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Wages and Employment in Frictional Labor Markets

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To My Parents

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Abstract

This dissertation contains five independent chapters dealing with wage dispersion and unemployment. The first chapter deals with the explanation of international changes in wage inequality and unemployment in the 80s and 90s. Both theoretically and empirically, social benefits and its link to average income are blamed for the different experiences across countries. The second chapter discusses the search framework, to explain residual wage inequality and finds that institutional wage compression has ambiguous effects on employment. In the third chapter, we apply the theory to German data. We show that job-to-job transitions are important in explaining both frictions and career advances. In the fourth chapter, we empirically assess the relationship between wage dispersion and unemployment for homogeneous workers. We find that neither a frictional nor a neo-classical view in explaining this relationship are convincing. Unemployment within cells is not negatively correlated with wage dispersion. Finally, the last chapter builds a theoretical model which treats heterogeneous individuals in a production function framework and a frictional labor market. The model generates both wage dispersion within and between skill groups and both frictional and structural unemployment. In sum, the dissertation stresses the importance of modelling frictions to understand different types of wage inequality and unemployment.

List of Papers

The thesis comprises the following articles:

(1) "Skill Biased Technological Change and Endogenous Benefits: The Dynamics of Unemployment and Wage Inequality," MEA Discussion Paper No. 100-2005, Mannheim, 2005, joint with Matthias Weiss.

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(4) "Unemployment, Labor Market Transitions and Residual Wage dispersion," ZEW Discussion Paper No. 05-04, Mannheim, 2005, joint with Bernd Fitzenberger.

(5) "Heterogeneity and Labor Demand in an Equilibrium Search Model," unpublished manuscript, Mannheim, April 2007, joint with Bernd Fitzenberger.

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Wages and employment in frictional labor markets: Introduction

Wages and employment as labor market outcomes

In modern societies, most households depend on market work to make their living. Labor market outcomes, thus, concern many members of the society in an important way. Two central tasks of labor markets are the allocation of employment and earnings across labor market participants. This dissertation deals with the allocation of employment and earnings as equilibrium outcomes of frictional labor markets and with the influence of other institutions.

Economic theory helps to understand and to explain those employment and earnings distributions which are realized. In addition, it helps to quantify the costs that arise if the distribution(s) obtained differ from a suitably defined optimum. As far as the allocation of employment is concerned, an extreme unequal allocation is unemployment. A failure of the labor market of providing individuals that are willing to work with jobs causes economic costs, because it is inefficient as long as these matches produce a positive surplus. An improvement of the situation in a Pareto-sense is conceivable.

If the distribution of earnings across individuals is too unequal, this causes costs as well. On the one hand, most people have some notion of fairness, and if the realized earnings distribution deviates from this norm, social costs arise. On the other hand, one might want to maximize the welfare of a society in terms of a social welfare function, aggregating individual utilities. When choosing an egalitarian form for this function, costs of a distribution of incomes, being to unequal, consist in the fact that the realized allocation does not maximize this function, or, put differently that the marginal utilities of consumption are not equated.

Clearly, the social, psychological and economic costs of unemployment and an uneven distribution of wage incomes are far beyond the economic costs discussed above. For example, further economic costs of unemployment include depreciation of human capital, or the deadweight loss caused by taxes required to finance unemployment. Psychological costs of unemployment exist, for example, because "People need to be needed" (Layard, Nickel, and Jackman (1991), p.1). Social costs of inequality arise, for example, if high inequality is accompanied by high criminality (Morris and Western (1999)). In the happiness research, it seems that unemployment is the most important single factor affecting life satisfaction (negatively). A high income inequality reduces life satisfaction as well. (Frey and Stutzer (2002))

These arguments justify the enormous interest of social sciences in recent international developments of wage inequality and unemployment. This development is briefly sketched here. After having diminished in the 1970s, wage inequality between high-skilled and low-skilled workers rose dramatically in the US and the UK in the 80s and the 90s (see Katz, Loveman, and Blanchflower (1995), Gottschalk and Smeeding (1997) and Katz and Autor (1999)). In these countries, similar trends can be observed for overall and residual wage inequality. There also was a modest increase in the college wage-premium and in overall inequality in Australia, Canada and Japan.

In Continental Europe, there was no such clear-cut increase in neither overall wage inequality, nor in within-skill or between-skill inequality in the same time span (see Katz and Autor (1999)). Instead, unemployment increased dramatically in most countries of Continental Europe in this period (see Bean (1994), Saint-Paul (2004) and Blanchard (2006)).

The larger part of the literature on wage inequality is concerned with wage inequality *between* individuals with comparable skills or with overall wage inequality rather than with wage inequality *within* skill groups. This may be due to the fact that from a traditional economic point of view, differences such as education premiums and their changes are easier to interpret than changes in residual wage inequality. Alternatively, it may be due to data limitations which until recently prevent a reasonably detailed definition of groups. However, there are good reasons to put a higher weight on understanding wage differentials between observationally equivalent individuals. First, empirical studies show that residual variation is important in wage level equations. Usually, half of the variance is left unexplained.[1] Second, in terms of wage changes, the empirical literature finds that a considerable part of the overall increase in inequality has been due to an increase in residual inequality (see Juhn, Murphy, and Pierce (1993), Katz and Autor (1999) and Cholezas and Tsakloglou (2007)). In addition, although wage dispersion both between and within groups have been rising, developments in the two kinds did not happen in a parallel fashion. For example, empirical studies for the US and for Germany show that the timing of the increase of residual wage inequality is different from the timing of the increase of the wage inequality between groups (see e.g. Juhn, Murphy, and Pierce (1993), Katz and Autor (1999) and Fitzenberger (1999)).

Against this background, this dissertation consists of five self-contained articles about wage inequality between groups, wage inequality within groups, and the evolution of unemployment. Chapters 2 and 5 are theoretical and assume a search-theoretic perspective to labor markets. Both chapters devote special attention to residual wage dispersion, whereas one of the two chapters models wage dispersion between groups as well. The two chapters demonstrate that a formalization of a framework that includes search frictions and where we allow for heterogeneities and eventually non-constant marginal productivities offers interesting insights, but proves diffi-

[1] Wage regressions rarely explain more than a third of the wage variance when including standard human capital variables (see Lemieux (2006)) and rarely more than 50% of the variance of wages when including explanatory variables beyond human capital theory (like firm side variables, see e.g. Van den Berg (1999)).

cult. The two chapters 3 and 4 are empirical and are also based on a search-theoretic background. Both articles provide evidence for the importance of search frictions in the German labor market. Job-to-job transitions are an important determinant for wage growth, and there is no evidence for the conjecture that a low residual wage dispersion causes unemployment to be high. Finally, the first chapter of this thesis is both theoretical and empirical and has, different from the other papers a neo-classical theoretical background.[2] It argues that labor market institutions are crucial for labor market outcomes and demonstrates that social benefits are a driving factor for wage inequality and unemployment and for their international development.

Wage dispersion between groups and unemployment

The **first chapter** (Weiss and Garloff (2005)) analyzes reasons for the diverging incidence of between-group wage inequality and unemployment between Anglo-Saxon and Continental European countries. The chapter supports the view that labor market institutions, and in particular different concepts of poverty reduction, contribute to these differences. Governmental poverty reduction can follow different philosophies. One philosophy defines poverty in absolute terms, by specifying amounts individuals need to be prevented from poverty. Since social legislation in the US and the UK is oriented towards this concept, we refer to it as the Anglo-Saxon concept. In the other philosophy, poverty is defined in relative terms, i.e., with respect to the average living standard of the society. Referring to the social legislation in these countries, we call that the European concept.

In a model with a neo-classical production function, two skill groups, and inelastic labor supply, a labor union is assumed to set wages for low-skilled employees. In order to prevent poverty, social benefits are linked to the average income in the European case, but not in the Anglo-Saxon model. Skill-biased technical change exogenously increases the demand for and thus the wages of high-skilled workers. Ceteris paribus, the average income increases and social benefits in the European model raise as well. In the European model wage inequality increases only weakly, because the wage of the low-skilled rises as well, as the fall back option (i.e., social benefits) increases. Thus, it counteracts the initial increase of the high-skilled wages. By the same reasoning, unemployment among the low-skilled is higher, since their equilibrium wage is raised above the market clearing level. By contrast, in Anglo-Saxony skill-biased technical change causes a strongly increasing wage inequality while leaving unemployment rates unchanged. The reason is that the higher demand for high-skilled labor does not affect social benefits and thus

[2] In the literature the term neo-classical has been used to separate mainstream economics from the neo-institutionalist approach (Boyer and Smith (2001)). In this use, this complete thesis would be neo-classical. I use the term neo-classical, however, to distinguish standard labor supply, demand and human capital results under complete information from the new information-theoretic approaches.

leaves the wages of the low-skilled unchanged. In the empirical analysis, the relationship between average income and social benefits in 14 OECD countries is studied. In the relevant period social benefits were indeed linked to the average income in European countries and not in the US or UK. The above reasoning is thus consistent with stylized empirical facts about central differences between the European and the Anglo-Saxon system over the last 20 years.

Residual Wage dispersion and unemployment

The **second chapter** (Garloff (2007)) reviews recent theories which are able to generate wage inequality *within* a group of individuals with identical marginal productivity, and it emphasizes the role of labor unions. Equilibrium search theory as introduced by Burdett and Mortensen (1998) explains wage differentials between identical individuals by search frictions. The unique equilibrium generated by the standard model is dispersed. Identical firms pay different wages to identical workers because there is a tradeoff between the number of workers and the profit per worker. The traditional framework is designed for homogeneous workers, thus neglecting heterogeneity and generating a wage density which is increasing over the support. These results are in contrast to empirical observations. More recent search models hence allow for heterogeneities on either side of the market. In particular, model extensions are presented and discussed that allow the productivities of firms and individuals and the reservation wages of individuals to be dispersed. Resulting wage densities are often hump shaped with a long right tail, and thus in accordance with stylized empirical facts.

In addition, labor unions are introduced to the search framework. Unions are assumed to set minimum wages. The impact of minimum wages on employment is not unique, though, as the complete wage distribution may be below marginal productivities of the individuals. In this case, a binding minimum wage lowers the profits of the firms and redistributes this to workers, while the labor demand of the firms is unchanged. Negative employment effects of union-set minimum wages exist in a model allowing for both heterogeneous firm productivities and heterogeneous individual productivities, where some matches get unprofitable with increasing minimum wages. In a model with identical firms and individual productivities but heterogeneous reservation wages, employment effects can even be positive, when an increasing minimum wage results in an increasing probability that a randomly drawn wage offer exceeds the reservation wage of a randomly drawn individual. Across models, generally, the complete wage density reacts to increases of the minimum wage, the average wage increases while the dispersion decreases.

In the light of the theoretical framework for residual wage dispersion, the **third chapter** (Fitzenberger and Garloff (2007b)) analyzes empirical implications based on German administrative data. Labor market transitions are interpreted as indicators of labor market frictions. Important indicators are the transition rates from employment to unemployment (job destruction rate), the transition rate from unemployment to employment (job finding rate) and the transition rate from job to job (job changing rate). They jointly characterize the amount of frictions in the market and the amount of firms' monopsony power. As predicted by search theory, transitions vary with certain demographic characteristics. Further, search theory implies that individuals change jobs to improve their wage. This view challenges human capital theory in which human capital accumulation in the form of experience drives individual wage growth without reference to mobility decisions. In fact, the desire for higher wages is a driving factor of direct job-to-job changes: Most job changers have wage gains and their wage gains are considerable on average. By contrast, there is also a remarkable amount of job-to-job transitions which come along with considerable wage losses. So, wage gains are a central but not the only determinant of job changes. This, in turn, challenges the simple search-theoretic framework, in which wage gains are the only determinant of job-to-job transitions. For people changing jobs with an intervening unemployment spell the share of winners slightly decreases with unemployment duration while for the gain of winners there is no clear trend. Job changes are also important in explaining why people move up or down in the *relative* position of wage distribution, most importantly for younger individuals.

In the **fourth chapter** (Fitzenberger and Garloff (2005b)) conflicting hypotheses between wage dispersion on the one hand and labor market dynamics and unemployment on the other hand are deduced from equilibrium search theory and the neo-classical labor market model as antagonistic approaches. In the neo-classical view, the wage structure that results in market equilibrium is compressed from below by institutions. Thus, the wage dispersion is too small. Wages, above market clearing level, are then responsible for unemployment.[3] This reasoning implies a negative relationship between wage inequality and unemployment. Instead, the search-theoretic approach predicts an opposite relationship, as search frictions cause both wage dispersion and unemployment to be high. Thus, a positive correlation between unemployment and wage dispersion for individuals with similar observable attributes is expected. A labor union compressing the wage distribution from below would then leave the unemployment rate unaffected. Further hypotheses concerning the relationship between wage dispersion and labor market dynamics are deduced from the two approaches.

The hypotheses are tested based on German administrative data. Central variables from Mincer equations (age, education) are used to stratify the data. Using the corresponding cells as observation units, the chosen approach allows for unobserved heterogeneity. The mutual reverse causality predicted by the two hypotheses is taken into account, using the time structure for identification. The results for the respective approaches are mixed. One stable finding is that

[3] This is one of the predominant explanations for the high unemployment in Europe and has been discussed in the literature under the terms "Krugman-hypothesis" (Krugman (1994)) and "unified theory" (Blank (1997)).

there is no negative connection between residual wage dispersion and unemployment. This contradicts the conventional wisdom that the “unbearable stability” (Prasad (2004)) of the German wage distribution be responsible for unemployment.

