808	-0.0031
								(0.0000)	(0.13)	(0.33)	(0.05)	(0.04)	(0.0004)	(0.0003)	(0.0003)
Cens.	Imp.	Avg. one year	EUR 3	0.04	208626	3.64	33.08	0.0065	5.32	20.50	6.30	5.05	0.0735	0.0808	-0.0031
								(0.0000)	(0.05)	(0.26)	(0.02)	(0.05)	(0.0004)	(0.0003)	(0.0003)

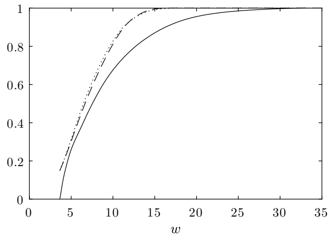
Note: The table reports robustness checks with respect to our parameter estimates using either imputed (Imp.) or censored (Cens.) wages, alternative definitions of weekly hours and wages as well as different truncation points. First row: preferred data preparation as reported in Table 2.1. For alternative data handlings at the SSC threshold, see Appendix A.5. For alternative definitions of weekly hours, see Appendix A.3. For alternative definition of wages, see Appendix A.4. Bootstrapped standard errors in parentheses (250 runs).

A.10. Model fit

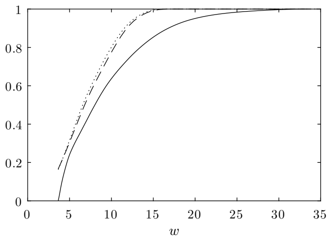
Table A.8.: In-sample fit: transitions after one year

	(1)	(2)	(3)	(4)	(5)	(6)
	Empirical			Predicted		
Sample	u → e	e → e	e → u	u → e	e → e	e → u
Whole sample	3.6	7.7	6.0	4.5	8.4	4.9
Region						
West	3.4	7.8	5.7	4.4	8.7	4.7
East	4.8	7.1	7.1	5.1	8.8	5.3
Skill Group						
Low-skilled	5.7	8.1	8.9	5.3	9.3	5.3
Medium-skilled	3.4	7.6	5.7	4.5	8.5	4.8
PFE quartile						
Quartile 1	6.7	7.8	11.4	7.8	9.8	8.1
Quartile 2	5.0	8.5	7.1	5.0	10.3	5.2
Quartile 3	2.0	7.3	3.5	3.8	7.1	4.0
Quartile 4	0.9	6.5	2.7	3.5	5.3	3.8

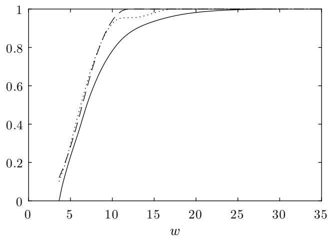
Note: Arrows (→) indicate that spells end in transitions to another employment spell (e) or to unemployment (u). Spells without an observed transition are right-censored. Additionally, spells might be left-censored. Predicted transitions are based on a simulation for 10,000 individuals within each sample. To obtain the complements of the transition rates similar to those reported in Figures A.13 and A.14, the $u \rightarrow e$-figures need to be divided by u and the $e \rightarrow e$- and $e \rightarrow u$-figures by (1-u), respectively. Discrepancies between the figures "Empirical" and the corresponding ones in Figures A.13 and A.14 may arise as the former represent the fraction of individuals with a transition within one year among all individuals observed on January 1, 2010, while the Kaplan-Meier-estimates in Figures A.13 and A.14 are based on the residual duration of unemployed and employed individuals, respectively.



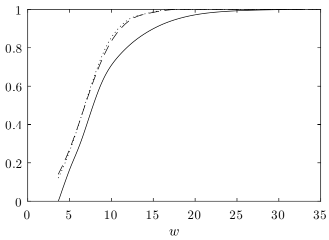
(a) Whole sample



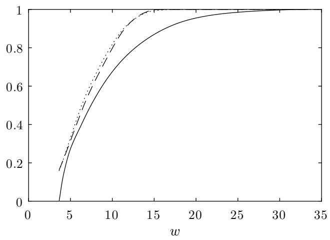
(b) West



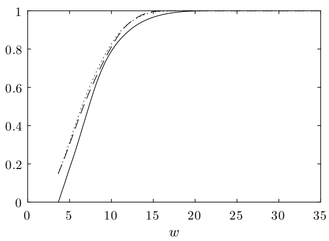
(c) East



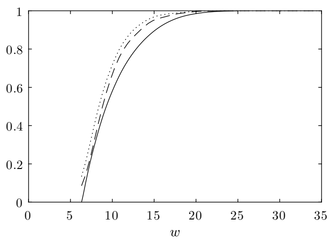
(d) Low-skilled



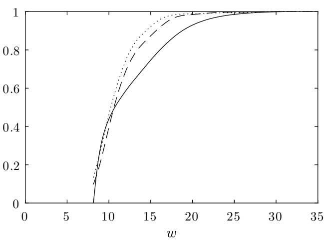
(e) Medium-skilled



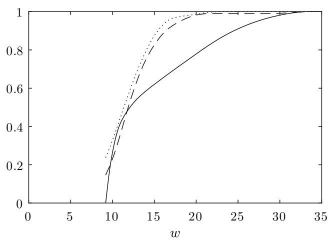
(f) PFE quartile 1



(g) PFE quartile 2

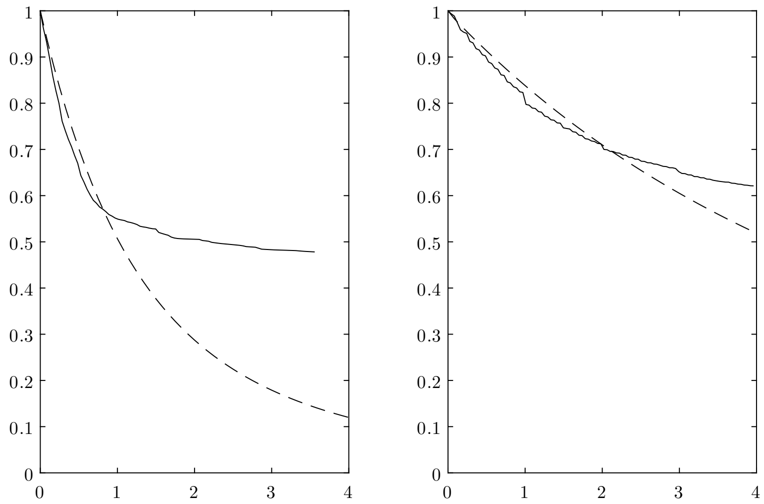


(h) PFE quartile 3



(i) PFE quartile 4

Figure A.12.: In-sample fit: wage distributions. *Note:* This figure shows the steady-state wage offer distribution $F(w)$ (——) in comparison to empirical wage distributions. The dashed line (----) shows the CDF of accepted wages after a job-to-job transition for wages in the range of $[\underline{w}; 1.25\underline{w}]$. The dotted line (············) shows the CDF of accepted wages after a job-to-job transition for wages in the range of $[\underline{w}; \underline{w} + 1]$.



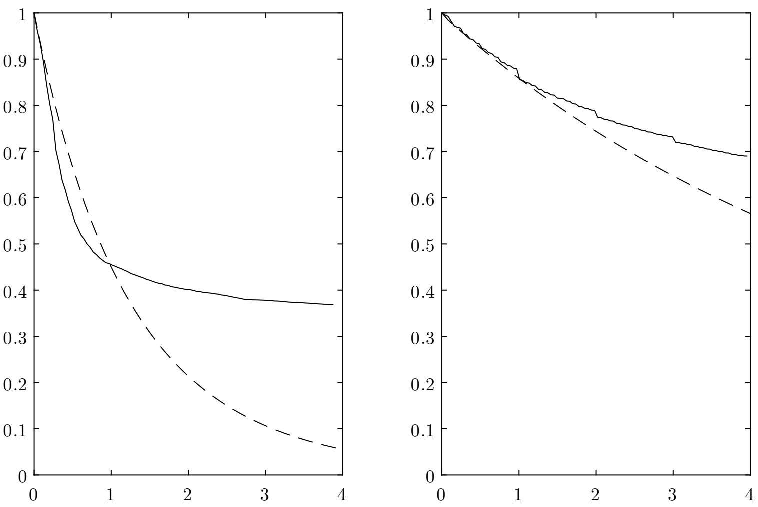
(a) Unemployment (b) Employment

Figure A.13.: Survival probabilities, residual duration, low-skilled. *Note:* This figure shows the Kaplan-Meier survival estimates for unemployment and employment residual durations in years (——) in comparison to the predicted survival function (----) which is given by $S_u(t) = A(\underline{w})/(1+\kappa_u)\cdot\exp(-\lambda_u \cdot \overline{F}(\underline{w})\cdot t)/u + \int_{\underline{w}}^{\overline{w}} dA(x)/(1+\kappa_u\overline{F}(x))\cdot\exp(-\lambda_u\cdot\overline{F}(x)\cdot t)/u + (1-A(\overline{w}))\cdot\frac{1}{u}$ and $S_e(t) = \int_{\underline{w}}^{\overline{w}} \exp(-(\delta+\lambda_e\cdot\overline{F}(x))\cdot t)dG(x)$. The figures' captions refer to the origin labour market state.

Table A.9.: In-sample fit: unemployment rate

	Empirical	Predicted
Whole sample	0.081	0.084
Region		
West	0.077	0.080
East	0.106	0.090
Skill group		
Low-skilled	0.154	0.107
Medium-skilled	0.075	0.083
PFE quartile		
Quartile 1	0.189	0.160
Quartile 2	0.093	0.075
Quartile 3	0.037	0.058
Quartile 4	0.030	0.065

Note: For empirical values, also see Table A.5. The predicted unemployment rate is based on equation (2.5) as implied by our estimates (see also Table 2.1 and Table A.12).