Search theory and neo-classical theory: A synthesis?

The **fifth chapter** (Fitzenberger and Garloff (2007a)) reconciles residual wage dispersion and wage dispersion between skill groups and also models determinants of different types of unemployment. Structural unemployment due to minimum wages and frictional unemployment due to search frictions are jointly modelled, by means of an equilibrium search framework in the spirit of Burdett and Mortensen (1998) which is linked with a neo-classical production function allowing for two distinct labor inputs. Under some restrictions an analytical solution for the dispersed wage offer distribution within skills is obtained. The optimal behavior of the firms can be described by their position in the continuous wage distributions for the two skill groups. Resulting equilibrium wage offer and (cross-sectional) wage densities are increasing in the wage. This must be the case in order to guarantee the employment to be increasing enough. For cases, where there is no analytical solution, simulation methods are used to characterize the resulting wage distribution. Under most parameter constellations the wage densities explode at the upper bound. At the resulting mass point, wages equal marginal productivity. The standard mechanism of the equilibrium search model is destroyed at this point, since the rent for an additional worker reduces to zero. Still, cutting the wage distribution in the continuous part of the distribution at some minimum wage does not have any employment effects.

In an extended setup, labor demand effects are introduced by endogenizing the contact frequency between firms and workers. The contact frequency is interpreted as a result of firms’ hiring efforts, which are costly to the firm. Under comparatively weak parameter restrictions it is shown that increasing minimum wages, in this case, lead to decreasing labor demand, thereby causing structural unemployment. This happens because firms must utilize their profits to insure enough worker contacts in order to replace all terminated matches. A minimum wage, however, decreases profits and thus reduces hiring efforts. Even in cases where we can calculate an analytical form for the moments of the wage distribution, effects of the increasing minimum wage on the moments are ambiguous. The reason is that the whole distribution and not only the lower bound reacts on a change of the binding minimum wage. Finally, the labor unions’ objective function in choosing a minimum wage is considered.

1 Unemployment and wage dispersion: The neo-classical view

1.1 Introduction

In this chapter, we develop a model that is able to account for the differential employment and wage dynamics in Europe and the U.S./UK. It is based on Weiss and Garloff (2005).

The well documented increase in wage inequality in the U.S. and the UK in the 1980s and early 1990s is attributed to an increase in the demand for skills that has been faster than the increase in skills supply. Predominantly so-called skill-biased technological change is blamed for the rapid increase in the demand of skills.[1] In most of Continental Europe, wage inequality increased much less if at all; instead it experienced a significant increase of unemployment, especially of the low-skilled.[2] As an illustration, Figures 1.1 and 1.2 draw the development of wage inequality and low-skilled unemployment, respectively, for the U.S. and for Germany.

Mainly, three arguments have emerged in the literature to explain the differences in the evolution of wage inequality. First, some authors argue that the supply of skills increased faster in Europe than in the U.S./UK (see Nickell and Layard (1999), Card and Lemieux (2001), Leuven, Oosterbeek, and van Ophem (2003) and Nickell, Nunziata, and Ochel (2005)). This approach is not able, however, to account for the differential evolution of unemployment.

The second, and maybe most important, approach argues that collective bargaining and labor market institutions kept the wage structure compressed in Europe so that skill-biased technological change has been leading to increasing unemployment.[3] This approach has been given the label "Krugman-hypothesis" (Krugman (1994)) and "unified theory" (Blank (1997)). The role of labor unions has obtained considerable attention (e.g., Lindbeck and Snower (2001)). Labor market institutions as the unemployment insurance system and employment protection (e.g., Mortensen and Pissarides (1999)), or minimum wages (e.g., Gautier and Teulings (2006)) have

[1] See, e.g., Gottschalk (1997), Berman, Bound, and Machin (1998), Katz and Autor (1999), and Acemoglu (2002). Other factors affecting the relative demand for skills that have been identified in the literature are organizational changes (e.g., Lindbeck and Snower (1996) and Caroli and van Reenen (2001)) and globalization of goods and labor markets (see, e.g., Fenstra and Hanson (1996), Wood (1998), Baldwin and Cain (2000), and Borjas, Freeman, and Katz (1996)).

[2] Italy is an exception and shows a pronounced increase in overall wage inequality especially in the beginning of the 90s, but not so in the college wage premium (see, e.g., Brunello, Comi, Lucifora, and Scarpa (2005)).

[3] See, e.g., Krugman (1994), Krugman (1995), Katz and Autor (1999), Blau and Kahn (1996), Freeman (1996), and Acemoglu (2002). Fewer authors argue that both, the stylized differences between the U.S. and Europe and the labor market rigidities used to explain these differences are overstated in the above literature (see, e.g., Nickell (1997), Gregg and Manning (1997), Manacorda and Petrongolo (1999) and Nickell, Nunziata, and Ochel (2005)).

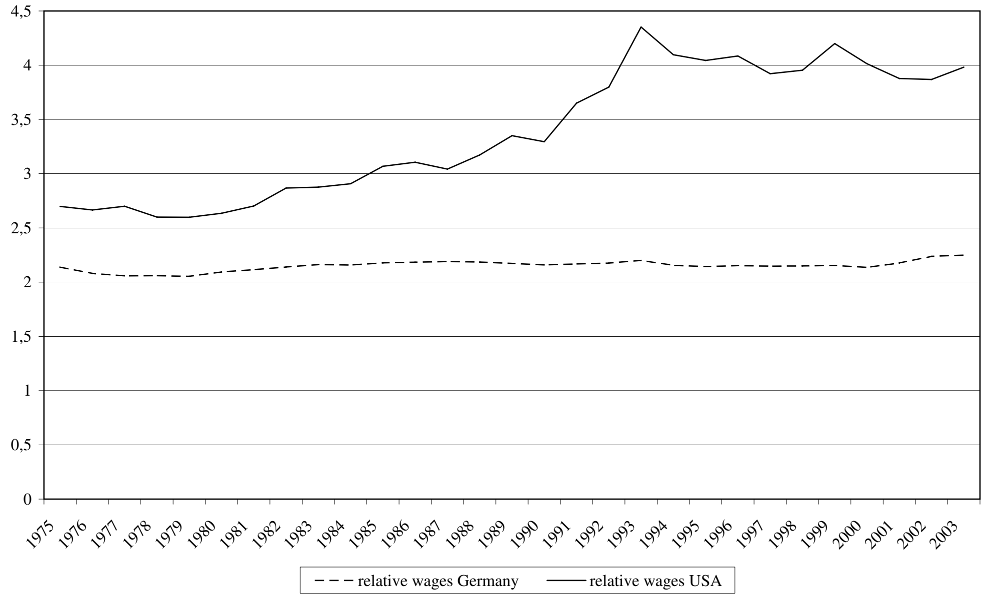

Figure 1.1: Wage inequality in the U.S. and in Germany

Data sources and definitions in appendix A.1.2.

also obtained attention in the literature. The major theoretical drawback of the institutional approaches is that they mostly explain differences in the level of unemployment and the level of wage dispersion. Only few[4] can explain a widening gap of wage dispersion and unemployment as long as the institutions are unchanged.[5]

Thirdly, and more recently, it has been argued that the demand for high-skilled increased less in Europe, because there, high wages for the low-skilled workers create an incentive for firms to invest in unskill-biased technologies, implying that technical progress is on average less skill-biased in Europe (see Acemoglu (2003)). Similarly, Beaudry and Green (2003) argue that it is the choice of the capital-intensity of production that makes the difference in skill-bias in the presence of a capital-skill complementarity.

Our paper contributes to the view that it is the institutions that matter for the diverging evolution between the U.S./UK and Continental Europe. Our model is able to reproduce the differential

[4] Krugman (1995) is such an exception. He uses the ad hoc assumption that—due to labor market institutions, the wage for low-skilled labor is proportional to the wage for skilled labor.

[5] Admittedly, it has been noted in the literature that institutions have changed in reaction to shocks, such as skill-biased technical change. There has been a tendency towards deunionization in the U.S. and UK while, at least in the beginning of the 80s in Continental Europe employment protection was strengthened and benefits of the unemployment insurance have become more generous (see Siebert (1997), Saint-Paul (2004) and Blanchard (2006).)

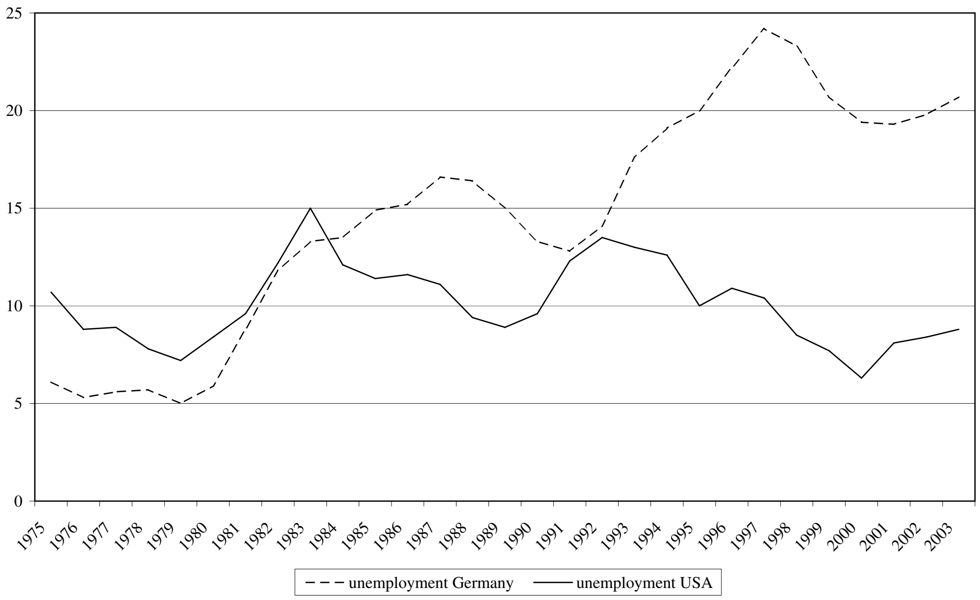

Figure 1.2: Low-skilled unemployment rates in the U.S. and in Germany

Data sources and definitions in appendix A.1.2.

dynamics of unemployment and wage inequality and not only levels. We argue that in Europe, skill-biased technological change has adverse effects on employment of low-skilled workers because their wages are linked to the skilled workers' wages. This link is established by the indexation of social benefits to per-capita income.

Modern welfare states usually possess social protection systems including schemes that provide needy people with subsistence benefits.[6] Often, the level of benefits is linked to the evolution of wages or per-capita income. The reason for this is that benefits are paid to avoid poverty so that their level must be closely related to the "subsistence level". But the subsistence level is a relative concept and so is poverty.[7] In Germany, for example, the subsistence level is defined in the social legislation (Bundessozialhilfegesetz §12 BSHG, Sozialgesetzbuch §27 SGB XII). Both articles explicitly state that the subsistence level does not only consist of sufficient food, housing, clothes, furniture, etc. but also of participation in social and cultural life. Social contacts and

[6] Names for these schemes in the different countries are "social assistance benefit", "welfare allowance", "right to the social integration", "minimum income, public assistance", "guaranteed minimum income benefit", "social benefit", "subsistence allowance", "social insertion income", "benefit in material need", etc. In the remainder of the paper, we use the label "benefits" as an umbrella term for all these schemes.

[7] See, e.g., Foster (1998): "Absolute versus Relative Poverty" and the other contributions to the session on "What is Poverty and Who are the Poor?" in the AEA Papers and Proceedings Issue of the *American Economic Review* of May 1998.

participation in cultural life perhaps more than food, housing, and the like depend on the average wealth of a society. In societies where most of the people can afford video cameras, mobile phones, flights to distant countries, etc., a life without electric light, running water or even without a television set is considered unacceptable.[8] Therefore benefits in general depend on the average wealth of a society. The strength of this link, however, varies across countries. We find that in most of Continental Europe the level of benefits is tied closely to per-capita income while in the Anglo-Saxon countries the benefits level has been kept constant in real terms and has not been adjusted to per-capita income over the last 20 years.[9] We show that this institutional difference is able to explain the transatlantic differences in wage and employment dynamics.

Endogeneity of the level of benefits with respect to the average income is important for labor market outcomes because it establishes a link from skilled workers' productivities to low-skilled workers' wages: Changes in skilled workers productivities affect average income and thereby the level of benefits. This increase in the fallback income improves the bargaining position of the low-skilled workers. In general this will result in higher wages and—for lack of respective productivity gains—higher unemployment.[10]

To demonstrate the mechanisms, our baseline model considers a "European" economy with skilled and low-skilled labor. Following papers on related issues (see, e.g., Davis (1998) and Krugman (1995)), we assume that the market for skilled labor clears, while the market for low-skilled labor does not. This is justified by the fact that the low-skilled workers are by far more likely to be unemployed which is evident from Table 1.1.[11] In the baseline model the wage for low-skilled labor is determined by a monopolistic labor union while employment is determined by competitive firms.[12] These assumptions are for simplicity. The focus of this paper is on the

[8] The German right-of-distraint legislation considers a television set as indispensable and excludes it from seizure.

[9] Note, that in Germany the explicit link between pensions and benefits has been kept in the new social legislation (the Hartz IV reform), for the so called Arbeitslosengeld II (§20 SGB II,(4)).

[10] In fact, most benefit systems have unemployment insurance elements that depend on the level of past earnings rather than the general income level of the economy. But for two reasons, we think that unemployment insurance is not the proper measure for the fallback income of workers:

1. Unemployment insurance benefits are generally limited in duration. After a certain time limit, eligibility for unemployment insurance expires and unemployed workers receive social benefits. So, in the long run, it is social benefits that constitute the fallback income.
2. For low-skilled workers, unemployment insurance benefits may easily fall short of the level of social benefits. In this case, the payment is increased to this level. So, the level of social benefits rather than the level of unemployment insurance benefits constitutes the lower bound to unskill wages.

[11] Wages are generally less flexible at the lower end of the distribution. For Germany, for example, Büttner and Fitzenberger (1998) (p. 1) find that "... employees with low wages have significantly lower wage flexibility than high wage employees. This effect is particularly relevant for the lower educational groups."

Table 1.1: Unemployment rates by education, Euro-zone, average: 1995 - 2004

Low Education[a]	Medium Education[b]	High Education[c]
13.42%	9.38%	6.43%

Source: Eurostat; ISCED 1997 classification a) lower secondary education or less (ISCED 0-2), b) upper secondary education, post-secondary, non-tertiary education (ISCED 3-4), c) first or second stage tertiary education (ISCED 5-6).

(strikingly large) extent to which the low-skilled workers' rate of unemployment exceeds that of the skilled workers. The fact that unemployment also exists among the skilled workers might indeed be explained by considerations of insider-outsider relations, search frictions, efficiency wages, or the like. These theories might be seen as complementary rather than contradictory to this paper.

The findings of the baseline model (and its generalizations) are consistent with the evolution of wages and employment of low-skilled workers in Europe over the past decades. Wages for all skill levels have risen over this period and, by and large, the employment prospects of the less skilled workers have deteriorated.[13] There has been increasing consensus among economists that asymmetric technological progress and possibly increasing trade with low-wage countries have led to a substantial shift in demand away from low-skilled workers toward skilled workers during the 1980's and the 1990's.[14] In the United States (and the UK), it seems, this demand shift has led to an increase in wage inequality while in (Continental) Europe, where the wage structure has remained fairly stable, it resulted in a rise in unemployment, in particular among low-skilled workers (see, e.g., Krugman (1994), Freeman (1995), Siebert (1997), and Davis (1998)).[15] This

[12] In the discussion paper version of this paper, this assumption is relaxed in three ways. Similar results are obtained when the wage is determined in negotiations between a labor union and firms, modeled as the generalized Nash-Bargaining solution. We also consider the case where the wages for both, skilled and low-skilled workers are determined by unions and unemployment occurs at both skill levels. In addition, a modified version where markets on all skill levels are assumed to be competitive is examined. All three modifications do not affect the results substantially.

[13] See, e.g., Siebert (1997), Katz and Autor (1999), Cahuc and Zylberberg (2004), Chapter 2.6, or Acemoglu (2002). For Germany a detailed analysis of the employment and wage development is performed in Fitzenberger (1999).

[14] Levy and Murnane (1992) and Gottschalk (1997) give surveys of the empirical literature on this subject.

[15] We are aware that the view that increasing unemployment in Continental Europe and increasing wage inequality in the U.S. and the UK are two sides of the same coin (namely skill-biased technological change) is not beyond controversy (see, e.g., Nickell and Bell (1996), Gregg and Manning (1997) and Krueger and Pischke (1998)). Yet, there seems to have emerged a large consensus among many economists that this view explains at least parts of the intercontinental differences (see, e.g., Cahuc and Zylberberg (2004), Chapter 10 or Borjas (2005), Chapter 11). Empirical support is given by, e.g., Puhani (2003). Zwick (2006) offer an interesting interpretation of the differences between the U.S. and Germany that is related to training costs.

coincidence of rising wage inequality in the United States and rising unemployment (at rather stable relative wages) in Europe suggests that the kind of feedback mechanism described in the baseline model has been an important feature of labor markets in Continental Europe but not in the U.S. and the UK. We show that, on the basis of only one institutional difference, namely the link between benefits and per-capita income, we can explain this difference in employment and wage dynamics.

The remainder of the paper is organized as follows. Section 2.1 discusses the contribution of collective bargaining to the explanation of the changes in wage dispersion and unemployment. Section 1.3 deals with the question whether and how tightly different countries link their benefit payments to the average income for a selection of OECD countries. The model is set up in section 1.4. Comparative static results and the implications of our model with respect to the transatlantic differences in the social legislation are discussed. Section 1.5 summarizes and concludes.

1.2 Union, wages, and employment

There is a huge literature on unions and their contribution to the assumed wage inflexibility. Most of the literature agrees that labor unions compress the wage structure (see Katz and Autor (1999), see Card, Lemieux, and Riddell (2003) for a survey on empirical wage effects of unions in the US, UK and Canada and Kahn (2000) for evidence of 15 OECD countries). The so called unified theory (Blank (1997)) on the high unemployment in Europe argues that institutional rigidities and labor unions as a part of these institutional rigidities play a significant role for the wage structure and therefore also for unemployment (see, e.g., Krugman (1994), Siebert (1997), Katz and Autor (1999), Kahn (2000), Blau and Kahn (2002) and Blanchard (2006)).[16] Another strand of the literature argues that different developments in the supply of skills are responsible for the international differences in wage inequality. The basic argument is that the supply of skills rose faster in Europe than in the U.S. (see Gottschalk and Joyce (1998), Nickell and Layard (1999) and Leuven, Oosterbeek, and van Ophem (2003)). When suggesting labor unions as an explanation for wage inflexibility *and* high unemployment in Europe, most of the literature seems to rely implicitly on a sort of textbook monopoly union model (as set out, e.g., in Booth (1995)). An exception for Germany is Fitzenberger (1999), who models union behavior with wage and wage dispersion aims explicitly and analyzes the effects on wage dispersion and employment. In

[16] Note, however, that the connection between wage (in)flexibility and unemployment is not uncontested. First, there are labor market models which posit that labor unions influence could be employment neutral (see, e.g., Garloff (2007)). Second, the empirical literature is controversial on this topic (see, e.g., Card, Kramarz, and Lemieux (1999), Fitzenberger and Garloff (2005a), Möller (2004) and the controversial literature on employment effects of minimum wages, see, e.g., Brown (1999) and Neumark and Wascher (2007)).

the literature on effects of union wage setting on the wage structure, the degree of centralization and coordination of wage negotiations has been considered an important determinant (see Calmfors and Driffill (1988), Franz (1994), Nickell (1997), Fitzenberger and Franz (1999) and Gürtzgen (2003)), implying that according to this union effects on the wage structure across European countries could be quite different, since both coordination and centralization degrees differ considerably across European countries (see Calmfors, Booth, Burda, Checchi, Naylor, and Visser (2001) and Flanagan (2003)).

In addition, the theoretical models we are aware of, generate differences in the level of unemployment and wage dispersion but are not able to account for the development over time observed in these variables. Siebert (1997), Saint-Paul (2004) and Blanchard (2006) argue that the institutions changed over time and that – as a reaction to the oil crises – the system at least in some European countries has become more generous by the beginning of the 70s.[17] Clearly, this trend was reverted later. In addition, concerning unions we observe a tendency towards deunionization in most European countries (see, e.g., Calmfors, Booth, Burda, Checchi, Naylor, and Visser (2001) and Ebbinghaus and Visser (2000)) and thus unemployment should have decreased.[18] The tendency towards deunionization seems to be strongest in the U.S. and the UK (see Card, Lemieux, and Riddell (2003)), which might explain part of the increase of the wage inequality in these countries (see Machin (1997) for the UK and Card (2001) for the U.S.). But, why did the wage inequality in those European countries that experienced a decline in unionization rates not react accordingly? Koeniger, Leonardi, and Nunziata (2004) develop a simple model and use OECD data to assess whether the observed changes in institutions are able to account for the observed changes in wage inequality across countries. They conclude that the interplay of assumed exogenous institutions is able to explain the developments in wage inequality in the 11 OECD countries for 1973-1999 they look at. However, both the data and the assumption that the effect of institutions is identical over countries are not innocent. Similar in spirit, Nickell, Nunziata, and Ochel (2005) try to explain changes in unemployment by the changes in institutions. They conclude, relying on union densities, that unions play only a minor role in the explanation of the development of the European unemployment. The reason is that there seems to be no persistent effect of unionization on unemployment.

There is a large empirical literature on the effect of unions on wages and employment for specific countries. However, there are only few structural models that model union behavior explicitly and derive low wage dispersion and high unemployment as a solution to this model. One of the

[17] The idea is that the policy reaction on the increasing unemployment was to design a more generous system to help the new unemployed.

[18] Recognize, however that this is not a uniform trend over all European countries and that some countries even experienced increases in unionization rates, as e.g. Spain and the Netherlands (see Visser (2003)).

notable exceptions is Fitzenberger (1999). In a structural model for Germany he finds that labor unions in deed compress the wage structure by decreasing the wage dispersion within groups. This low wage dispersion involves unemployment, although according to his results unions put a high weight on employment; but it does not imply increasing unemployment. Other empirical studies for Germany include Büttner and Fitzenberger (1998), Büttner and Fitzenberger (2003), Fitzenberger and Kohn (2006), Fitzenberger, Kohn, and Lembcke (2007) and Gürtzgen (2006). Using administrative data Büttner and Fitzenberger (2003) shows that union wage setting is responsible for a low wage flexibility in the lower part of the wage distribution. Fitzenberger and Kohn (2006) and Fitzenberger, Kohn, and Lembcke (2007) find that a higher net union density is associated with lower average wages and lower wage dispersion. They interpret the lower average wage as stemming from an insurance premium that workers are ready to pay for a lower (residual) wage risk. Using linked employer-employee data with time-series variation, Gürtzgen (2006) concludes that a huge part of the observed compression through unions is a selection effect. She further concludes that there is a small and statistically significant premium for industry-level contracts in Western-Germany. Card, Lemieux, and Riddell (2003) survey wage effects of unions wage setting in Canada, the U.S. and UK. They conclude that unions compress male wage inequality.

The unified theory has been criticized on various grounds. First, a part of the literature has pointed out, that differences in institutions might explain different levels of unemployment and wage dispersion, but that, especially in face of the situation in the 60s, they do not suffice to explain the different developments. Changing institutions are necessary to explain the development (see Blanchard and Wolfers (2000), Hildreth and Oswald (1997), Saint-Paul (2004) and Nickell, Nunziata, and Ochel (2005)). Institutional changes, however, are endogenous with respect to the result (see Ebbinghaus and Kittel (2005)). Secondly, a literature argues that a mere supply and demand framework can explain the changes in wage inequality, accounting for the fact that the human capital content of years of schooling and school leaving certificates is not the same and accounting for the fact that the education expansion was faster in Europe than in the U.S. (see Leuven, Oosterbeek, and van Ophem (2003) and the literature cited above). Thirdly, Freeman and Schettkat (2000) argue that the low wage dispersion is not the main reason for the low employment in Germany, they argue that it is a lack of demand for low-skilled jobs that is unrelated to wages. Fourth, Ebbinghaus and Kittel (2005) argue that the experiences in Europe are too heterogeneous across countries to allow for an easy opposition of European and Anglo-Saxon countries. They argue that institutions are reactive to labor market conditions and thus that it is critical to use them as exogenous determinants of wage flexibility in empirical analysis. They argue that there is no easy deregulatory way out of unemployment but that strategies to fight unemployment must be country- and context-specific. Finally, Blank (1994) note that it is difficult to judge the effect of one institution or institutional change on labor market outcomes without observing the complete institutional framework, since each country has his own traditions and specificities, which influences the effectiveness of political reforms.

Summarizing, concerning the influence of collective bargaining on the increasing European unemployment the fact remains valid that in most European countries there was a tendency towards deunionization and thus, it is difficult to identify labor unions as responsible for low wage dispersion and increasing unemployment. We offer an interpretation for these phenomena that is connected with the institution of social benefits in the following sections.

1.3 Transatlantic differences in the social legislation

In this section we analyze the legal situation both in Continental Europe and in the U.S. and the UK to demonstrate how benefits depend on per-capita income in different welfare systems. We find that in the United States and the UK benefits have not been adjusted to average income in the last 20 years, while in most European countries this adjustment is automatic and by law. Having observed this, in the next section our model shows that it is precisely this institutional difference that can account for diverging experiences in the evolution of wage inequality and unemployment.

We are aware that this binary classification into European and Anglo-Saxon countries is crude. There is substantial variation in the social legislation within these groups of countries.[19] But, when it comes to the evolution of benefits over time, the similarities within and the disparities between these two groups of countries are striking: In most European countries, these benefits depend on per-capita income by law, while this is not the case in Anglo-Saxon countries.

Let us consider the European countries first. In some countries, the adjustment of the benefits level over time is automatic by law, i.e., there is a clear adjustment frequency and there are clear rules to what the benefits level is to be adapted. In other countries the legislation gives more scope to the government or the parliament to act and adjustments are discretionary. In some countries where there exist rules for the adjustment of benefits, the evolution of benefit payments is linked to the evolution of wages and/or income while in others, benefits are linked to consumer prices. Figure A.1 in the appendix contains a synopsis of the social legislation in a selection of countries. In most European countries (Austria, Denmark, Finland, Germany, Italy, Netherlands, and Portugal), welfare benefits are automatically linked to the evolution of average

[19] There have been several attempts in the European Union to harmonize social legislation - without much success, though. Two of the more successful attempts have led to the European Social Charter of 1989 and to the social protocol annexed to the Maastricht Treaty of 1992 - both not signed by the United Kingdom. If compared to other policy areas of the European Community, the treaties on social standards remain vague.

wages, average income or public pensions (which on their part are linked to the evolution of average wages or average income) by law. Exceptions are Belgium, France, Greece and Spain. In Greece a general income support scheme does not exist. We discuss the remaining three countries in appendix A.1.1 and provide empirical evidence that is in accordance with our main hypothesis.