(a) Unemployment

(b) Employment

Figure A.14.: Survival probabilities, residual duration, medium-skilled. *Note:* This figure shows the Kaplan-Meier survival estimates for unemployment and employment residual durations in years (——) in comparison to the predicted survival function (----) which is given by $S_u(t) = A(\underline{w})/(1 + \kappa_u) \cdot \exp(-\lambda_u \cdot \overline{F}(\underline{w}) \cdot t)/u + \int_{\underline{w}}^{\overline{w}} dA(x)/(1 + \kappa_u \overline{F}(x)) \cdot \exp(-\lambda_u \cdot \overline{F}(x) \cdot t)/u + (1 - A(\overline{w})) \cdot \frac{1}{u}$ and $S_e(t) = \int_{\underline{w}}^{\overline{w}} \exp(-(\delta + \lambda_e \cdot \overline{F}(x)) \cdot t) dG(x)$. The figures' captions refer to the origin labour market state.

Table A.10.: Out-of-sample fit: unemployment rate

	Empirical	Predicted
Whole sample	0.051	0.081
Region		
West	0.049	0.076
East	0.060	0.108
Skill group		
Low-skilled	0.103	0.109
Medium-skilled	0.048	0.079
PFE quartile		
Quartile 1	0.118	0.163
Quartile 2	0.049	0.076
Quartile 3	0.022	0.058
Quartile 4	0.024	0.065

Note: Empirical refers to an out-of sample period using the original data set and the same sample restrictions. The unemployment rate refers to 1 January 2016. Note that the out-of-sample period is affected by shocks not related to the minimum wage as discussed in Section 2.7.4. The predicted unemployment rate is based on equation (2.5) as implied by our estimates Table A.12 for a counterfactual of a minimum wage of EUR 8.50.

Table A.11.: Out-of-sample fit: transitions after one year

	(1)	(2)	(3)	(4)	(5)	(6)
	Empirical			Predicted		
Sample	u → e	e → e	e → u	u → e	e → e	e → u
Whole sample	1.8	6.7	3.1	4.5	8.5	4.7
Region						
West	1.7	6.8	3.1	4.4	8.8	4.6
East	2.5	6.6	3.4	5.4	7.4	5.4
Skill group						
Low-skilled	2.1	5.8	4.1	5.5	8.8	5.3
Medium-skilled	1.8	6.8	3.1	4.5	8.5	4.7
PFE quartile						
Quartile 1	3.3	8.1	5.9	8.2	9.3	8.3
Quartile 2	2.2	7.3	3.3	4.9	9.8	5.2
Quartile 3	1.0	5.9	1.8	3.9	7.1	4.0
Quartile 4	0.8	5.4	1.7	3.6	5.2	3.9

Note: Arrows (→) indicate that spells end in transitions to another employment spell (e) or to unemployment (u). Spells without an observed transition are right-censored. Additionally, spells might be left-censored.

A.11. Minimum wage simulations

Table A.12.: Unemployment rate u for different minimum wages

	(1)	(2)	(3)	(4)	(5)	(6)
	Level	Change compared to no MW				
Minimum wage	No MW	EUR 7.00	EUR 8.50	EUR 10.00	EUR 11.50	EUR 13.00
Whole sample	0.084	-0.003	-0.003	-0.003	-0.003	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
By region						
West	0.080	-0.004	-0.005	-0.005	-0.004	-0.002
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
East	0.090	0.010	0.018	0.026	0.032	0.035
	(0.001)	(0.003)	(0.005)	(0.006)	(0.007)	(0.007)
Total	0.082	-0.002	-0.001	-0.000	0.001	0.004
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
By skill group						
Low-skilled	0.107	-0.002	0.001	0.006	0.010	0.015
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Medium-skilled	0.083	-0.003	-0.004	-0.005	-0.004	-0.002
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Total	0.085	-0.003	-0.004	-0.004	-0.003	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
By PFE quartile						
Quartile 1	0.160	-0.002	0.004	0.012	0.019	0.024
	(0.002)	(0.001)	(0.001)	(0.004)	(0.006)	(0.007)
Quartile 2	0.075	-0.000	0.001	0.003	0.005	0.009
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Quartile 3	0.058	0.000	0.001	-0.002	-0.003	-0.003
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Quartile 4	0.065	0.000	0.000	-0.008	-0.011	-0.012
	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Total	0.083	-0.000	0.001	0.001	0.002	0.004
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)

Note: The table reports the level of u and model predicted changes in u for different minimum wage levels. The first row shows simulations based on the whole sample while the rows *Total* aggregate the minimum wage effects over subsamples. Bootstrapped standard errors in parentheses (250 runs).

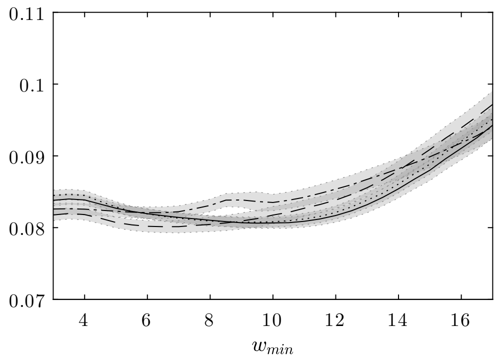


Figure A.15.: Unemployment rate u for different minimum wages. The figure shows the unemployment rate for the whole sample (——) and totals over different subsamples (cf. Table A.12). *Key:* Total over region (----); Total over skill group (··········); Total over PFE quartile (-·-·-). Grey area indicates 95% confidence bands based on 250 bootstrap runs.

Appendix B.

Appendix to Chapter 3

Table B.1.: Wage equation, Heckman selection model: variable definitions

Variable	Explanation
Dep. var: log hourly wage	
1	Constant
Work exp.	Working experience in years (defined as years in full-time employment plus 0.5× years in part-time employment)
Work exp.^{2} / 100	Work exp. squared and divided by 100
Unemployment exp.	Unemployment experience in years
Unemployment exp.^{2} / 100	Unemployment exp. squared and divided by 100
Tenure	Length of time with firm in years
Tenure^2 / 100	Tenure squared and divided by 100
Education: low	1 if "inadequately" or "general elementary" following ISCED-97 classification of education, values 0, 1, and 2
Education: high	1 if "higher vocational" or "higher education" following ISCED-97 values 5 and 6 (reference category for education: Medium: "middle vocational" or "Abitur + vocational", values 3 and 4)
Foreigner	1 if no German nationality
Federal state	Dummy variables for each federal state
Dep. var: participation	
1	Constant
Age	Age in years
Age^2 / 100	Age squared and divided by 100
Age^3 / 1,000	Age cubed and divided by 1,000
Education: low	*see above*
Education: high	*see above*
Foreigner	*see above*
Married	Individual is married
Couple	Individual lives with a partner
Disability	Indicator for disability status of the individual
Nursing case in HH	Indicator for presence of nursing case in household
N. child 0–2	Number of dependent children age 0–2
N. child 3–6	Number of dependent children age 3–6
N. child 7–16	Number of dependent children age 7–16
I(Welfare income > 0)	Indicator for positive income from welfare participation: *Arbeitslosenhilfe*, *Sozialhilfe* (1998–2004); *Arbeitslosengeld II* (2005-2018); *Erwerbsminderung*
Capital income / 100	Monthly income from interest and dividends divided by 100
Capital income^2 / 10,000	Capital income squared and divided by 10,000
Rental income / 100	Monthly income from rental and leasing minus operation and maintenance cost divided by 100
Rental income^2 / 10,000	Rental income squared and divided by 10,000
Federal state	*see above*

Note: This table shows variable definitions for the wage equation and the participation selection model. Variables refer to individual and household characteristics at the time of the interview. Monetary variables in EUR.

Table B.2.: Descriptive statistics, 1998, 2008, 2018

	Singles						Couples					
	Men			Woman			Men			Woman		
	1998	2008	2018	1998	2008	2018	1998	2008	2018	1998	2008	2018
Weekly hours of work choice (mean)												
0	0.087	0.104	0.126	0.124	0.119	0.098	0.049	0.053	0.049	0.283	0.197	0.137
10	0.003	0.024	0.020	0.044	0.058	0.055	0.011	0.015	0.020	0.088	0.145	0.108
20	0.016	0.013	0.036	0.067	0.094	0.068	0.011	0.011	0.012	0.145	0.156	0.153
30	0.007	0.028	0.055	0.084	0.107	0.152	0.011	0.016	0.028	0.095	0.139	0.205
40	0.551	0.468	0.485	0.522	0.403	0.430	0.553	0.495	0.528	0.314	0.265	0.300
50	0.216	0.238	0.209	0.110	0.153	0.140	0.251	0.294	0.277	0.057	0.065	0.073
60	0.120	0.124	0.068	0.050	0.066	0.057	0.114	0.115	0.085	0.018	0.032	0.024
Hourly gross wage												
Mean	12.66	15.04	17.48	11.55	12.14	15.88	15.50	17.11	22.09	10.36	12.52	16.07
Quartile 1	8.18	9.61	10.84	8.02	7.65	10.34	10.13	10.71	13.60	7.53	8.26	10.36
Quartile 2	11.35	13.65	15.43	10.60	10.63	14.06	13.41	14.82	18.89	9.47	10.58	13.90
Quartile 3	15.47	18.31	21.48	13.89	15.30	19.05	17.73	20.91	26.47	12.17	14.80	19.27
Hourly gross wage (real, in 2018 prices)												
Mean	16.77	16.97	17.48	15.29	13.71	15.88	20.53	19.31	22.09	13.72	14.13	16.07
Quartile 1	10.83	10.85	10.84	10.61	8.63	10.34	13.42	12.09	13.60	9.97	9.33	10.36
Quartile 2	15.03	15.40	15.43	14.03	12.00	14.06	17.76	16.73	18.89	12.54	11.94	13.90
Quartile 3	20.48	20.67	21.48	18.40	17.27	19.05	23.48	23.61	26.47	16.11	16.70	19.27
Mean Age	37.6	41.1	42.3	41.1	42.5	45.1	42.3	44.3	45.6	41.6	44.0	45.3
Mean number of children by age group												
Age 0–2	0.002	0.001	0.002	0.026	0.016	0.014	0.157	0.137	0.145	0.090	0.071	0.082
Age 3–6	0.010	0.003	0.007	0.064	0.089	0.048	0.214	0.166	0.193	0.171	0.137	0.155
Age 7–16	0.069	0.015	0.014	0.299	0.216	0.195	0.555	0.458	0.422	0.534	0.434	0.409
Nursing case	0.003	0.009	0.002	0.007	0.012	0.015	0.017	0.015	0.019	0.018	0.022	0.021
Handicapped	0.026	0.054	0.069	0.044	0.032	0.041	0.029	0.033	0.033	0.028	0.032	0.027
East Germany	0.248	0.232	0.223	0.167	0.194	0.174	0.195	0.172	0.171	0.179	0.172	0.163
Observations	395	638	962	568	865	1,672	2,838	2,926	3,748	2,993	3,245	3,928