In Anglo-Saxon countries, on the other hand, benefits are not linked to average wages or income. In the UK, "income support" is tied to the evolution of consumer prices only. [20] In the U.S., the institutional and legal situation is more complex.[21] At the federal level, the *Food Stamp Program* is the only program in the overall social safety net that is not restricted to certain eligibility groups. The maximum amount of food stamps that an entitled person can get is indexed to the costs of the Thrifty Food Plan, a nutritious low-cost diet (see Gundersen, LeBlanc, and Kuhn (1999), page 3). In addition, there exist special schemes for special groups: *Aid to Families with Dependent Children* (AFDC) provides cash payments primarily to poor single mothers. Not eligible are for example poor families with employed principal wage earners (even if they were financially eligible). The program has been replaced in 1996 by the *Temporary Assistance for Needy Families* (TANF) which is more restrictive in terms of duration and eligibility. The amounts granted to families have been adjusted only infrequently and very little. Between 1970 and 1993, for example, payments to a family of three have dropped by nearly 45% in real terms (see Gundersen, LeBlanc, and Kuhn (1999)). The *Supplemental Security Income* (SSI) is designed to help aged, blind, and disabled people, who have little or no income. The level of these payments is indexed to the COLA-Index ("Cost of Living Adjustments").[22] Finally, *Medicaid* provides medical assistance to poor persons, but eligibility is generally tied to eligibility for SSI or AFDC.

On the state level, the *General Assistance* (GA) provides income support to those poor persons who are not eligible for federal programs. Despite the common name, there is great variation across states with respect to availability, eligibility, form of benefits (cash vs. vendor payments/vouchers), duration, and the level of benefits. The program is not very generous. In all states but Nebraska, the maximum cash benefits are below the federal poverty threshold for 1995 published by the Bureau of the Census ($7,763 for one person).[23] Adjustments are rare and very

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[20] There were no additional discretionary increases between 1979 and 2001 (see Cantillon, van Mechelen, Marx, and van den Bosch (2004) and Goodman and Shephard (2002).

[21] For a concise overview, see Uccello and Gallagher (1997) from where most of the following information is taken.

[22] The adjustment to the cost of living index is automatic and based on the CPI-W, the consumer price index for urban wage earners and clerical workers. In the period between 1975 and 2005, there is only one change that is above the COLA (in 1983), a legislated increase which corresponds to changes in the taxation of social benefits.

low. "Eight states have enacted nominal benefit increases since 1992, but none of these have exceeded the rate of inflation. Thus, real benefit levels have remained stagnant or fallen. Six states have actually reduced nominal benefits." (Uccello and Gallagher (1997), p.5)

In summary, we can conclude, that none of the U.S. income support programs links benefits to the evolution of average income or wages. In fact, in many cases, amounts are not even adjusted for inflation.

Figure A.1 in the appendix summarizes the institutional setting. It shows that welfare benefits are linked to average wages or income by law in most of Continental Europe but not in the U.S. and the UK. In appendix A.1.1, we take a closer look at those European countries, that have no legal automatic link between benefits and wages or income and provide empirical evidence that is in accordance with our assumptions. The next section containing the baseline version of our model demonstrates that this institutional difference in the determination of benefits can account for diverging experiences in the evolution of employment and inequality.

1.4 The model

1.4.1 The baseline case: Europe

Consider an economy with a continuum of mass 1 of homogeneous firms producing a single good. The good is produced using two input factors, low-skilled and skilled labor. There is a continuum of mass 1 of workers of each type. Each worker supplies one unit of labor. For simplicity, the model is essentially static. There is no capital in the model so that consumption equals production at any point in time.[24]

Technology

The firm produces according to the production function

$$Y = (a_u \cdot l_u)^\rho + (a_s \cdot l_s)^\rho, \quad 0 < \rho < 1, \quad 0 < a_u < a_s, \tag{1.1}$$

where Y is the quantity of the final good, l_u and l_s are the levels of employment of low-skilled and skilled labor respectively, and ρ, a_u, and a_s are productivity parameters. This specification has the following properties:

[23] The average percentage is 39%. Missouri pays the lowest amounts (12%).

[24] This allows us to focus on differences in employment and inequality that do not stem from different capital-labor ratios, as, e.g., in Beaudry and Green (2003).

- The elasticity of substitution between low-skilled and skilled labor is $\sigma = 1/(1-\rho) > 1$. We restrict the analysis to substitution elasticities larger than one because only in this case does skill-biased technological change have adverse effects on the relative position of the low-skilled workers. Furthermore, the majority of the empirical estimates are between 1 and 2. See, e.g., Autor, Katz, and Krueger (1998) who argue that a consensus estimate is a value around 1.5.

- The marginal productivities of low-skilled and skilled workers are independent of each other and the cross wage elasticities of the factor demands are zero. We make this arguably strong assumption to guarantee that any relation between the wages for the two kinds of labor that arises in the model can be attributed solely to the institutional peculiarities.

These restrictions are also for simplicity. In Weiss and Garloff (2005), we consider the case of a more general CES (constant elasticity of substitution) technology. The results are shown to be independent of these different specifications.

Demand for Low-skilled and Skilled Labor

Firms sell their products on the world market at the world market price $P = 1$ (by choice of the numéraire). At given wage levels, firms choose the level of employment so as to maximize their profit

$$\pi = Y - w_u \cdot l_u - w_s \cdot l_s. \tag{1.2}$$

The demand for low-skilled and skilled labor is respectively

$$l_u^d(w_u) = \left(\frac{\rho \cdot a_u^\rho}{w_u}\right)^{\frac{1}{1-\rho}} \quad \text{and} \quad l_s^d(w_s) = \left(\frac{\rho \cdot a_s^\rho}{w_s}\right)^{\frac{1}{1-\rho}}, \tag{1.3}$$

where w_u and w_s are the wages for low-skilled and skilled labor respectively.

Benefits

The model involves unemployment of low-skilled workers. All unemployed individuals are assumed to receive benefits, $\tilde{w}$. In accordance with the reasoning in the introduction, the benefits are assumed to depend on the net average income

$$\tilde{w} = \mu \cdot (1-t) \cdot \frac{Y}{2}, \tag{1.4}$$

where $Y/2$ is the per-capita income, t is the income tax rate, and $\mu \in [0,1]$ is a proportionality factor. The benefits are financed through a proportional income tax. The tax rate t is endogenously determined by the government's budget constraint:

$$(1 - l_u) \cdot \tilde{w} = t \cdot Y. \tag{1.5}$$

The Union's Objective Function

All low-skilled workers are assumed to be members of a labor union. The union chooses the wage to maximize the expected labor income of its members.

$$U = E\left[net\ labor\ income|w_u\right] = l_u\left(w_u\right) \cdot (1-t) \cdot w_u + \left[1 - l_u\left(w_u\right)\right] \cdot \tilde{w} \tag{1.6}$$

The first term in expression (1.6) represents the probability for any union member to become (or remain) employed (conditional on the wage level) times the net wage of employed low-skilled workers. The second term represents the conditional probability to become unemployed times the alternative income (i.e., benefits).

Wage Determination

We assume that the market for skilled labor clears. This determines the wage for skilled labor $w_s = \rho \cdot a_s$. The wage for low-skilled labor is assumed to be determined by a monopolistic labor union whereas the firm has the "right to manage". The union maximizes its objective function taking into account the effect of the wage level on employment. We assume that, out of idleness or lack of comprehension of the economic system, the union does not consider the second-round effects the wage has on the level of benefits and on the tax rate.[25] In the formal model, this means that the objective function (1.6) is maximized subject to (1.3) but taking the level of benefits $\tilde{w}$ and the tax rate t as exogenously given. Solving the maximization problem yields the following result which is familiar from the literature.[26]

Lemma 1.1 *Under the above assumptions, the wage for low-skilled labor, w_u, is an increasing function of the level of benefits, $\tilde{w}$:*

$$w_u = \frac{\tilde{w}}{\rho \cdot (1-t)}. \tag{1.7}$$

[25] This assumption is also for simplicity. In Weiss and Garloff (2005), we consider the case where the union takes into full account the effects of the wage level on the level of benefits and the tax rate. The results are virtually unaffected.

[26] See, e.g., Cahuc and Zylberberg (2004), Chapter 7, Muthoo (1999), Chapter 2.5, or Borjas (2005), Chapter 13.

The Interdependence of Wages and Benefits

In contrast to standard union models (and in contrast to what the union takes into account), in this model, the level of benefits is a function of the net average income which, in turn, is a function of the wage for low-skilled labor. Accounting for this endogeneity in (1.7) yields[27]

$$w_u^* = \frac{1}{2} \cdot \frac{\mu}{\rho} \cdot \left[\left(\frac{\rho \cdot a_u}{w_u^*} \right)^{\frac{\rho}{1-\rho}} + a_s^\rho \right]. \tag{1.8}$$

The equilibrium wage for low-skilled labor, w_u^*, is implicitly given by this equation.[28] It is easily verified that under the above assumptions, an equilibrium, $w_u^*(a_u, a_s, \mu, \rho)$, exists and is unique. [29]

1.4.2 Comparative statics

The comparative static properties of the equilibrium allocation are presented in the following propositions:

Proposition 1.2 *An increase [respectively decrease] in the low-skilled workers' productivity, as measured by the productivity parameter a_u, leads to an increase [respectively decrease] in both, the equilibrium wage and the level of employment of low-skilled labor.*

$$\frac{\partial w_u^*}{\partial a_u} \cdot \frac{a_u}{w_u^*} = \frac{\eta_{Y,l_u}}{1-\rho+\eta_{Y,l_u}} > 0 \tag{1.9}$$

$$\frac{\partial l_u^*}{\partial a_u} \cdot \frac{a_u}{l_u^*} = \frac{\rho-\eta_{Y,l_u}}{1-\rho+\eta_{Y,l_u}} > 0 \tag{1.10}$$

where $\eta_{Y,l_i} = \frac{\partial Y}{\partial l_u} \cdot \frac{l_u}{Y}$.

A decrease in the low-skilled workers' productivity leads—via a decrease in the average income—to a decrease in the low-skilled workers' wage. But this decrease is less than would be required by the productivity loss because the wage is linked to the average income level which decreases

[27] Equations (1.7) and (1.8) are two different ways of writing down the same result. In equation (1.7) the focus is on the dependency of the low-skilled workers' wage on the level of (endogenous) benefits while in equation (1.8) the low-skilled workers' wage is shown as a function of the exogenous parameters of the model.

[28] Throughout the paper, the term "equilibrium" will be used to refer to the allocation which results from union wage setting, given the other institutional features of the model.

[29] **Existence**: For w_u sufficiently small (resp. sufficiently large), the right hand side of the equilibrium condition (1.8) is larger (resp. smaller) than the left hand side. As both sides of the equation are continuous in w_u there must exist at least one value of w_u, w_u^*, for which both sides are equal. **Uniqueness**: The left hand side of (1.8) is strictly increasing in w_u whereas the right hand side is strictly decreasing in w_u. Therefore, if a solution to (1.8), w_u^*, exists, it must be unique.

by less than the low-skilled workers productivity. Therefore unemployment of the low-skilled increases. This failure of the wage to fully adjust to changes in productivity can be seen as a rigidity in the *relative* wage w_u/w_s.

While the wage for skilled labor always adjusts to clear the market, the wage for low-skilled labor depends on the productivities of both, low-skilled *and* skilled workers. In other words, the wage for low-skilled labor is linked to the wage for skilled labor. The relative wage cannot fully adjust to changes in the relative productivity. This rigidity leads to an increase in unemployment in response to a decrease in the productivity for the low-skilled workers. Similar results are obtained in standard union models where the reservation wage of the workers is exogenous.

Proposition 1.3 *An increase [respectively decrease] in the skilled workers' productivity, as measured by the productivity parameter a_s, leads to an increase [respectively decrease] in the wage for low-skilled labor and a decrease [respectively increase] in the level of employment for low-skilled workers.*

$$\frac{\partial w_u^*}{\partial a_s} \cdot \frac{a_s}{w_u^*} = \frac{(1-\rho) \cdot \eta_{Y,l_s}}{1-\rho+\eta_{Y,l_u}} > 0 \tag{1.11}$$

$$\frac{\partial l_u^*}{\partial a_s} \cdot \frac{a_s}{l_u^*} = -\frac{\eta_{Y,l_s}}{1-\rho+\eta_{Y,l_u}} < 0 \tag{1.12}$$

The increased productivity of the skilled workers leads to a rise in the average income. This in turn increases—through higher benefits—the low-skilled workers' reservation wage and thereby their wage. Since the productivity of the low-skilled workers remains unchanged, unemployment increases.

While the result in Proposition 1.2—that the wage *falls too little* in response to a fall in the productivity of the low-skilled—is also obtained in standard union models, the result in Proposition 1.3—that the wage *increases too much* in response to a productivity gain of the *skilled* workers—is unique to this model where the feedback mechanism from income levels to wages is accounted for. In this model, the driving force behind *both* effects is the above mentioned rigidity in the *relative* wage.

Propositions 1.2 and 1.3 consider cases where only one type of labor becomes more productive. Depending on whose productivity increases, unemployment increases or decreases. Since in reality, technological change tends to affect the productivities of different types of labor at the same time, the question naturally arises which of the two opposite effects dominates. The following Proposition answers this question.

Proposition 1.4 *Technological change leads to a decrease [respectively increase] in employment of the low-skilled and an increase [decrease] in wage inequality whenever it leads to an increase [decrease] in* $\frac{a_s}{a_u}$.

$$\frac{\partial l_u^*}{\partial \frac{a_s}{a_u}} \cdot \frac{\frac{a_s}{a_u}}{l_u^*} = -\frac{\eta_{Y,l_s}}{1-\rho+\eta_{Y,l_u}} < 0 \tag{1.13}$$

$$\frac{\partial (\frac{w_s}{w_u})^*}{\partial \frac{a_s}{a_u}} \cdot \frac{\frac{a_s}{a_u}}{(\frac{w_s}{w_u})^*} = \frac{\rho \cdot \left(\frac{\frac{w_s}{w_u}}{\frac{a_s}{a_u}}\right)^{\frac{\rho}{1-\rho}}}{1-\rho+\left(\frac{\frac{w_s}{w_u}}{\frac{a_s}{a_u}}\right)^{\frac{\rho}{1-\rho}}} > 0 \tag{1.14}$$

Skill-biased technological progress favoring the skilled workers' productivity in a way that leads to an increase in a_s/a_u has a negative effect on the *relative* demand for low-skilled labor, l_u^d/l_s^d. Since the *relative* wage for low-skilled labor, w_u/w_s, cannot fully adjust to this shift in labor demand, unemployment of low-skilled workers increases.[30] On the other hand, if the productivity of low-skilled workers grows faster [or falls more slowly] than the skilled workers' productivity, the wage for low-skilled labor increases [respectively falls], but by less [respectively more] than would be justified by the shift in the relative productivity so that the employment of low-skilled workers increases. Any technological change that leaves the ratio a_s/a_u unaffected has no effect on the level of employment.

This result is consistent with the view that it is the same factors that boost wage inequality in the U.S. and the UK and result in higher unemployment in Continental Europe. In a model in which the welfare system is less generous and wages are to a greater extent market-determined—the alleged features of U.S. and UK labor markets—skill-biased technological change (in the form of an increase in a_s/a_u) leads to a stronger increase in wage inequality while unemployment is affected less or not all. Appendix A.1.2 provides some descriptive evidence for this result.

Increasing trade with and outsourcing to low-wage countries have been cited as a second culprit of the rise in wage inequality in the United States.[31] In fact, in a two-sector version of this model, it can be shown that increasing trade with low-wage countries (as modeled by a decrease in the relative price of the import good—whose production is assumed to be intensive in the use of low-skilled labor) has exactly the same effect on wages and employment as skill-biased technological change (as modeled by an increase in a_s/a_u). Increasing trade with low-wage countries also

[30] It is easily verified that $\frac{\partial (\frac{w_s}{w_u})^*}{\partial \frac{a_s}{a_u}} \cdot \frac{\frac{a_s}{a_u}}{(\frac{w_s}{w_u})^*} = \frac{\rho \cdot \left(\frac{\frac{w_s}{w_u}}{\frac{a_s}{a_u}}\right)^{\frac{\rho}{1-\rho}}}{1-\rho+\left(\frac{\frac{w_s}{w_u}}{\frac{a_s}{a_u}}\right)^{\frac{\rho}{1-\rho}}}$ is unambiguously smaller than ρ, the respective elasticity that prevailed if wages were perfectly flexible.

[31] See, e.g., Fenstra and Hanson (1996), Wood (1998) and more recently Baldwin and Cain (2000).

leads to a (downward) shift in the relative demand for low-skilled labor. As the relative wage for low-skilled labor does not fully adjust, unemployment of low-skilled labor rises.

1.4.3 Wage and employment dynamics: Anglo-Saxony vs. Continental Europe

In this section, we explore the implications of our model for the differences in wage and employment dynamics between Anglo-Saxon countries (AS) and Continental European countries (EU). For ease of presentation, we denote $\frac{a_s}{a_u} \equiv \alpha$ and $\frac{w_s}{w_u} \equiv \omega$ and normalize the productivity parameter of low-skilled labor to 1. The technology is thus given by $Y = l_u^\rho + (\alpha \cdot l_s)^\rho$. Benefits are given by

$$\tilde{w} = \mu \cdot \left((1-t) \cdot \left(\frac{Y}{2} \right) \right)^\xi , \tag{1.15}$$

where $\xi = 1$ in Europe and $\xi = 0$ in Anglo-Saxon countries. As expounded in Section 1.3, benefits are tied to the evolution of average income in Europe, but not in the U.S. and the UK.

In both regimes, the wages for low-skilled and skilled labor are given by $w_u = \frac{\tilde{w}}{\rho \cdot (1-t)}$ and $w_s = \rho \cdot \alpha^\rho$. Taking into account the differences in the determination of benefits the relative wage for skilled labor is given by

$$\omega_{EU} = \frac{2}{\left(\frac{\omega_{EU}}{\alpha}\right)^{\frac{\rho}{1-\rho}} + 1} \cdot \frac{\rho^2}{\mu} \quad \text{and} \quad \omega_{AS} = \alpha^\rho \cdot \frac{\rho^2}{\mu}. \tag{1.16}$$

in European and Anglo-Saxon countries respectively. The effect of skill-biased technological change on wage inequality is given by

$$\left(\frac{\partial \omega}{\partial \alpha} \cdot \frac{\alpha}{\omega} \right)_{EU} = \frac{\rho \cdot \left(\frac{\omega}{\alpha}\right)^{\frac{\rho}{1-\rho}}}{1 - \rho + \left(\frac{\omega}{\alpha}\right)^{\frac{\rho}{1-\rho}}} \quad \text{and} \quad \left(\frac{\partial \omega}{\partial \alpha} \cdot \frac{\alpha}{\omega} \right)_{AS} = \rho. \tag{1.17}$$

It is easily shown that $\left(\frac{\partial \omega}{\partial \alpha} \cdot \frac{\alpha}{\omega}\right)_{EU} < \left(\frac{\partial \omega}{\partial \alpha} \cdot \frac{\alpha}{\omega}\right)_{AS}$ as long as $\rho < 1$. The effect of skill-biased technological change on wage inequality is smaller in European countries, where the linkage of benefits to the evolution of average income keeps the wage distribution compressed.

The effects of skill-biased technological change on unemployment in European countries have been discussed in Subsection 1.4.2. In the Anglo-Saxon regime, employment of low-skilled workers is given by $l_u(w_u) = \left(\frac{\rho}{w_u}\right)^{\frac{1}{1-\rho}} = \left(\frac{\rho^2}{\mu}\right)^{\frac{1}{1-\rho}}$. Thus (un-)employment does not depend on the relative productivity parameter α. In summary, skill-biased technological change leads to an increase in unemployment in European countries and has no effect on unemployment in Anglo-Saxon countries:

$$\left(\frac{\partial l_u}{\partial \alpha} \cdot \frac{\alpha}{l_u} \right)_{EU} = -\frac{\eta_{Y,l_s}}{1 - \rho + \eta_{Y,l_u}} < 0 \quad \text{and} \quad \left(\frac{\partial l_u}{\partial \alpha} \cdot \frac{\alpha}{l_u} \right)_{AS} = 0. \tag{1.18}$$

We end this section by noting that a difference in bargaining power on the side of labor unions does not suffice to explain the differential unemployment and wage inequality dynamics between the two sets of countries in the presence of skill-biased technological change. If as in the model AS, the outside option does not react in response to an increasing demand for high-skilled labor, unemployment is unchanged irrespectively of the market power of labor unions. An explanation of the transatlantic difference that is linked to the bargaining power of labor unions requires a change in the bargaining power. In our model, it is the interaction of an increasing outside option and (an unchanged) bargaining power of the workers which cause the unemployment to increase. Of course, we do not negate the importance of the observed deunionization in the U.S. and UK (see, e.g., Blanchflower and Bryson (2004)) and see our paper as complementary to studies that link the transatlantic differences to a change in bargaining power.

1.4.4 Robustness

In order to assess the robustness of our results we considered a wealth of alternative specifications. These include:

- generalized Nash-Bargaining instead of monopoly union wage setting,
- risk averse rather than risk neutral workers,
- rational expectations with respect to the effects of wage-setting on the level of benefits and the tax rate,
- unemployment at the low-skilled *and* the skilled level,
- CES technology,
- benefits as a function of the average *wage* rather than average income,
- competitive market for low-skilled labor, and
- a two-sector version of the model where increasing competition from low-wage countries as another potential source of wage inequality/unemployment is considered.

Our results turn out to be robust to all these different specifications. For a detailed presentation of these robustness checks, the reader is referred to the discussion paper version Weiss and Garloff (2005).

1.5 Conclusion

In this paper, we study the effects of skill-biased technological change on unemployment and wage inequality when benefits are linked to per-capita income. This link to per-capita income introduces a tie between the wages for different skills.

In standard models of union wage setting, wages—especially at the lower end of the wage distribution—depend on the level of unemployment or social security benefits (which constitute the workers' reservation wage). As a consequence, these wages are downwardly rigid. This rigidity causes unemployment when productivity falls and wages do not adjust sufficiently. In our paper, benefits are endogenous and depend on wages. The interdependence between wages and benefits yields an allocation where the wage for low-skilled labor depends positively on the wage for skilled labor. The obtained wage rigidity is a rigidity in the *relation* between the wages for low-skilled and skilled labor. The wage for low-skilled labor is *too rigid* with respect to the low-skilled workers' productivity and it is *overly sensitive* to changes in the skilled workers' productivity.

If—as a result of skill-biased technological change—the productivity of the skilled workers rises faster than that of the low-skilled workers, the wage of the latter increases by more than would be justified by their productivity gains because it is linked to the skilled workers' wage via the benefits. As a result, unemployment of low-skilled labor increases. The matter of concern here is not that the low-skilled workers' wage falls too little—as in standard union models—but that it *rises too much*.

The findings of this paper are consistent with the evolution of wages and employment of low-skilled workers in Europe over the past decades. Wages for all skill levels have risen over this period and, by and large, the employment prospects of the less skilled workers have deteriorated.

Comparing the social legislation in the U.S. and many European countries, we find that benefits are linked to the evolution of average income or wages in Continental Europe but not in the U.S. and the UK. Given this institutional difference, our model predicts that skill-biased technological change leads to rising unemployment in Continental Europe and rising wage dispersion in the U.S. and the UK.

We can deduce interesting policy implications from the model. Any increase in the *relative* productivity (or more generally in the relative "market value") of skilled workers leads to a higher rate of unemployment the European model—even if the absolute productivity of low-skilled workers increases as well, but less than proportionately. From the point of view of the model, we can blame two factors for the high unemployment of the low-skilled. First, benefits are tied to the average income and second, benefits are a determinant of the wage of the low-skilled.

So, any policy measure that aims at weakening either of these links will decrease unemployment. It is to be noted, however, that our model does not alter a principal insight in the literature, namely the tradeoff between wage inequality and unemployment. A decrease in unemployment would come at the cost of higher wage inequality. There might be possibilities, however, to overcome this dilemma. One way might be the introduction of a negative income tax. Such a tax scheme allows the uncoupling of gross from net wages. Gross wages (and thus wage costs for firms) are determined by market forces and reflect productivities and at the same time, inequality in net wages can be kept from growing. These wage subsidies to low-skilled workers would have to be financed of course, but as these workers would not earn benefits anymore, the government's budget might even be relieved.

2 Unemployment and wage dispersion: Equilibrium search and heterogeneity

2.1 Wage dispersion and unemployment: Alternative views

This chapter reviews the equilibrium search literature, discusses extensions that include heterogeneity, introduces labor unions in this framework and thus builds a framework for analyzing residual wage dispersion. It is based on Garloff (2007).

Since labor unions compress the wage structure, they contribute to the high unemployment, especially for low-skilled individuals. This hypothesis is common in the economic literature in the context of the different experiences in the US and Continental Europe regarding wage dispersion and unemployment (see e.g. Siebert (1997), Blau and Kahn (2002) and Blanchard (2006)). Krugman (1994) states: "...that growing U.S. inequality and growing European unemployment are different sides of the same coin" (ibid., p.62). Many observers argue that skill-based technical progress, reorganization processes or globalization have decreased the demand for low-skilled work, thereby lowering the market wage. However, in Europe, and particularly in Germany, strong unions have prevented wages from falling (enough), causing a reaction via the amount of labor employed and thereby increasing unemployment of the low-skilled.[1] One problem with this explanation is that changes in the employment rates in Europe were quite similar across skill groups and changes in the employment rates of the low-skilled were quite similar in Europe and the US (see Acemoglu and Pischke (1999)). In this article they argue that the reason for the high European unemployment is more likely to be found in institutional restrictions on the side of the product market. Another strand of the literature argues that the differences between the US and Continental Europe could be interpreted in the context of a choice of different technologies, the European being more capital-intensive than the American (see Beaudry and Green (2003)). For a more comprehensive discussion of the literature, see chapter 1, especially sections 1.1 and .