Note: This table shows descriptives for the estimation samples for the years 1998, 2008, and 2018. Wages in EUR. Sample restrictions apply (for details, see Section 3.3). Flexible and semi-flexible couples are aggregated and summary statistics for the flexible person only are reported.

Table B.3.: Wage equation, Heckman selection model estimates, 1998

	(1) Men	(2) Women
Log hourly wage		
1	2.3387***	2.1043***
	(0.0440)	(0.0518)
Work exp.	0.0193***	0.0151***
	(0.0021)	(0.0029)
Work exp.^{2} / 100	-0.0379***	-0.0275***
	(0.0050)	(0.0076)
Unemployment exp.	-0.0555***	-0.0467***
	(0.0109)	(0.0117)
Unemployment exp.^{2} / 100	0.3549*	0.3619*
	(0.1454)	(0.1488)
Tenure	0.0172***	0.0239***
	(0.0021)	(0.0030)
Tenure^2 / 100	-0.0278***	-0.0449***
	(0.0060)	(0.0097)
Education: low	-0.0671***	-0.1410***
	(0.0202)	(0.0243)
Education: high	0.2963***	0.2235***
	(0.0150)	(0.0191)
Foreigner	-0.0464*	-0.0316
	(0.0189)	(0.0264)
Participation		
1	-9.2791***	-8.6487***
	(1.1359)	(0.9878)
Age	0.7529***	0.7697***
	(0.0957)	(0.0819)
Age^2 / 100	-1.6517***	-1.7368***
	(0.2550)	(0.2106)
Age^3 / 1,000	0.1124***	0.1195***
	(0.0215)	(0.0172)
Education: low	-0.0063	-0.1895**
	(0.1032)	(0.0678)
Education: high	0.1790	0.2953***
	(0.1143)	(0.0747)
Foreigner	-0.2535*	-0.3006***
	(0.1027)	(0.0737)
Married	0.1288	-0.5627***
	(0.1280)	(0.1024)
Couple	0.2979*	0.2494*
	(0.1271)	(0.1089)

(continued on next page)

Table B.3: *(continued)*

	(1) Men	(2) Women
Disability	-0.1218	-0.1476
	(0.2034)	(0.1441)
Nursing case in HH	-0.5035*	-0.5321***
	(0.2056)	(0.1541)
N. child 0–2	0.5501**	-0.9482***
	(0.1844)	(0.0890)
N. child 3–6	0.0749	-0.7085***
	(0.1196)	(0.0610)
N. child 7–16	0.0126	-0.3290***
	(0.0646)	(0.0355)
I(Welfare income > 0)	-1.7750***	-1.1594***
	(0.1091)	(0.0943)
Capital income / 100	0.3674**	0.2043*
	(0.1340)	(0.0964)
Capital income^2 / 10,000	-0.0440	-0.0228*
	(0.0252)	(0.0105)
Rental income / 100	-0.0167	-0.0197
	(0.0725)	(0.0705)
Rental income^2 / 10,000	0.0010	0.0002
	(0.0063)	(0.0038)
Inverse Mills ratio	-0.1227	-0.1485
	(0.0213)	(0.0278)
N	3,663	3,684

Note: This table shows the estimated coefficients for wage equation for the year 1998. Dummy variables for federal states were also included. Standard errors in parentheses with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. SOEP v36, ifo Microsimulation Model.

Table B.4.: Wage equation, Heckman selection model estimates, 2018

	(1) Men	(2) Women
Log hourly wage		
1	2.5253***	2.4307***
	(0.0376)	(0.0373)
Work exp.	0.0231***	0.0102***
	(0.0022)	(0.0022)
Work exp.^{2} / 100	-0.0487***	-0.0154**
	(0.0050)	(0.0056)
Unemployment exp.	-0.0606***	-0.0383***
	(0.0053)	(0.0050)
Unemployment exp.^{2} / 100	0.2172***	0.1201***
	(0.0298)	(0.0304)
Tenure	0.0150***	0.0179***
	(0.0019)	(0.0019)
Tenure^2 / 100	-0.0067	-0.0186***
	(0.0054)	(0.0056)
Education: low	-0.1091***	-0.1215***
	(0.0225)	(0.0250)
Education: high	0.3316***	0.2553***
	(0.0135)	(0.0136)
Foreigner	-0.1419***	-0.0977***
	(0.0196)	(0.0218)
Participation		
1	-7.2310***	-7.5696***
	(0.7621)	(0.6853)
Age	0.5367***	0.5891***
	(0.0641)	(0.0568)
Age^2 / 100	-1.0747***	-1.1787***
	(0.1683)	(0.1454)
Age^3 / 1,000	0.0678***	0.0730***
	(0.0139)	(0.0117)
Education: low	0.2541**	-0.1529*
	(0.0804)	(0.0660)
Education: high	0.4867***	0.3024***
	(0.0772)	(0.0512)
Foreigner	-0.1523	-0.4016***
	(0.0826)	(0.0617)
Married	-0.0312	-0.3506***
	(0.1004)	(0.0790)
Couple	0.7806***	0.2261**
	(0.0961)	(0.0790)

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Table B.4: *(continued)*

	(1) Men	(2) Women
Disability	-0.5757***	-0.4559***
	(0.1190)	(0.1111)
Nursing case in HH	-0.4726**	-0.3413***
	(0.1475)	(0.1036)
N. child 0–2	0.1705	-0.5120***
	(0.1214)	(0.0777)
N. child 3–6	0.0490	-0.3642***
	(0.0917)	(0.0563)
N. child 7–16	-0.0315	-0.1541***
	(0.0444)	(0.0278)
I(Welfare income > 0)	-1.4411***	-1.1115***
	(0.0730)	(0.0604)
Capital income / 100	0.1412	0.0749
	(0.0761)	(0.0747)
Capital income^2 / 10,000	-0.0035	-0.0026
	(0.0025)	(0.0045)
Rental income / 100	0.0045	0.0203
	(0.0611)	(0.0310)
Rental income^2 / 10,000	0.0022	0.0001
	(0.0062)	(0.0015)
Inverse Mills ratio	-0.1540	-0.1522
	(0.0207)	(0.0272)
N	5,411	6,062

Note: This table shows the estimated coefficients for wage equation for the year 2018. Dummy variables for federal states were also included. Standard errors in parentheses with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. SOEP v36, ifo Microsimulation Model.

Table B.5.: Model estimates, 1998

	(A) Single M	(B) Single F	(C) Couple M	(D) Couple F	(E) Couple M F
$\ln C$	-5.219*	-4.819*	-4.663*	0.302	-3.970*
	(2.424)	(2.101)	(2.048)	(1.875)	(1.547)
$(\ln C)^2$	0.162**	0.285***	0.163*	0.262***	0.248***
	(0.049)	(0.034)	(0.068)	(0.072)	(0.024)
$\ln C \ln L^m$	1.059*		0.823*		0.358
	(0.521)		(0.412)		(0.226)
$\ln L^m$					
× 1	27.488***		42.421***		41.212***
	(7.496)		(5.841)		(3.598)
× East Germany	-0.095		-0.815*		-0.831***
	(0.382)		(0.331)		(0.174)
× Age^m	-0.200		-0.479***		-0.291***
	(0.110)		(0.113)		(0.061)
× (Age^m)^2	0.003*		0.006***		0.004***
	(0.001)		(0.001)		(0.001)
× Disability^m	0.753		1.739		0.925*
	(0.889)		(0.950)		(0.422)
$(\ln L^m)^2$	-4.783***		-5.980***		-6.266***
	(0.894)		(0.674)		(0.357)
$\ln C \ln L^f$		0.777		-0.564	0.166
		(0.464)		(0.406)	(0.245)
$\ln L^f$					
× 1		11.508		36.092***	20.450***
		(6.191)		(5.467)	(3.613)
× East Germany		-0.715*		-2.484***	-1.944***
		(0.330)		(0.329)	(0.173)
× Age^f		-0.286**		-0.136	-0.207**
		(0.102)		(0.101)	(0.063)
× (Age^f)^2		0.004***		0.003**	0.004***
		(0.001)		(0.001)	(0.001)
× Disability^f		0.588		-1.301	0.030
		(0.890)		(0.814)	(0.443)
× Nursing case in HH		1.850		1.554	0.742
		(1.612)		(0.904)	(0.669)
× N. child 0–2		1.203		5.124***	3.707***
		(0.982)		(0.799)	(0.324)
× N. child 3–6		2.145***		1.978***	2.410***
		(0.622)		(0.454)	(0.205)