Most of the literature that considers unions as a culprit for the high unemployment seems to be based implicitly on a sort of monopoly union model. In general it is assumed that the pivotal determinant of wages is marginal productivity. If people differ in their marginal productivity, in equilibrium, they obtain different wages. The wage distribution is entirely determined by the distribution of marginal productivities. If unions can influence wages, e.g. in collective wage

[1] There are further institutional reasons that can imply wage compression as benefit payments and the like (see, e.g., Weiss and Garloff (2005)). However, the focus in this paper is on minimum wages, which in the German context is set by labor unions (see, e.g., Fitzenberger, Kohn, and Lembcke (2007)).

bargaining, and if they have a preference for equality, they might compress the wage distribution. In this chapter, labor unions are supposed to compress wages via a binding minimum wage.[2] Then, if the minimum wage is binding, there are individuals with marginal productivity below the minimum wage. Depending on substitution elasticities at least part of these individuals become unemployed. This implies that labor unions wage compression causes structural unemployment. (union compression hypothesis)

The situation is different under a frictional setting. The reason is that frictions are a source of monopsony power for employers and that wages are below marginal productivity (see Manning (2003b)). Clearly, there is potential for redistribution of rents without necessarily altering employment. Do labor unions purely redistribute rents from the firms to the workers or do they cause structural unemployment as well? I show that the answer to this question is ambiguous and that the discussed model variants yield different results. I obtain mostly zero employment effects. In one case the minimum wage generates positive employment effects, because the minimum wage does not alter the incentive of the firm to employ individuals but the wages are more likely to be above the reservation wage.

Building on new information theoretic models and on the "change of paradigm in economics" (Stiglitz (2002), p.460), the basic hypothesis of this paper is that market frictions are an important phenomenon of the labor market and therefore that the neo-classical model is insufficient in describing the labor market. I focus on search frictions as a source of incomplete information. Information is symmetric and incomplete and the process of generating information is time-consuming. A main difference to neo-classical models is that identical workers can earn different wages. The source of wage dispersion is then not necessarily the marginal productivity but search duration and luck in a frictional market. This is an alternative model of endogenous wage formation and equilibrium unemployment even in the absence of state institutions and allows an alternative view on the influence of labor unions on wages and employment. (frictional hypothesis)

If individuals possess all the relevant information, i.e. if they know all potential employers and know the wage they would obtain, wage-maximizing individuals would always work for the firm with the highest wage. Thus, firms pay the workers their marginal products. The law of one price holds. But, it is more realistic to assume that information about jobs and wages has to be generated in a time-consuming and costly process. Then, workers might earn different wages in different firms. This is the basic idea behind search theories. The information decision of the individuals depends on the wage offer distribution, while the wage setting of the firms depends

[2] This assumption can be justified by the fact that wages cannot fall below negotiated union wages but they can be and are often higher (see Franz (2006), chapter 7).

on the information decision of the individuals. For tractability reasons, basic search theories assume that individuals are identical in their relevant characteristics. In addition their marginal productivity is assumed constant. Under some assumptions an endogenous equilibrium wage distribution for identical employees can be derived. A central result of these theories challenges the neo-classical framework: rising wage dispersion is associated with rising unemployment. Low wage dispersion is associated with low unemployment. This contradicts the basic idea of the union compression hypothesis.[3]

To put it somewhat stronger: in this framework labor unions have in general no influence on unemployment. From the point of view of this theory the labor market is characterized by monopsony power of the firms, so that it might even be desirable from a normative point of view that unions exist, since their minimum wages do not affect employment but redistribute simply monopsony rents from the employers to the employees.[4] Here, unemployment and wage dispersion are simultaneously determined by the amount of search frictions, as long as the minimum wage of the labor unions does not exceed marginal productivity.[5]

In what follows, I present different search models of increasing complexity and examine the effect of labor unions on wages and employment. Since heterogeneity is an important feature of labor markets, a focus lies on the integration of heterogeneity in search models. In the following section, I present some stylized facts, that should be accounted for by the theory. Subsections 2.3.1 and 2.3.2 establish the theoretical basis on which most models are built upon. In subsection 2.3.1, I present basics from partial search theory with exogenous wage dispersion and derive the reservation wage property. In subsection 2.3.2, I establish the baseline model, a model with an endogenous wage distribution and homogeneous individuals and firms. In order to introduce heterogeneity in the model, I look at model extensions that allow heterogeneity on one or the other side of the market and which serves to check the sensitivity of the results of the baseline model.

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[3] This idea is taken as a test between the frameworks presented in Weiss and Garloff (2005).

[4] Search frictions are not the only source of monopsony power. For a more extensive treatment of monopsony power, compare Manning (2003a).

[5] In principle this is not so much different in neo-classical models: employment only reacts if the minimum wage exceeds marginal productivity. The difference, however, is that a binding minimum wage in the sense that some individuals are paid below this wage means always that this wage exceeds marginal productivity of a part of the employees, which implies a reaction of employment.

Table 2.1: Heterogeneity in search models

	Frictions	Endogenous Wage Dispersion	Heterogeneity of employees	Heterogeneity of firms
Neo-classical Model Framework	-	X	X	-
Partial search theory	X	-	X	X
Burdett and Mortensen (1998)	X	X	-	-
Burdett and Mortensen (1998) with continuous search costs, Van den Berg and Ridder (1997)	X	X	X	-
Bontemps, Robin, and Van Den Berg (2000), Acemoglu und Shimer (2000)	X	X	-	X
Postel-Vinay and Robin (2002b), Holzner and Launov (2005)	X	X	X	X

2.2 Stylized facts

Wage dispersion is a central attribute of free market economies. It is important to understand whether different wages originate indeed in different productivities of individuals and firms or whether search frictions cause severe deviations from the law of one price. Human capital theory concentrates on the human capital equipment of individuals. Instead, wage regressions that control for a wide variety of demographic and firm variables rarely explain more than 50% of the variance of the wages (see Van den Berg (1999)). On the other hand search models concentrate exclusively on the effect of search frictions, which is not sufficient either. If one tries to explain the variance of wages, at least the following three factors are necessary: the first and probably most important is the productivity of the individuals, the second factor that causes wage dispersion are different firm characteristics (see Abowd, Kramarz, and Margolis (1999)). Finally, search frictions must be taken into account, since they explain a considerable amount of the variance of the wages (see e.g. Postel-Vinay and Robin (2002b)).

Empirical wage distributions in a cross section are skewed to the right. A model with an endogenous wage distribution should be able to reproduce this. The theory of marginal productivity pay allows for wage distributions that are skewed to the right, provided that marginal productivities are skewed to the right. The baseline search model instead, implies a density that is increasing on the entire support (see below). But, a mixture of such wage distributions of homogeneous segments can replicate a wage distribution that is skewed to the right (see below). In addition, it is demonstrated in section 2.4.2, that models which allow different productivities across firms are also capable to produce such wage distributions.

A further well documented fact is that large firms pay on average higher wages controlling for human capital (see e.g. Katz, Summers, Hall, Schultze, and Topel (2005), Abowd, Kramarz, and Margolis (1999) and Cahuc and Zylberberg (2001), p.70f.). From the point of view of the neo-classical framework, wage differentials between firms should reflect productivity differentials; but these differences themselves are not easily explained in this framework. Firms with low productivity should be driven out of the market, at least in the long run. Search theory assumes another perspective. First, wage differentials do not reflect necessarily productivity differentials, but might originate from a trade-off between the number of employees and the profit per employee. Second, search frictions imply a certain degree of monopsony power for firms which means that less productive firms are not necessarily driven out of the market. Models that are based on search frictions imply indeed that big firms pay higher wages and therefore account for this stylized fact.

Hazard rate models are concerned with the determinants of the duration in certain labor market states. A huge part of this literature cares about the individual determinants of the duration in unemployment. Important variables are beyond others the level and the length of unemployment benefits. Yet, the static theory of marginal productivity pay gives little advice, which variables matter, whereas dynamic search theory explicitly models hazard rates depending on covariates. This is one of the most important fields of application of search theory (see Devine and Kiefer (1991), Eckstein and Van den Berg (2007) for surveys). Stylized facts are that the level of unemployment benefits is less important than the duration of entitlement (see Cahuc and Zylberberg (2001), p.74f.) and that job offers are rarely rejected by unemployed individuals (ibid., p.77 and Van den Berg (1999), p.F290). I will show that search models partly accommodate this facts.

Elderly individuals earn in general more than younger individuals (Topel (1991)) and wage dispersion is higher (Neal and Rosen (2000)). Further it can be observed that senior individuals change jobs less often than their younger counterparts (Fitzenberger and Garloff (2005a)). These facts can partly be explained by both theories. Theories that are based on marginal productivity pay postulate that employees accumulate human capital on the job (experience), which they are paid for (Becker (1973)). In addition they often accumulate human capital that is only useful in the firm where they work (specific human capital). Then, if on average people have more specific capital if they are older, they will change jobs less often. If wage dispersion rises with age, this might be the case since individuals have different learning efficiencies in acquiring human capital. Search theories explain the same facts by using a different argumentation. If employees obtain job offers from competing employers, then individuals that are older have obtained on average more job offers and have changed jobs more often than the younger ones. Thus, they gain more and change jobs less often since job offers from competing employers rarely exceed their wage. However, wage dispersion for elderly individuals should then be lower.

Finally, the search framework offers a *common* theory of labor market transitions and wage dispersion. Equilibrium wage dispersion and equilibrium unemployment depend on the transition rates. We construct such connections in Fitzenberger and Garloff (2005b) in the neo-classical framework as well. However, there, causality is reversed and we argue that wage dispersion affects the transition rates. In the empirical application we show that neither direction is convincingly found in the data.

2.3 Frictional labor markets

2.3.1 Exogenous wage dispersion: basic results

First, I present the partial search model, where the behavior of the firms is not modeled. Starting point from search theory is that working places are in some relevant way heterogeneous. From the point of view of the job searching individuals there is an information problem which can be decomposed in two subproblems: the search problem and the choice problem. The search problem consists in choosing means how to search for jobs and how information about jobs is generated. Since search is time-consuming and costly, it is impossible to collect all information and the agents have to compare the costs of acquiring information with the expected benefits. The choice problem consists in choosing criteria under which the job is chosen under a given information situation.

The search problem is modeled, hereafter, by an exogenous hazard rate at which individuals receive job offers. The complex choice problem is reduced to one dimension. Job seekers maximize the present value of their lifetime income: the wage is the only relevant characteristic of the job. The optimization problem of the job seeker to get as high as possible a wage, without searching too long will be solved explicitly. Under the Poisson assumption search is sequential and optimality is guaranteed by a critical wage level, where wage offers above are accepted and wage offers below are rejected. The critical wage is called reservation wage. The expected search duration that depends obviously on the reservation wage determines the expected wage level. Wages that differ across individuals can be explained by the luck of a high wage offer and by different reservation wages.

The following illustration is inspired by Cahuc and Zylberberg (2001) (chapter 1.2) and Franz (2006) (chapter 6.2).

Assumptions

The assumptions under which the reservation wage property and the reservation wage can be deduced are concluded in what follows.

- (A0) Environment: The model is dynamic, time will be treated as continuous and the environment is stationary.
- (A1) Employees: Individuals exclusively either work or search, which precludes both on-the-job search and the existence of inactive individuals. There is no choice in the number of hours worked or searched. Individuals are risk-neutral, have rational expectations and maximize expected present value of their life time income over an infinite time horizon. Job seekers obtain $z = b - a$ per time unit, where b are unemployment benefits and a search costs. Employees obtain a wage w per time unit. The value of unemployment is called W_U (the expected income), while $W_L(w)$ is the value of employment at the wage w.[6] The wage offer distribution $H(w)$ is constant over time and is known to job seekers, while the offered wage of a specific firm is generally not known.[7]
- (A4) Search: Search is sequential, which means that if an individual has received an offer, he decides whether to accept or not and then in the case of rejection, i.e. if the wage offer is below the reservation wage w_R, continues search.[8] This is an optimal stopping problem, since job offers that have been rejected once cannot be accepted later on. The future is discounted at interest rate r.

[6] $W_L(w)$ and W_U are called value equations, which stem from the theory of dynamic programming. Often these equations are also termed Bellmann-equations. Its principal idea is that the optimization problem of an individual over an infinite time horizon can be described in formulating the optimal decision in one specific point of time, given the individual acts optimal in all other time periods. In the case of a job seeker it is the decision to accept or reject a job offer at a certain point in time, depending on which choice optimizes the expected life time income. (see also Dixit (1990), chapter 11)

[7] The wage offer distribution is the distribution of wages when randomly drawing a firm, whereas the wage distribution is the distribution of wages when randomly drawing a worker.

[8] I assume sequential search, since it has been shown that sequential search is superior to fixed sample search (see McCall (1965)).

- (A6) Transition rates: At an exogenous, constant rate λ an individual samples independent wage offers from $H(w)$. Individuals leave unemployment at a rate that is the product of the job offer rate and their acceptance probability. Employees loose their job at the exogenous, constant rate δ (the job destruction rate). The number of sampled job offers and the number of terminated jobs are poisson-distributed.

The basic model

The value of employment $W_L(w)$ at wage w can be derived as follows. In a small time interval[9] dt a worker obtains the wage wdt. With probability δdt the worker looses its job in this time interval. If losing the job the worker is left with value W_U. With the complementary probability $(1-\delta dt)$ the worker remains employed. Under stationarity the value of employment is constant over time and therefore the worker is left with $W_L(w)$. In case of linear discounting, the Bellmann-equation is:

$$\begin{aligned} W_L(w) &= \frac{1}{1+rdt}\left\{wdt + \delta dt W_U + (1-\delta dt)W_L(w)\right\} \\ rW_L(w) &= w + \delta(W_U - W_L(w)). \end{aligned} \tag{2.1}$$

The second line can be found multiplying by $(1 + rdt)$, subtracting $W_L(w)$ and dividing by dt. The return to the value $W_L(w)$ in capital market must equal the return to employment $w + \delta(W_U - W_L(w)$ and, therefore, can be interpreted as no-arbitrage condition.[10] Per definition the reservation wage is the critical wage above which a job offer is accepted. Therefore, the value of employment at the reservation wage must equal the value of unemployment. Rewriting 2.1 as $W_L(w) - W_U = \frac{w - rW_U}{r+\delta}$, taking into account that $\frac{\partial W_L(w)}{\partial w} = \frac{1}{r+\delta} > 0$ and that W_U is independent from the wage previously paid, then w_R is a unique solution to $W_L(w_R) = W_U$ and is given from $w_R = rW_U$ as the reservation wage.[11]

The value of unemployment can be calculated as follows. Job seekers obtain $z = b - a$ per time unit. At poisson rate λ job seekers obtain job offers w as independent draws from $H(w)$. If an individual gets a job offer, the expected value is given by W_λ which consists in two components. The first component is the share of job offers that the job seeker rejects since the wage is below

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[9] The small time interval must be chosen such that the poisson probability that two events occur in that time interval is zero.