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Table B.5: *(continued)*

	(A) Single M	(B) Single F	(C) Couple M	(D) Couple F	(E) Couple M F
$\times$ N. child 7–16		0.205		1.264***	1.248***
		(0.250)		(0.212)	(0.108)
$(\ln L^f)^2$		-1.657**		-4.173***	-3.019***
		(0.596)		(0.571)	(0.309)
$\ln L^m \ln L^f$					0.900***
					(0.255)
P	-0.837*	-0.518**	0.097	-0.897**	-0.726***
	(0.355)	(0.182)	(0.242)	(0.322)	(0.135)
$I(h^m > 0)$	-6.869***		-5.268***		-5.935***
	(0.944)		(0.694)		(0.369)
$I(h^m = 20)$	0.708		0.482		0.215
	(0.642)		(0.512)		(0.305)
$I(h^m = 40)$	1.802***		1.534***		1.582***
	(0.167)		(0.129)		(0.066)
$I(h^f > 0)$		-2.124***		-1.912***	-1.594***
		(0.317)		(0.231)	(0.122)
$I(h^f = 20)$		-0.004		0.561***	0.388***
		(0.208)		(0.135)	(0.078)
$I(h^f = 40)$		1.483***		1.043***	1.292***
		(0.129)		(0.127)	(0.073)
$\sum_n \lvert J_n \rvert$	3,678	5,397	4,879	5,225	133,239
N	395	568	559	714	2,279
Pseudo R^2	0.42	0.32	0.40	0.23	0.33

Note: This table shows the estimated coefficients for utility functions for equation (3.5) for the year 1998. Standard errors in parentheses with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Column (A) refers to single males, column (B) to single females, column (C) to semi-flexible couples in which only the male has a flexible labour market attachment, column (D) to semi-flexible couples with a flexible female, and column (E) to couples in which both partners have a labour market attachment. SOEP v36, ifo Microsimulation Model.

Table B.6.: Model estimates, 2018

	(A) Single M	(B) Single F	(C) Couple M	(D) Couple F	(E) Couple M F
$\ln C$	-1.444	-1.916	0.426	2.046	1.141
	(1.164)	(1.034)	(1.370)	(1.201)	(1.151)
$(\ln C)^2$	0.143***	0.204***	0.143**	0.218***	0.294***
	(0.017)	(0.016)	(0.045)	(0.036)	(0.020)
$\ln C \ln L^m$	0.213		-0.355		0.169
	(0.255)		(0.285)		(0.170)
$\ln L^m$					
× 1	21.706***		38.553***		35.527***
	(4.195)		(4.538)		(3.064)
× East Germany	0.588**		-0.264		0.111
	(0.216)		(0.307)		(0.156)
× Age^m	0.017		-0.104		-0.381***
	(0.059)		(0.089)		(0.054)
× $(\text{Age}^m)^2$	0.000		0.001		0.005***
	(0.001)		(0.001)		(0.001)
× Disability^m	1.346***		1.874*		1.944***
	(0.387)		(0.734)		(0.338)
$(\ln L^m)^2$	-3.374***		-4.872***		-4.839***
	(0.444)		(0.480)		(0.268)
$\ln C \ln L^f$		0.249		-0.694**	-0.758***
		(0.228)		(0.264)	(0.177)
$\ln L^f$					
× 1		19.486***		41.661***	28.270***
		(3.577)		(4.654)	(3.097)
× East Germany		-0.404*		-0.886**	-1.622***
		(0.185)		(0.285)	(0.157)
× Age^f		-0.296***		-0.373***	-0.100
		(0.056)		(0.101)	(0.057)
× $(\text{Age}^f)^2$		0.004***		0.005***	0.002**
		(0.001)		(0.001)	(0.001)
× Disability^f		1.193**		1.550*	1.224**
		(0.409)		(0.681)	(0.434)
× Nursing case in HH		1.646**		0.436	1.407**
		(0.554)		(0.575)	(0.480)
× N. child 0–2		2.208***		1.326**	2.482***
		(0.623)		(0.509)	(0.256)
× N. child 3–6		1.344***		1.523***	1.565***
		(0.319)		(0.386)	(0.166)

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Table B.6: *(continued)*

	(A) Single M	(B) Single F	(C) Couple M	(D) Couple F	(E) Couple M F
× N. child 7–16		0.360**		1.033***	0.823***
		(0.138)		(0.166)	(0.085)
$(\ln L^f)^2$		-2.060***		-3.905***	-3.250***
		(0.324)		(0.459)	(0.242)
$\ln L^m \ln L^f$					1.235***
					(0.230)
P	-0.646***	-0.598***	-0.548*	-0.878***	-0.791***
	(0.159)	(0.091)	(0.215)	(0.251)	(0.097)
$I(h^m > 0)$	-3.848***		-2.956***		-4.069***
	(0.312)		(0.409)		(0.227)
$I(h^m = 20)$	-0.128		-0.248		0.033
	(0.220)		(0.314)		(0.170)
$I(h^m = 40)$	1.139***		1.047***		1.225***
	(0.090)		(0.097)		(0.049)
$I(h^f > 0)$		-1.363***		-0.885***	-0.545***
		(0.148)		(0.180)	(0.091)
$I(h^f = 20)$		-0.444***		0.163	-0.031
		(0.103)		(0.103)	(0.057)
$I(h^f = 40)$		0.830***		0.581***	0.530***
		(0.068)		(0.101)	(0.056)
$\sum_n \lvert J_n \rvert$	9,250	16,520	6,196	6,817	183,279
N	962	1,672	729	909	3,019
Pseudo R^2	0.30	0.20	0.31	0.14	0.26

Note: This table shows the estimated coefficients for utility functions for equation (3.5) for the year 2018. Standard errors in parentheses with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Column (A) refers to single males, column (B) to single females, column (C) to semi-flexible couples in which only the male has a flexible labour market attachment, column (D) to semi-flexible couples with a flexible female, and column (E) to couples in which both partners have a labour market attachment. SOEP v36, ifo Microsimulation Model.

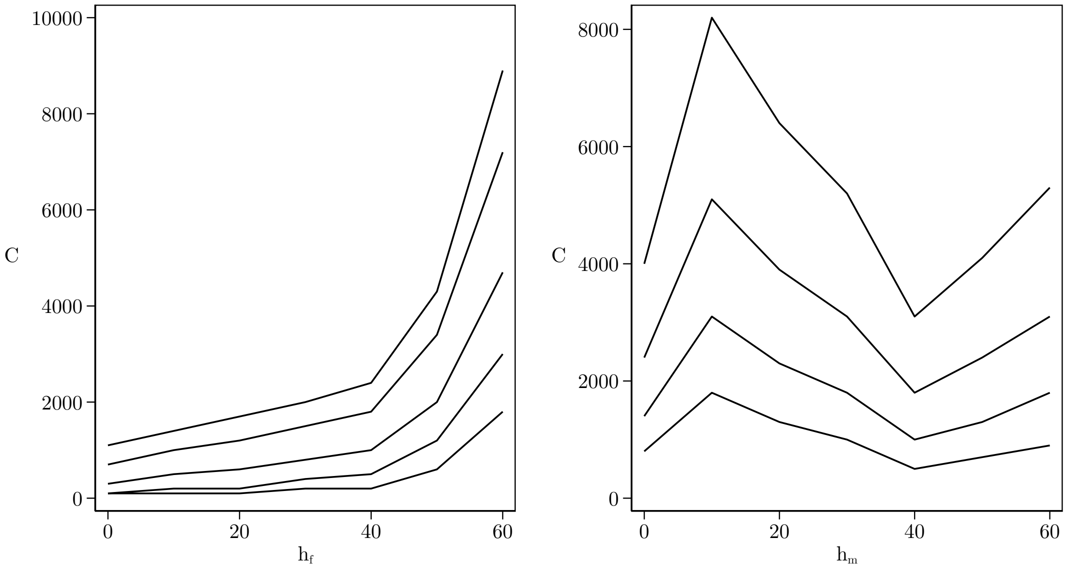
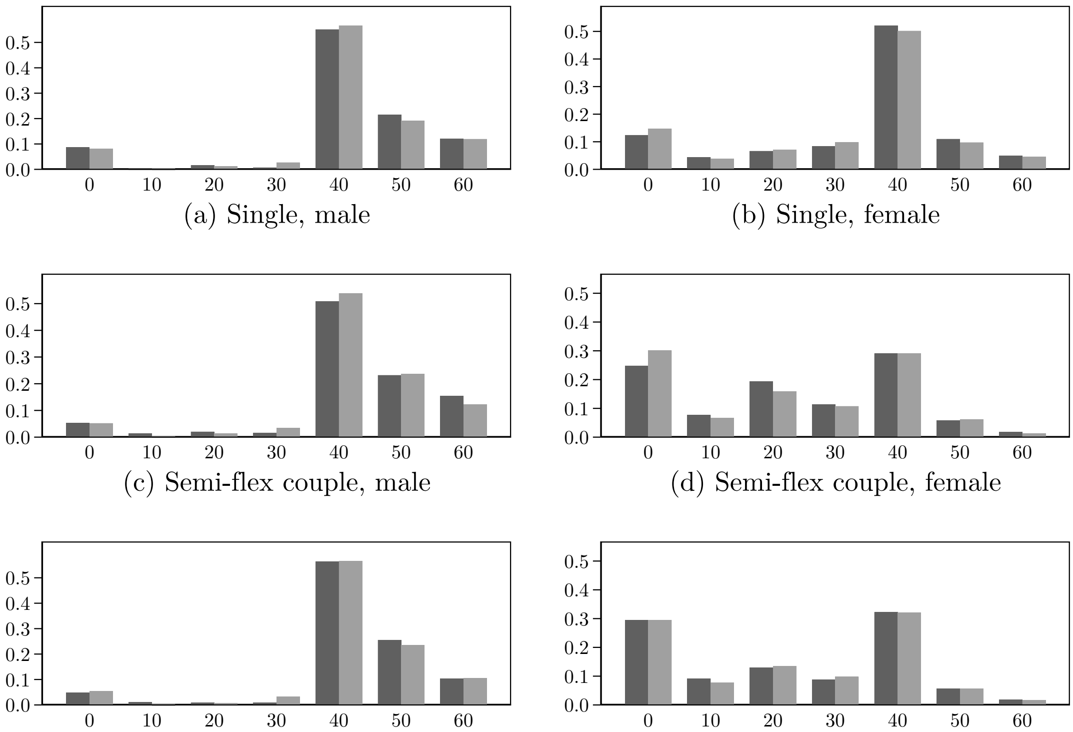


Figure B.1.: Indifference curves, couple M F, 2018. *Note:* The figure shows indifference curves, for estimated model (E), Table B.6 for fixed working hours of the partner at 40 hours per week. Characteristics are: Both partners are 40 years old, one child in age range 0–2 and one child in age range 3–6, West Germany, no welfare take-up. *Source:* ifo Microsimulation Model; SOEP v36.



(a) Single, male

(b) Single, female

(c) Semi-flex couple, male

(d) Semi-flex couple, female

(e) Flexible couple, male

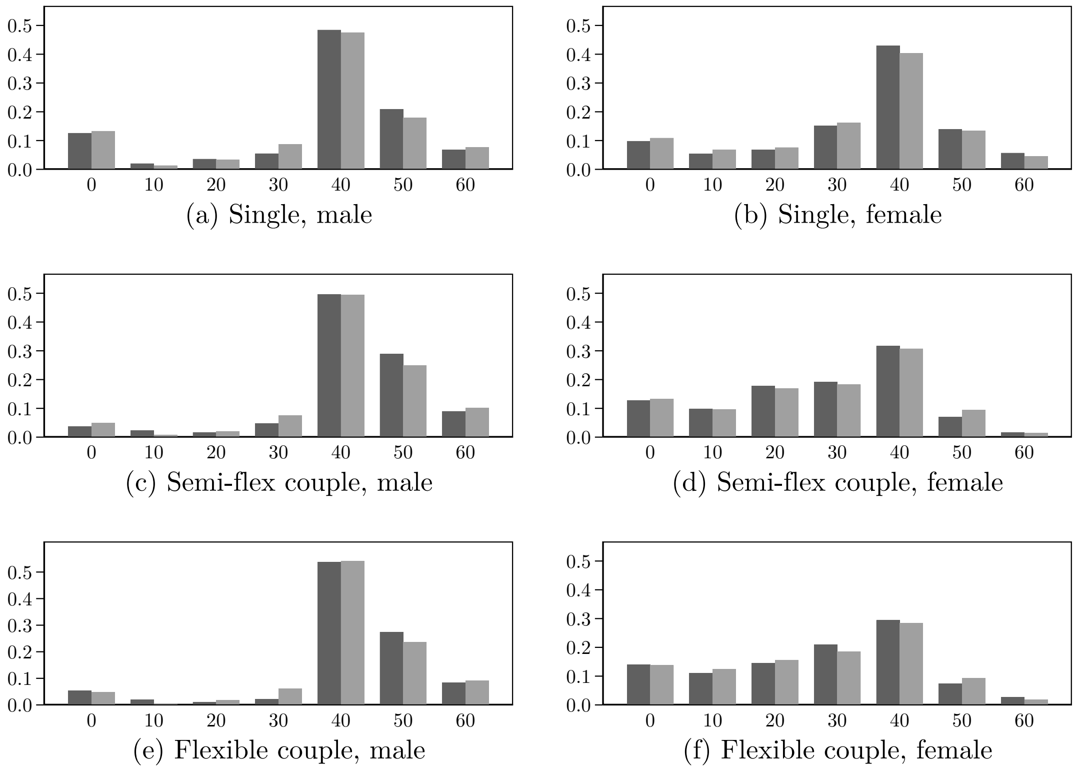
(f) Flexible couple, female

Figure B.2.: Model fit: hours density, 1998. *Note:* The figure shows the density of choices observed (■) and choices predicted by the models (■) for 1998 for the estimation sample.

Table B.7.: Model fit: overprediction of the hours density (predicted−observed), 1998

	0	10	20	30	40	50	60
(a) Single, male	-0.006	-0.001	-0.004	0.020	0.015	-0.024	-0.001
(b) Single, female	0.023	-0.005	0.004	0.015	-0.020	-0.012	-0.005
(c) Semi-flex couple, male	-0.001	-0.012	-0.007	0.018	0.030	0.004	-0.033
(d) Semi-flex couple, female	0.053	-0.010	-0.035	-0.006	-0.000	0.004	-0.005
(e) Flexible couple, male	0.006	-0.009	-0.001	0.022	0.002	-0.020	0.000
(f) Flexible couple, female	0.001	-0.014	0.005	0.010	-0.001	0.000	-0.001

Note: This table shows the difference in prediced versus observed density by hours choice for 1998.



(a) Single, male (b) Single, female (c) Semi-flex couple, male (d) Semi-flex couple, female (e) Flexible couple, male (f) Flexible couple, female

Figure B.3.: Model fit: hours density, 2018. *Note:* The figure shows the density of choices observed (■) and choices predicted by the models (■) for 2018 for the estimation sample.

Table B.8.: Model fit: overprediction of the hours density (predicted−observed), 2018

	0	10	20	30	40	50	60
(a) Single, male	0.007	-0.007	-0.002	0.032	-0.009	-0.030	0.009
(b) Single, female	0.011	0.014	0.008	0.010	-0.027	-0.005	-0.011
(c) Semi-flex couple, male	0.013	-0.014	0.004	0.027	-0.001	-0.040	0.012
(d) Semi-flex couple, female	0.006	-0.002	-0.008	-0.009	-0.009	0.024	-0.001
(e) Flexible couple, male	-0.005	-0.016	0.007	0.039	0.005	-0.037	0.008
(f) Flexible couple, female	-0.003	0.014	0.012	-0.024	-0.010	0.020	-0.009

Note: This table shows the difference in prediced versus observed density by hours choice for 2018.

Individual elasticity:

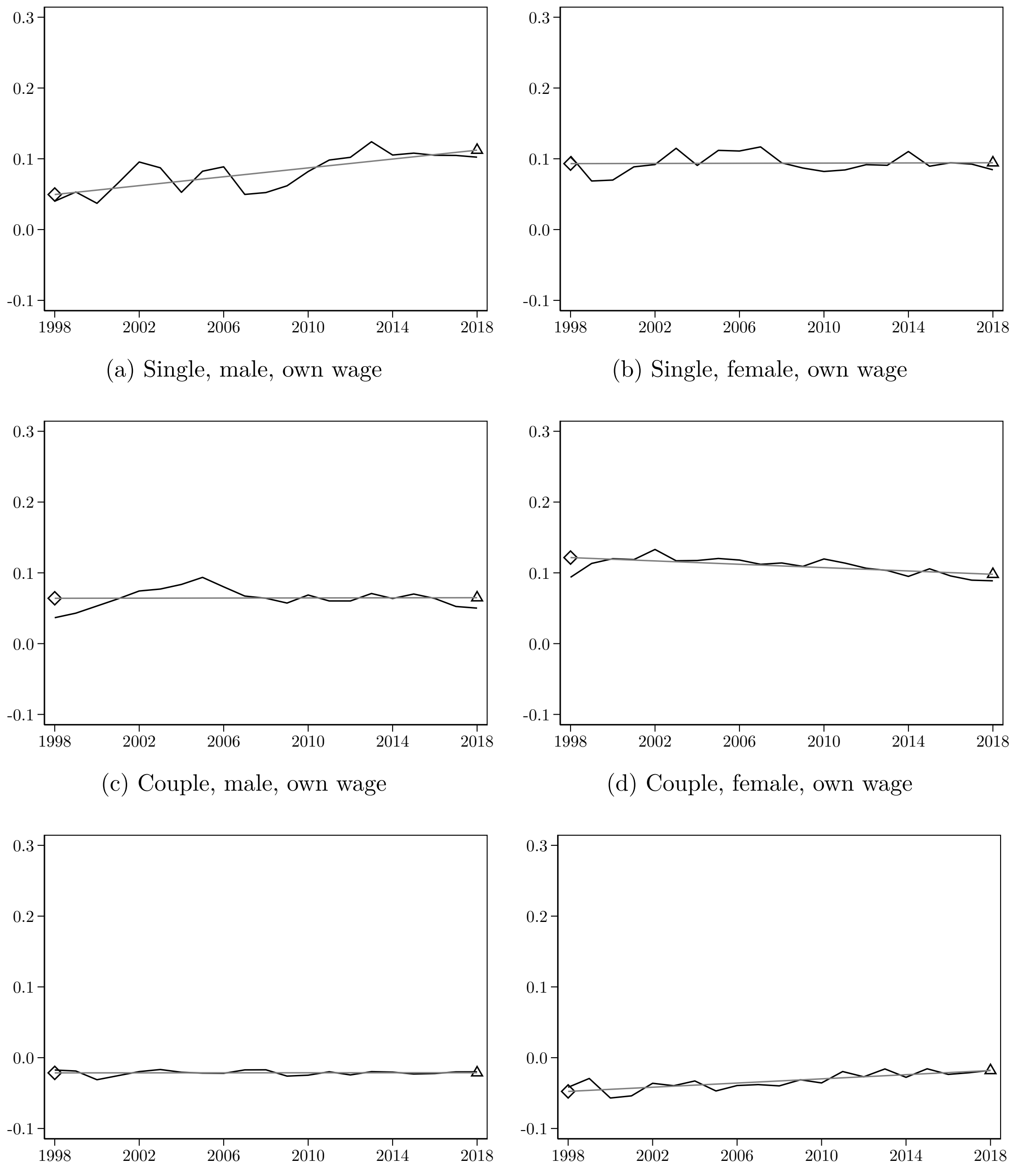
$$\frac{\sum_j h_{nj}\hat{p}'_{nj} - \sum_j h_{nj}\hat{p}_{nj}}{\sum_j h_{nj}\hat{p}_{nj}}\frac{1}{0.1} \tag{B.1}$$