[10] The investment of the value $W_L(w)$ in the labor market should yield no expected gain or loss as compared to its investment in the capital market. In the strict sense arbitrage means risk-free profits. Therefore, the interpretation as no-arbitrage condition is only correct because of the assumption of risk-neutrality. Employment is risky (δ) and therefore if people were risk-averse they should be paid for that risk.

[11] Of course, the value of unemployment depends on the expected wage of a future job.

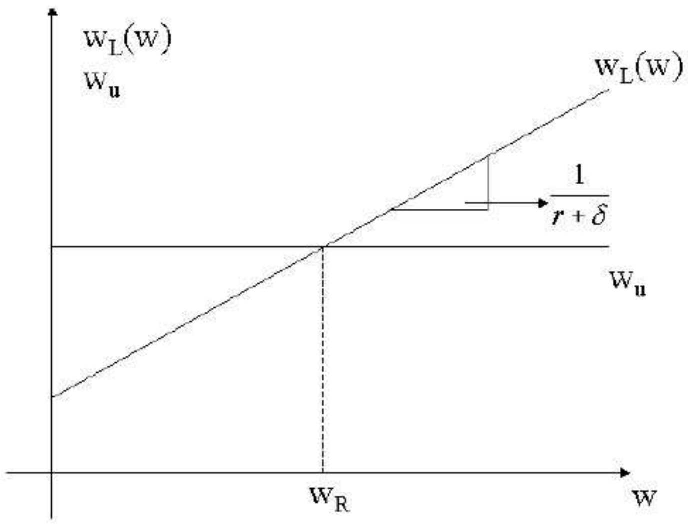

Figure 2.1: Calculation of the reservation wage

the reservation wage $H(w_R)$ multiplied by the corresponding value of rejection W_U. The second part is the complementary probability, multiplied by the average value of an accepted job offer:

$$W_\lambda = H(w_R)W_U + (1 - H(w_R))E_w[W_L(w)|w > w_R] = \int_0^{w_R} W_U dH(w) + \int_{w_R}^{\infty} W_L(w)dH(w). \tag{2.2}$$

With probability $(1 - \lambda dt)$ the job seeker does not obtain a job offer in dt. The value in this case remains $W_U = W_{\bar{\lambda}} = \int_0^\infty W_U dH(w)$ because of stationarity. The probability that an individual obtains more than one job offers in dt is zero, because of the Poisson assumption. Using this:

$$\begin{aligned} W_U &= \frac{1}{1+rdt}(zdt + \lambda dt W_\lambda + (1 - \lambda dt)W_U) \\ rW_U &= z + \lambda \int_{w_R}^{\infty} (W_L(w) - W_U)dH(w). \end{aligned} \tag{2.3}$$

The second line follows solving the equation for rW_U and resuming the remainder under an integral. In analogy to equation (2.1) this equation too, can be interpreted as no-arbitrage condition.

Recognizing that $W_L(w) - W_U = \frac{w - rW_U}{r+\delta}$ and $w_R = rW_U$ the reservation wage is implicitly defined as:

$$w_R = rW_U = z + \frac{\lambda}{r+\delta}\int_{w_R}^{\infty}(w - w_R)dH(w) = z + \frac{\lambda}{r+\delta}[(1 - H(w_R))(E(w|w > w_R) - w_R)]. \quad (2.4)$$

Subtracting z on both sides of the equation, the left hand side is the instantaneous cost of rejecting a wage offer w_R. At the reservation wage the cost of waiting must equal the expected gains from waiting. It is given by the probability that a job seeker obtains a wage offer that is acceptable $\lambda(1 - H(w_R))$, multiplied with the discounted conditional expectation of the wage given it exceeds the reservation wage (see Devine and Kiefer (1991), p.16/23).

Optimal behavior of the individuals is completely described by equation (2.4). A job seeker with net income z, who is confronted with a job offer rate λ, with a job destruction rate δ, with an interest rate r and a wage offer distribution $H(w)$ will accept any job offer that exceeds w_R and reject otherwise.

On-the-job search

Hereafter, I will present a first extension of this basic model, which integrates on the job search in the partial model. For further extensions as e.g. the decision of an individual to work or not or as the influence of benefit claims, the reader is referred to Cahuc and Zylberberg (2001). However, I present this extension in detail since it is empirically important (see e.g. Franz (2006)) and since I need the results in later parts of this paper. I assume that job seekers do not have search costs ($a_L = 0$) and that they are confronted with an exogenous job offer rate λ_L.[12] The assumptions (A0), (A1'), (A4) and (A6) are assumed to hold where:

- (A1'): as (A1), but: Employees search on the job, receive independent job offers at constant exogenous rate λ_L from the wage offer distribution $H(w)$ and do not have search cost.

One term must be added to the return to employment equation (2.1), which reflects the expected gain from a job change. An employee accepts all job offers that exceed its own wage $\bar{w}$ (Mortensen and Neumann (1988)). It follows:

$$rW_L(\bar{w}) = \bar{w} + \delta(W_U - W_L(\bar{w})) + \lambda_L \int_{\bar{w}}^{\infty}(W_L(w) - W_L(\bar{w}))dH(w). \quad (2.5)$$

[12] The subscript L always confers to the employed individuals.

The return to unemployment is still given by equation (2.3). Evaluating equation (2.5) at w_R, equalizing $rW_L(w_R)$ with (2.3) and solving for w_R yields:

$$w_R = z + (\lambda - \lambda_L) \int_{w_R}^{\infty} (W_L(w) - W_U) dH(w). \tag{2.6}$$

Equation (2.6) can be rewritten in terms of the parameters of the model (see appendix B.1):

$$w_R = z + (\lambda - \lambda_L) \int_{w_R}^{w^o} \frac{1 - H(w)}{r + \delta + \lambda_L(1 - H(w))} dw. \tag{2.7}$$

Intuitively, the possibility to search on the job lowers the reservation wage, since this opens the possibility to accept a low paid job and to search further on the job. If the chance to get a good job is independent on the job seekers status ($\lambda_L = \lambda$) unemployed job seekers will accept every job offer that exceeds net unemployment benefits z. With the characterization of the reservation wage for unemployed job seekers and the critical wage for employed job seekers, optimality in the behavior of the individuals is guaranteed. Unemployed job seekers accept every wage offer that exceeds w_R and continue searching otherwise, while employed job seekers accept every job offer that exceeds their current wage and continue working in their current job otherwise.

The reservation wage increases with unemployment benefits b with the probability to obtain a job offer when unemployed λ, decreases with search cost a, the probability to obtain a job offer when employed λ_L, the interest rate r and with the job destruction rate δ. Given the impact of the parameters on the reservation wage, the impact of the parameters on the average unemployment duration can be calculated, which increases itself with the reservation wage.

In the following subsection, I present a model of endogenous wage dispersion for (ex-ante) homogeneous individuals and firms.

2.3.2 Endogenous wage dispersion - the baseline model

A necessary condition for the existence of equilibrium wage dispersion is a positive connection between wage level and output. There are two arguments of why there could be such a positive connection. First, heterogeneities could explain such a positive connection if either high wages attract more productive individuals or if more productive firms pay higher wages. Second, it is possible that there is equilibrium wage dispersion across c.p. homogeneous workers and firms. If firms have monopsony power, firms make positive profits per employee. If firms can attract additional workers by setting high wages, there exists a trade-off between profits per worker and the number of workers in a firm. This means that there is indeed a positive connection between wages and production. The model of Burdett and Mortensen (1998) is based on this idea.

The depiction is based on Cahuc and Zylberberg (2001) (p.66ff.) and on Mortensen and Pissarides (1999) (p.2612ff.). On-the-job search is central for the existence of equilibrium wage dispersion, since this implies that part of the job seekers, namely the employed, can compare wages, a necessary condition for equilibrium wage dispersion (see Burdett and Judd (1983)). They compare their own wage with the wage of an arriving job offer. Then, high wage firms attract many new workers from competing firms, while loosing only little. As a result they have a high employment, making low profits per employee. On the contrary low wage firms have a low employment level, thereby making high profits per worker.

The assumptions of the model are given by (A0), (A1"), (A2), (A3), (A4), (A5) and (A6), where:

- (A1"), as (A1'), but all N individuals produce an identical amount y of the consumption good per time unit, which can be interpreted as labor productivity, where $y > w_R$ holds and z is identical across all unemployed individuals.
- (A2) firms: An infinite amount of risk-neutral, c.p. identical firms on an interval $[0, 1]$ maximizes profits. There is nor market entrance or exit.
- (A3) wage formation: Firms determine wages ex ante from their profit maximization calculus.[13] This wage is payed forever, provided that the match does not end.
- (A5) economy: Small open economy with two goods and an exogenous interest rate r. The consumption good C is produced without capital (or with identical capital endowment in firms without depreciation) and marginal productivity of labor is constant. The price of the consumption good is the numéraire, while w is the price of labor.

Starting with the reservation wage for the unemployed, it is given by equation (5.1), where I assume for simplicity that $r = 0$. Employed job seekers accept every wage offer that exceeds their current wage. Equilibrium unemployment follows from stationarity and from equating in- and outflows to and from the pool of unemployed. In a small time interval dt $\lambda dt(1 - H(w_R))U$ unemployed individuals find a job, while $\delta dt(N - U)$ employees loose their job. Dividing by dt and building the limit for $dt \to 0$, I obtain $\dot{U} = \delta(N - U) - \lambda(1 - H(w_R))U$. Since firms that offer wages below the reservation wage make zero profits and since, as I will show, in equilibrium all firms make positive profits $H(w_R) = 0$ holds. Therefore equilibrium unemployment is

$$U = \frac{\delta N}{\delta + \lambda(1 - H(w_R))} = \frac{\delta N}{\delta + \lambda}. \tag{2.8}$$

[13] Since firms determine wages ex-ante, it is possible that there is a meeting between agents where cooperation is profitable but where the match is not formed. Such a situation is called non-transferable utility.

Let $g(w)$ denote the density of the distribution of paid wages. The equilibrium employment of *one* firm that offers wage w is given by $l(w) = (N-U)g(w)/h(w)$. Then, $L(w) = (N-U)G(w) = \int_0^w l(\zeta)dH(\zeta)$ is the amount of employees, that is employed at a wage below w and $G(w)$ is the distribution of paid wages. Now, concentrating on employment changes in firms in an interval dt that offer (and pay) wages above w, they have inflows from the pool of unemployed and from firms that pay wages below w, while they loose employees only through exogenous job destruction. Employees that make a job-to-job transition remain in this wage class. Unemployed job seekers obtain a wage offer with probability λdt which exceeds with probability $(1-H(w))$ the wage w. Individuals that are employed at a wage below w obtain with probability $\lambda_L dt$ a wage offer that exceeds w with probability $(1-H(w))$. From this, total inflows are $\lambda dtU(1-H(w)) + \lambda_L dtL(w)(1-H(w)) = dt(\lambda U + \lambda_L L(w))(1-H(w))$. With probability δdt exogenous shocks destroy existing jobs. The amount of jobs in firms that pay wages above w is given by $N-U-L(w)$. In equilibrium, employment in firms that pay wages above w is constant because of the stationarity assumption.

Using stationarity and solving for $G(w) = \frac{L(w)}{N-U}$ yields:

$$G(w) = \frac{\lambda U}{(N-U)} \frac{H(w)}{(\lambda_L(1-H(w))+\delta)} = \frac{\delta H(w)}{(\lambda_L(1-H(w))+\delta)}. \tag{2.9}$$

The second equality follows from using equation (2.8). It shows the connection between the distribution of wage offers $H(w)$ across firms and the distribution of paid wages in a cross section of workers $G(w)$. [14] Since $L'(w) = l(w)h(w)$, equilibrium employment in firms that pay wage w, is given by:

$$l(w) = \frac{\lambda U(\lambda_L+\delta)}{(\lambda_L(1-H(w))+\delta)^2} = \frac{\lambda\delta N(\lambda_L+\delta)}{(\lambda_L(1-H(w))+\delta)^2(\delta+\lambda)} = \delta(N-U)\frac{(\lambda_L+\delta)}{(\lambda_L(1-H(w))+\delta)^2}. \tag{2.10}$$

Because of higher inflows and smaller outflows, employment grows with the wage: $l'(w) > 0$. Thus, there is a positive connection between the wage level and the output level of firms. In equilibrium, every firm pays a wage from the support of the equilibrium wage offer distribution and makes expected profits of $\Pi(w) = (y-w)l(w) = \frac{\lambda\delta N(y-w_R)}{(\delta+\lambda_L)(\delta+\lambda)}$ (see appendix B.2), which are strictly positive. The wage offer density $h(w)$ is defined on the support $[w_R, w^o]$, where $w^o = y - (y-w_R)\left(\frac{\delta}{\delta+\lambda_L}\right)^2$(see appendix B.2).