Individual intensive elasticity:

$$\frac{\sum_j h_{nj}\hat{p}'_{nj} - \frac{(1-\hat{p}'_{n0})}{(1-\hat{p}_{n0})}\sum_j h_{nj}\hat{p}_{nj}}{\sum_j h_{nj}\hat{p}_{nj}}\frac{1}{0.1} \tag{B.2}$$

Individual extensive elasticity:

$$\frac{(1-\hat{p}'_{n0}) - (1-\hat{p}_{n0})}{(1-\hat{p}_{n0})}\frac{1}{0.1} \tag{B.3}$$



(a) Single, male, own wage

(b) Single, female, own wage

(c) Couple, male, own wage

(d) Couple, female, own wage

(e) Couple, male, partner's wage

(f) Couple, female, partner's wage

Figure B.4.: Wage elasticity, extensive margin, 1998 to 2018. *Note:* The figure shows the total extensive elasticity (——) calculated as the aggregate expected hour change due to a simulated ten percent increase in own or the partner's gross wage. A linear trend regression line is shown and symbols mark the fitted value for the beginning and the end of the observational period. *Source:* ifo Microsimulation Model; SOEP v36.

Table B.9.: Wage elasticity, 1998 to 2018

	Singles		Couples			
	M w^m	F w^f	M w^m	F w^f	M w^f	F w^m
1998	0.019	0.128	0.046	0.134	-0.022	-0.056
	(0.049)	(0.047)	(0.012)	(0.025)	(0.006)	(0.020)
1999	0.040	0.116	0.065	0.178	-0.023	-0.043
	(0.042)	(0.041)	(0.011)	(0.021)	(0.006)	(0.022)
2000	0.014	0.096	0.073	0.193	-0.039	-0.085
	(0.023)	(0.034)	(0.010)	(0.017)	(0.006)	(0.016)
2001	0.058	0.144	0.094	0.194	-0.030	-0.080
	(0.025)	(0.030)	(0.009)	(0.020)	(0.006)	(0.015)
2002	0.112	0.150	0.126	0.234	-0.022	-0.055
	(0.027)	(0.027)	(0.011)	(0.018)	(0.004)	(0.013)
2003	0.105	0.177	0.123	0.195	-0.018	-0.058
	(0.032)	(0.029)	(0.011)	(0.019)	(0.006)	(0.014)
2004	0.071	0.153	0.125	0.225	-0.023	-0.048
	(0.033)	(0.026)	(0.012)	(0.019)	(0.006)	(0.014)
2005	0.108	0.183	0.147	0.238	-0.024	-0.073
	(0.036)	(0.032)	(0.012)	(0.022)	(0.006)	(0.015)
2006	0.100	0.174	0.130	0.240	-0.027	-0.068
	(0.033)	(0.031)	(0.012)	(0.022)	(0.006)	(0.014)
2007	0.050	0.180	0.115	0.234	-0.021	-0.067
	(0.029)	(0.033)	(0.010)	(0.020)	(0.005)	(0.015)
2008	0.032	0.149	0.116	0.247	-0.023	-0.069
	(0.027)	(0.030)	(0.011)	(0.019)	(0.005)	(0.015)
2009	0.063	0.125	0.091	0.245	-0.036	-0.049
	(0.036)	(0.031)	(0.011)	(0.022)	(0.006)	(0.014)
2010	0.085	0.144	0.113	0.270	-0.036	-0.058
	(0.037)	(0.025)	(0.008)	(0.016)	(0.005)	(0.014)
2011	0.144	0.166	0.104	0.262	-0.030	-0.032
	(0.031)	(0.024)	(0.007)	(0.017)	(0.005)	(0.013)
2012	0.119	0.161	0.106	0.257	-0.038	-0.049
	(0.029)	(0.021)	(0.008)	(0.016)	(0.005)	(0.013)
2013	0.166	0.158	0.114	0.230	-0.024	-0.022
	(0.028)	(0.026)	(0.009)	(0.015)	(0.005)	(0.013)
2014	0.127	0.179	0.102	0.224	-0.027	-0.051
	(0.031)	(0.022)	(0.008)	(0.015)	(0.005)	(0.014)
2015	0.137	0.155	0.113	0.245	-0.030	-0.028
	(0.039)	(0.022)	(0.009)	(0.017)	(0.006)	(0.014)
2016	0.156	0.162	0.102	0.229	-0.030	-0.035
	(0.035)	(0.025)	(0.008)	(0.018)	(0.006)	(0.014)
2017	0.132	0.178	0.088	0.213	-0.026	-0.032
	(0.030)	(0.021)	(0.008)	(0.016)	(0.005)	(0.013)
2018	0.130	0.145	0.084	0.212	-0.028	-0.029
	(0.030)	(0.023)	(0.009)	(0.017)	(0.005)	(0.014)

Note: This table shows the total wage elasticities, 1998 to 2018. Bootstrapped standard errors in parentheses.

Table B.10.: Wage elasticity, intensive margin, 1998 to 2018

	Singles		Couples			
	M w^m	F w^f	M w^m	F w^f	M w^f	F w^m
1998	-0.021	0.024	0.010	0.040	-0.004	-0.014
	(0.021)	(0.025)	(0.006)	(0.010)	(0.002)	(0.006)
1999	-0.013	0.047	0.022	0.065	-0.004	-0.014
	(0.020)	(0.026)	(0.006)	(0.009)	(0.002)	(0.007)
2000	-0.023	0.026	0.019	0.073	-0.007	-0.028
	(0.014)	(0.022)	(0.005)	(0.008)	(0.001)	(0.006)
2001	-0.008	0.056	0.030	0.075	-0.004	-0.026
	(0.012)	(0.019)	(0.005)	(0.010)	(0.002)	(0.006)
2002	0.017	0.058	0.051	0.101	-0.002	-0.019
	(0.012)	(0.017)	(0.005)	(0.009)	(0.001)	(0.005)
2003	0.018	0.062	0.046	0.078	-0.001	-0.019
	(0.013)	(0.017)	(0.005)	(0.009)	(0.001)	(0.006)
2004	0.019	0.062	0.042	0.107	-0.002	-0.015
	(0.017)	(0.018)	(0.005)	(0.010)	(0.001)	(0.006)
2005	0.026	0.071	0.054	0.118	-0.002	-0.026
	(0.016)	(0.020)	(0.005)	(0.012)	(0.002)	(0.007)
2006	0.012	0.063	0.050	0.122	-0.005	-0.028
	(0.015)	(0.018)	(0.005)	(0.012)	(0.002)	(0.006)
2007	0.001	0.063	0.048	0.122	-0.004	-0.029
	(0.015)	(0.019)	(0.005)	(0.012)	(0.002)	(0.007)
2008	-0.021	0.055	0.052	0.133	-0.006	-0.029
	(0.014)	(0.020)	(0.006)	(0.011)	(0.002)	(0.007)
2009	0.001	0.038	0.033	0.136	-0.010	-0.018
	(0.016)	(0.019)	(0.006)	(0.013)	(0.002)	(0.007)
2010	0.003	0.062	0.044	0.150	-0.011	-0.022
	(0.018)	(0.019)	(0.004)	(0.010)	(0.002)	(0.007)
2011	0.046	0.082	0.044	0.148	-0.010	-0.013
	(0.016)	(0.018)	(0.005)	(0.010)	(0.002)	(0.006)
2012	0.017	0.070	0.046	0.150	-0.014	-0.022
	(0.014)	(0.015)	(0.005)	(0.010)	(0.002)	(0.007)
2013	0.042	0.068	0.043	0.127	-0.005	-0.006
	(0.013)	(0.017)	(0.005)	(0.009)	(0.002)	(0.006)
2014	0.021	0.069	0.038	0.129	-0.006	-0.023
	(0.015)	(0.015)	(0.004)	(0.010)	(0.002)	(0.007)
2015	0.029	0.065	0.043	0.139	-0.007	-0.012
	(0.016)	(0.015)	(0.005)	(0.010)	(0.002)	(0.007)
2016	0.051	0.068	0.038	0.134	-0.007	-0.011
	(0.015)	(0.015)	(0.004)	(0.011)	(0.002)	(0.007)
2017	0.027	0.085	0.035	0.123	-0.006	-0.010
	(0.014)	(0.014)	(0.004)	(0.010)	(0.002)	(0.007)
2018	0.028	0.060	0.034	0.123	-0.008	-0.012
	(0.015)	(0.016)	(0.005)	(0.011)	(0.002)	(0.007)

Note: This table shows the intensive wage elasticities, 1998 to 2018. Bootstrapped standard errors in parentheses.

Table B.11.: Wage elasticity, extensive margin, 1998 to 2018

	Singles		Couples			
	M w^m	F w^f	M w^m	F w^f	M w^f	F w^m
1998	0.040	0.104	0.037	0.094	-0.017	-0.042
	(0.030)	(0.026)	(0.006)	(0.016)	(0.005)	(0.015)
1999	0.053	0.069	0.043	0.113	-0.019	-0.029
	(0.025)	(0.018)	(0.007)	(0.013)	(0.005)	(0.015)
2000	0.037	0.070	0.053	0.120	-0.031	-0.057
	(0.011)	(0.015)	(0.006)	(0.010)	(0.005)	(0.011)
2001	0.066	0.089	0.063	0.119	-0.025	-0.054
	(0.016)	(0.014)	(0.006)	(0.011)	(0.005)	(0.010)
2002	0.095	0.092	0.074	0.133	-0.020	-0.036
	(0.019)	(0.015)	(0.008)	(0.010)	(0.003)	(0.009)
2003	0.087	0.115	0.077	0.117	-0.017	-0.040
	(0.021)	(0.017)	(0.007)	(0.011)	(0.005)	(0.009)
2004	0.053	0.091	0.084	0.117	-0.021	-0.033
	(0.019)	(0.014)	(0.008)	(0.010)	(0.005)	(0.009)
2005	0.082	0.112	0.094	0.120	-0.022	-0.047
	(0.022)	(0.017)	(0.009)	(0.011)	(0.005)	(0.009)
2006	0.089	0.111	0.080	0.118	-0.022	-0.039
	(0.022)	(0.017)	(0.008)	(0.011)	(0.004)	(0.009)
2007	0.050	0.117	0.067	0.112	-0.017	-0.038
	(0.016)	(0.018)	(0.007)	(0.010)	(0.003)	(0.009)
2008	0.052	0.094	0.064	0.114	-0.017	-0.040
	(0.016)	(0.014)	(0.007)	(0.009)	(0.003)	(0.009)
2009	0.062	0.087	0.057	0.109	-0.026	-0.031
	(0.023)	(0.017)	(0.007)	(0.010)	(0.005)	(0.008)
2010	0.082	0.082	0.069	0.120	-0.025	-0.036
	(0.023)	(0.010)	(0.006)	(0.007)	(0.004)	(0.007)
2011	0.098	0.084	0.060	0.114	-0.020	-0.020
	(0.020)	(0.010)	(0.004)	(0.008)	(0.003)	(0.007)
2012	0.102	0.092	0.060	0.107	-0.024	-0.027
	(0.018)	(0.009)	(0.004)	(0.007)	(0.003)	(0.007)
2013	0.124	0.091	0.071	0.103	-0.020	-0.016
	(0.018)	(0.011)	(0.005)	(0.007)	(0.004)	(0.007)
2014	0.105	0.110	0.064	0.095	-0.020	-0.028
	(0.020)	(0.011)	(0.005)	(0.007)	(0.003)	(0.007)
2015	0.108	0.090	0.070	0.106	-0.023	-0.016
	(0.026)	(0.010)	(0.006)	(0.008)	(0.004)	(0.007)
2016	0.105	0.094	0.064	0.096	-0.022	-0.024
	(0.022)	(0.012)	(0.005)	(0.008)	(0.004)	(0.007)
2017	0.105	0.092	0.052	0.090	-0.020	-0.021
	(0.018)	(0.010)	(0.005)	(0.007)	(0.003)	(0.006)
2018	0.102	0.084	0.050	0.089	-0.020	-0.018
	(0.018)	(0.011)	(0.005)	(0.008)	(0.004)	(0.007)

Note: This table shows the extensive wage elasticities, 1998 to 2018. Bootstrapped standard errors in parentheses.

Table B.12.: Wage elasticity, 2015

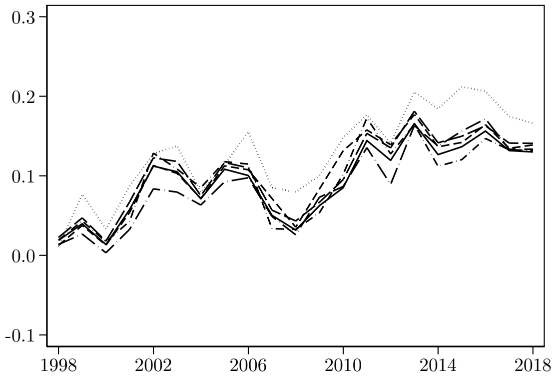
	Bruckmeier et al. (2021)	This study	
Male, single	0.22	0.137	
Female, single	0.23	} 0.155	
Female, single parent	0.13		
Male, own wage, semi-flexible couple	0.11	0.093	} 0.113
Male, own wage, flexible couple	0.08	0.118	
Female, own wage, semi-flexible couple	0.24	0.184	} 0.245
Female, own wage, flexible couple	0.27	0.266	
Male, partner's wage, semi-flexible couple		-0.003	} -0.030
Male, partner's wage, flexible couple	-0.03	-0.036	
Female, partner's wage, semi-flexible couple		-0.041	} -0.028
Female, partner's wage, flexible couple	-0.16	-0.023	

Note: This table shows own wage hours elasticities for 2015 from this study and from Bruckmeier et al. (2021, Tabelle A1).

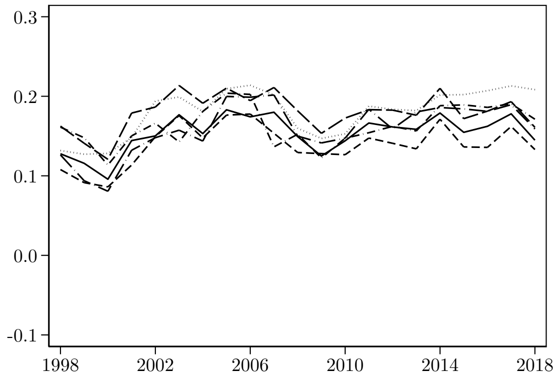
Table B.13.: Change in wage elasticity, 1998 to 2018

	Singles		Couples			
	M w^m	F w^f	M w^m	F w^f	M w^f	F w^m
Total elasticity						
1998	0.019	0.128	0.046	0.134	-0.022	-0.056
2018	0.130	0.145	0.084	0.212	-0.028	-0.029
Change	0.111	0.017	0.037	0.078	-0.006	0.026
Intensive elasticity						
1998	-0.021	0.024	0.010	0.040	-0.004	-0.014
2018	0.028	0.060	0.034	0.123	-0.008	-0.012
Change	0.049	0.037	0.024	0.083	-0.004	0.002
Extensive elasticity						
1998	0.040	0.104	0.037	0.094	-0.017	-0.042
2018	0.102	0.084	0.050	0.089	-0.020	-0.018
Change	0.062	-0.019	0.014	-0.005	-0.003	0.024
Fraction intensive of total elasticity						
1998	-1.130	0.187	0.212	0.302	0.194	0.248
2018	0.213	0.417	0.401	0.581	0.286	0.397

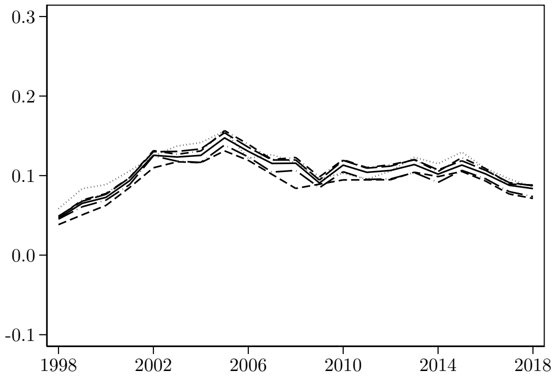
Note: This table shows the change in wage elasticities 1998 to 2018.



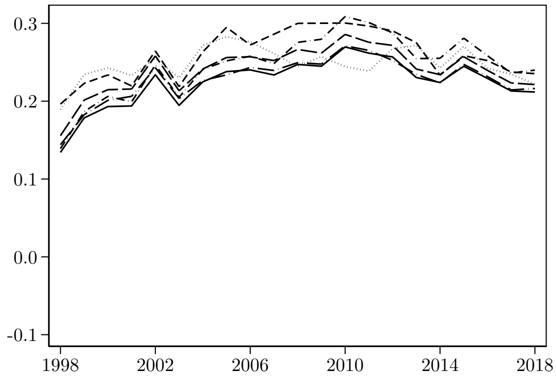
(a) Single, male, own wage



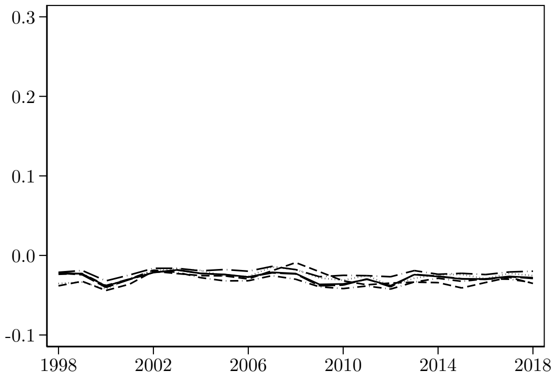
(b) Single, female, own wage



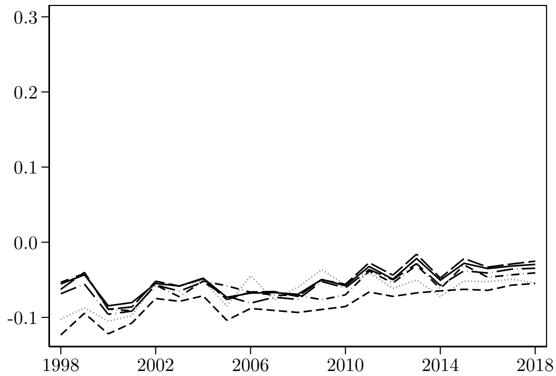
(c) Couple, male, own wage



(d) Couple, female, own wage

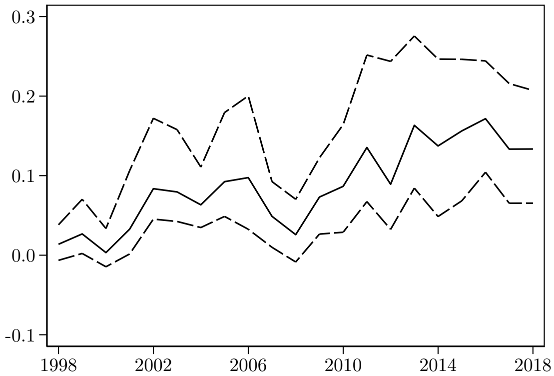


(e) Couple, male, partner's wage

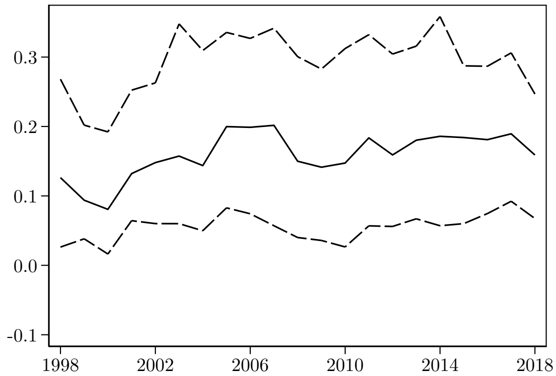


(f) Couple, female, partner's wage

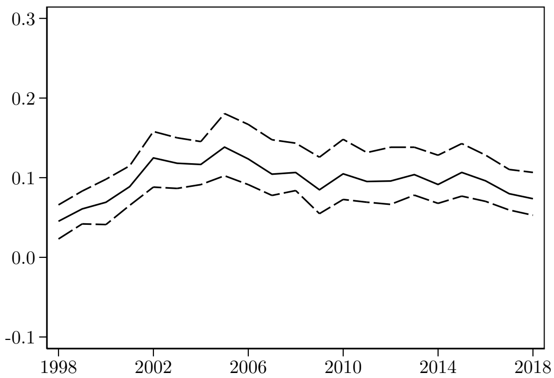
Figure B.5.: Wage elasticity, 1998 to 2018, robustness checks. *Note:* The figure shows hours elasticities due to a simulated increase in own or the partner's gross wage for alternative specifications of the model and alternative data preparation procedures. *Key:* Baseline (——); One percent wage increase (----); Random coefficients model (-·-·-); Quadratic utility (·········); Mean individual elasticity (–––); Median individual elasticity (–·–). *Source:* ifo Microsimulation Model; SOEP v36.



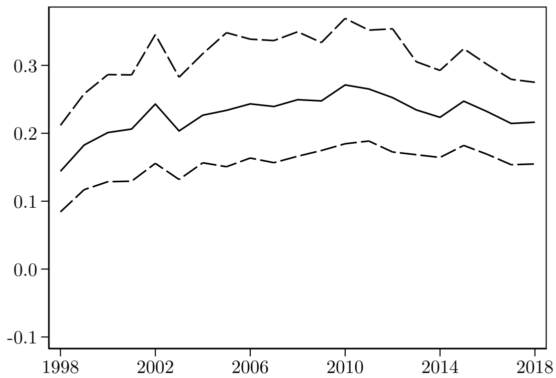
(a) Single, male, own wage



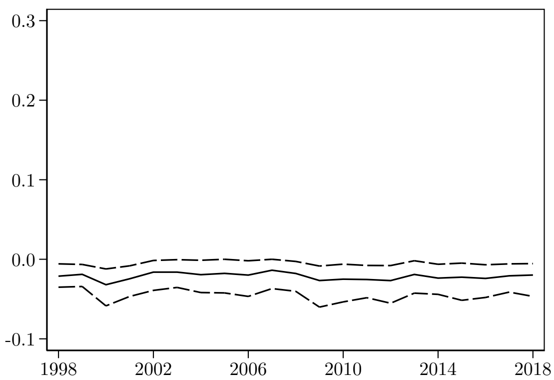
(b) Single, female, own wage



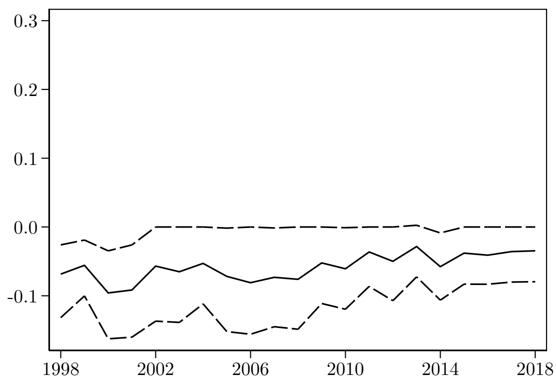
(c) Couple, male, own wage



(d) Couple, female, own wage



(e) Couple, male, partner's wage



(f) Couple, female, partner's wage

Figure B.6.: Wage elasticity, 1998 to 2018. *Note:* The figure shows the median (——) and the first and third quartile (– – –) of the individual hours elasticities due to a simulated ten percent increase in own or the partner's gross wage. *Source:* ifo Microsimulation Model; SOEP v36.

Table B.14.: Change in wage elasticity, linear trend, 1998 to 2018, robustness checks and alternative statistics

	Singles		Couples			
	M w^m	F w^f	M w^m	F w^f	M w^f	F w^m
Baseline	0.112	0.033	0.013	0.055	-0.005	0.039
One percent wage increase	0.128	0.030	0.015	0.031	-0.002	0.053
Random coefficients model	0.104	0.031	0.014	0.083	-0.009	0.028
Quadratic utility	0.151	0.059	0.005	0.013	0.004	0.042
Individual elasticity, mean	0.118	0.016	0.014	0.041	-0.005	0.047
Individual elasticity, median	0.139	0.066	0.007	0.048	-0.002	0.044

Note: This table shows the change in wage elasticities 1998 to 2018 for alternative specifications of the model and alternative statistics. The first row refers to the baseline specification (cf. Table B.13). Additional rows show robustness checks with modified specifications relative to baseline. Changes are calculated using the fitted value for 2018 minus the fitted value for 1998 from a linear regression over the entire time span for each specification and subgroup.

Appendix C.

Appendix to Chapter 4

C.1. The budgetary process in Germany

The budget process can be divided into three distinct phases. First, external forecasts from the German Council of Economic Experts (GCEE) and internal forecasts prepared by the Federal Ministry of Finance feed into the preparation of internal benchmark figures and the annual 'Stability Programme' as required under EU rules. Second, a new round of economic forecasts – by a panel of experts from independent research institutes, the federal government and the Working Party on Tax Revenue Forecasting, an independent advisory council – leads to the preparation of the draft federal budget and the five-year Financial Plan, which are submitted to the federal parliament in August each year. Third, a similar sequence of budgetary forecasts in the autumn is the basis for the finalisation of the federal budget documentation. The budget is scrutinised by the Budget Committee of the *Bundestag* and finally adopted by the parliament. A recent budget review by the OECD (2014) comes to the conclusion that independent experts such as the GCEE, independent research institutes and the newly-introduced Stability Council and its Advisory Council (a fiscal watchdog that monitors the budget plans of the federal government and the *Länder*) play an important role in the German budgetary framework. Although the government could rely on its own macroeconomic assumptions and forecasts, it would need convincing reasons to deviate significantly from the forecasts of the independent bodies.

C.2. Short-time work in Germany during the crisis

The German short-time working scheme aims to preserve jobs during recessions (i.e. when firms experience temporary demand shocks). In short-time work, employees temporarily reduce their weekly working hours. Employees are paid by their employer for their actual hours worked, while the government pays between 60 and 67 per cent of the net wage loss due to reduced working hours. Employees keep their health insurance and obtain the same pension entitlements as if they had worked full-time during this period. Similarly, social security contributions for hours worked are paid by the employer and the fees for the reduced hours are paid by the government. Before the crisis, the maximum duration of short-time work was six months. The maximum duration was extended by Economic Stability Plans 1 and 2, to 18 and 24 months respectively. Since 2012, it has been reduced again to six months. Short-time work had already been used heavily during the economic downturn of the early 1990s, with over 2 million short-time workers in 1991 and 1.2 million short-time workers in 1993. From 1997 to 2008, the use of short-time work was comparatively low (around 100,000–200,000 workers per year) and was mainly a seasonal phenomenon. In May 2009, about 1.4 million people (5 per cent of all employees in jobs subject to social security contributions) were on short-time work. In total, the additional cost to the federal budget amounted to EUR 4.4 billion in 2009 and EUR 3.9 billion in 2010 (German Council of Economic Experts, 2009). Short-time work allowed for higher internal flexibility during the temporary demand shocks in 2009 (German Council of Economic Experts, 2013) and can be seen as one key factor in explaining the mild job losses during the crisis (e.g. Brenke et al., 2013). As the German economy has been hit mainly by shocks in export demand, short-time work especially helped firms that experienced declining output. Firms that applied for short-time work had a high export share and were concentrated in the manufacturing sector (Boeri and Bruecker, 2011).

Declaration on independence and resources

I hereby declare that I completed the doctoral thesis independently based on the stated resources and aids.

I testify through my signature that all information that I have provided about resources used in the writing of my doctoral thesis, about the resources and support provided to me as well as in earlier assessments of my doctoral thesis correspond in every aspect to the truth.

Berlin, 14.11.2022
Maximilian Joseph Blömer

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