Taking into account that $\Pi(w) = \Pi(w') = (y-w)l(w)\ \forall(w,w') \in [w_R, w^o]$[15] and equating the profit at the reservation wage with an arbitrary wage from the support of the wage offer

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[14] These are different, since workers climb the job (wage) ladder through job-to-job transitions in the course of their career.

distribution, one obtains $(y-w)\frac{\lambda U(\lambda_L+\delta)}{(\lambda_L(1-H(w))+\delta)^2} = (y-w_R)\frac{\lambda U(\lambda_L+\delta)}{(\lambda_L+\delta)^2}$. Solving for $H(w)$ yields the equilibrium wage offer distribution.

$$H(w) = \left\{ \begin{array}{cc} 0 & \text{für } w < w_R \\ \frac{\lambda_L+\delta}{\lambda_L}\left(1-\sqrt{\frac{y-w}{y-w_R}}\right) & \text{für } w_R \leq w < w^o \\ 1 & \text{für } w \geq w^o \end{array} \right\} \tag{2.11}$$

The distribution H does not contain mass points, i.e.[16] $\Pr\{W=w\}=0$ for all $w \in \{w_R, w^o\}$ (see Mortensen and Pissarides (1999), p.2615f).

To show that this wage distribution is indeed the unique equilibrium distribution of wage offers, it remains to show that wages outside the support of $H(w)$ imply strictly lower profits for the firms (see Mortensen and Pissarides (1999), p.2615). It has been shown above, that the profit of firms in equilibrium is strictly positive. This confirms that wages below w_R cannot be an equilibrium (zero profit). If on the other side a firm offering w^o chooses to pay a wage $w^o+\varepsilon$, it cannot attract more workers, but profits are decreasing. This can be seen from equation (2.10) and using that $H(w^o)=1$. w_R is the lower limit of the support, since otherwise a firm offering the lowest paid wage w could increase profits in lowering their paid wage to $w-\varepsilon$, which would increase profit per worker but would not alter the employment of the firm. With an induction argument, one shows easily that the density of the wage offer distribution is strictly positive on the support: $h(w) > 0$, $\forall w \in [w_R, w^o]$ (see Ridder and Van den Berg (1997), p.101).[17]

The corresponding density can be calculated as $h(w) = H'(w) = \frac{\lambda_L+\delta}{2\lambda_L}\sqrt{\frac{1}{(y-w_R)(y-w)}}$ and is increasing in w. Plugging $H(w)$ in equation (5.1) yields an expression for the reservation wage for this wage distribution: $w_R = \frac{(\delta+\lambda_L)^2 z+(\lambda-\lambda_L)\lambda_L y}{(\delta+\lambda_L)^2+(\lambda-\lambda_L)\lambda_L}$. The reservation wage is a weighted mean

[15] This is the case, since otherwise the result cannot be an equilibrium. If profits were different for different wages, then low-profit firms would have an incentive to change their paid wage, since by assumption all firms are identical.

[16] In this equation W does not stand for a value equation, but is a random variable, while w is a realization of this random variable. The fact that the distribution does not contain mass points can be justified by the fact that no wage from the wage distribution is paid with positive probability. This is the case since if a wage is paid with a positive probability, then firms that pay that wage w have an incentive to pay a wage $w+\varepsilon$ for $\varepsilon \to 0$. This would increase their labor costs only marginally while employment $l(w+\varepsilon)$ would be discretely higher (see Varian (1980), p.653/658f., Bontemps, Robin, and Van den Berg (2000), p.314 and Acemoglu and Shimer (2000), p.590).

[17] If several firms have paid the lowest wage before the departure from one firm from the lowest price, the deviating firm has employment losses. However, this is an unlikely event in the sense that the probability that several firms pay the same wage is zero (see the above discussion of mass points) and therefore the expected loss of employees is zero. Second there would be an incentive for all other firms too to deviate from the original wage. With the induction argument that after the price decrease to w_R of the first firm it would be worthwhile for the firm with the second lowest price to lower its price to a price just above the reservation wage, one can justify that the reservation wage is indeed the lower limit of the support and that the support must be connected, i.e. $h(w) > 0$, $\forall w \in [w_R, w^o]$.

of the net unemployment benefits z and the labor productivity y (see Mortensen and Pissarides (1999), p.2614).[18] If individuals cannot change jobs ($\lambda_L = 0$) the reservation wage equals z and $w^o = w_R$ and one obtains the Diamond (1971) solution. If on the other hand the job offer rate on the job becomes big ($\lambda_L \to \infty$), then the frictions vanish and the wage offer distribution collapses to a mass point at y. The same is true if there is no job destruction $\delta = 0$ or no search friction for the unemployed $\lambda \to \infty$ (that is no unemployment).[19] For all intermediary cases ($0 < \lambda_L < \infty$, $U > 0$) the wage offer distribution has a positive variance. The monopsony power of the firms depends of the degree of the friction. The higher the friction, i.e. the lower λ_L and the higher δ, the higher is the monopsony power of the firms and the lower is the average wage. The wage dispersion also depends on these parameters and under some parameter restrictions is increasing in the degree of friction (see Van den Berg and Ridder (1993)).

Discussion

The first remarkable point of this model is, that it generates an equilibrium wage dispersion across identical individuals. Further it gives a justification of the empirical fact that big firms pay higher wages than small firms and that senior workers gain on average more than their junior counterparts. Problematic is however that the density of the distribution of paid wages $G'(w) = \frac{\delta(\lambda_L+\delta)h(w)}{[\delta+\lambda_L(1-H(w))]^2}$ increases in w, which is difficult to reconcile with observed wage distributions. In addition empirical studies point to the fact that this explanation of wage dispersion, i.e. monopsony power of firms through frictions in connection with on the job search is able to explain only a small part of the variance of an empirical wage distribution (see Van den Berg and Ridder (1998), p.1212 and Bontemps, Robin, and Van den Berg (2000), p.348f.).

Voluntary unemployment does not exist in this model. This result follows from the homogeneity assumption: each individual is a good allocation for each vacancy and vice versa. This result holds as long as wages are below marginal productivity, a typical result in search equilibrium models. This implies that a binding minimum wage does not affect unemployment as long as the marginal productivity exceeds the minimum wage.[20] Employers respond on an increase or the

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[18] If the discount rate r is positive, the reservation wage formula can be generalized to $w_R = \frac{(\delta+\lambda_L)^2 z+\delta(\lambda+\lambda_L)y\tau}{(\delta+\lambda_L)^2+\delta(\lambda+\lambda_L)\tau}$, where $\tau = \frac{\lambda_L}{\delta} - 2\frac{r}{\delta} + 2\frac{r(\delta+r)}{\lambda_L\delta}\ln\left(1+\frac{\lambda_L}{\delta+r}\right)$ (see Bontemps, Robin, and Van den Berg (2000), p.314).

[19] That is also intuitive, since, in the case of no unemployment, the firm with the lowest wage looses its workers at rate λ_L while it does not gain any new workers, which implies zero employment in the long run. This argument can be traced up to marginal productivity as equilibrium wage.

[20] Obviously, the same is true in the neo-classical model of the labor market. But if a minimum wage is binding, there are always people whose marginal productivity is below this minimum wage, since everybody is paid its marginal productivity. So, the central point is that, under the search-theoretic perspective, people are not paid their marginal productivity, and therefore a binding minimum wage does not necessarily mean higher unemployment.

introduction of a binding minimum wage by raising their wage offers. This reduces the profit of the firms, but not labor demand since the profit is positive for each individual employed.

There is empirical evidence that indeed the unemployed accept every job offer, which is a central result of the model above. Many studies estimate an acceptance probability of almost one: "Il apparaît que la première offre d'emploi reçue est pratiquement toujours acceptée"(Cahuc and Zylberberg (2001), p.77; see also Van den Berg (1999), p.F290). But this means that the mechanism that explains voluntary unemployment in the partial search model is not central for understanding unemployment. From this point of view unemployment is involuntary.

An increase in the binding minimum wage alters the complete wage distribution. It is likely that the expectation increases and that the variance decreases. Unemployment does not change. A similar effect is obtained for an increase in unemployment benefits in the absence of a minimum wage. It does in general affect neither unemployment duration nor the unemployment stock. An increase leads to an increase of the reservation wage of the unemployed, which firms counter with higher wage offers. The unemployed accept any wage offer they obtain. This are interesting results, compared to the neo-classical framework: an increasing (labor union) minimum wage or increasing unemployment benefits compress the wage structure but are employment neutral.

A reverse connection can be constructed from this model: a wage distribution with a big variance is associated with high unemployment. Both phenomena have the same causes, namely a high degree of labor market frictions (low job offer rates, high job destruction rates).

Clearly, a major drawback of this model is the homogeneity assumption. Note however that Jolivet, Postel-Vinay, and Robin (2006) (p.1) conclude from an empirical implementation of the homogeneous search model in a cross country comparison that the "(...) model fits the data surprisingly well".

2.4 Heterogeneity

In reaction on the drawback of the homogeneity assumption, several models have been developed that introduce heterogeneity on either side of the market in the basic equilibrium search model. For individuals heterogeneity can take the form of different reservation wages caused by differences in search costs or different productivities. For firms the effect of different productivities has been examined.

2.4.1 Different search costs

In this subsection I present a model extension that allows for different search costs across unemployed job seekers (see Burdett and Mortensen (1998)). If unemployed job seekers have different search costs a, then z varies conditional on b.

First, notice that compared to the basic model different search costs have no effect on labor demand. Because of identical productivity every (or no) match is profitable. But there is an effect on offered and paid wages and therefore an effect on the behavior of the job seekers. Intuitively this is the case, since for firms in this case it might be profitable to offer wages below the reservation wage of a part of the unemployed. Provided that the offered wage is still above the reservation wage of some individuals, a firm has still positive inflows and therefore a positive number of employees. Then, for unemployed not every contact with a firm means at the same time a profitable match. This is true, although the match is potentially profitable.

The resulting wage distribution combines the effect of the informational imperfection with the effect of the heterogeneity in search costs. On the one hand, the wage distribution compensates the job seekers for its different search costs. On the other hand firms differ in size and they have to pay different wages to ensure their size.

The model

Assumptions (A0), (A1"'), (A2'), (A3), (A4), (A5) and (A6) hold, where:

- (A1"'), as (A1"), but N individuals differ in their search costs. Their net search costs z follow a continuous distribution on $[\underline{z}, \bar{z}]$, where $R(z)$ is the share of individuals whose search costs are below z. $r(z)$ is the corresponding density. In addition $\lambda_L = \lambda$ holds.
- (A2'), as (A2), but firms know the distribution $R(z)$, but cannot observe z individually.

Different reservation wage policies across individuals are a consequence of the assumption of different net search costs. Note that (A1"') implies that $w_R = z$. Then, equating in-and outflows to and from unemployment yields the equilibrium unemployment rate for any z-type. It is given by $U_z = \frac{\delta N r(z)}{\delta + \lambda[1-H(z)]}$.

The optimal behavior of the firm can be deduced as follows. The amount of unemployed that accepts a wage offer w is given by:

$$S(w) = \int_{\underline{z}}^{w} \left(\frac{\delta N r(z)}{\delta + \lambda[1 - H(z)]} \right) dz = \int_{\underline{z}}^{w} \left(\frac{\delta N}{\delta + \lambda[1 - H(z)]} \right) dR(z). \tag{2.12}$$

Let $G(w)$ be the distribution of paid wages, then $L(w) = (N - S(\bar{z}))G(w)$ is the amount of employees that are employed at a wage below w.[21] In equilibrium, employment must remain constant in firms that pay wages below w. Inflows to this group of firms stem only from unemployment. $dS(z)$ unemployed z-individuals obtain an acceptable job offer below w with probability $H(w) - H(z)$. Thus, expected inflows are $\lambda \int_{\underline{z}}^{w} (H(w) - H(x))dS(x)$. Outflows are composed of job destruction δ and of offers from better paying competitors $\lambda(1 - H(w))$ to employees in this wage group $(N - S(\bar{z}))G(w)$. Taken together:

$$(\delta + \lambda[1 - H(w)])(N - S(\bar{z}))G(w) = \lambda \int_{\underline{z}}^{w} (H(w) - H(x))dS(x).$$

Solving for $L(w)$ and differentiating with respect to w, after some simplifications[22] the equilibrium employment in a firm, offering the wage w is given by:

$$l(w) = \frac{(N - S(\bar{z}))G'(w)}{h(w)} = \frac{\lambda\delta N R(w)}{(\delta + \lambda[1 - H(w)])^2}.$$

The wage offer distribution can be derived from the equality of profits $\Pi = (y - w)l(w)$ on the support of $H(w)$ in equilibrium. Let $\underline{w}$ be the lower bound of the support, then $(y - \underline{w})\frac{\lambda\delta N R(\underline{w})}{(\delta+\lambda)^2} = (y - w)\frac{\lambda\delta N R(w)}{(\delta+\lambda[1-H(w)])^2}$ holds and it follows:

$$H(w) = \frac{\delta + \lambda}{\lambda}\left[1 - \sqrt{\frac{(y - w)R(w)}{(y - \underline{w})R(\underline{w})}}\right], \text{ für } w \in [\underline{w}, w^o]. \tag{2.13}$$

$\underline{w}$ is the biggest solution to $w = \arg\max_w[(y - w)R(w)]$ and w^o the biggest value that satisfies $\frac{(y-\bar{w})R(\bar{w})}{(y-\underline{w})R(\underline{w})} = \frac{\delta^2}{(\delta+\lambda)^2}$ (see Burdett and Mortensen (1998), p.266).

Discussion

Unemployed individuals in this extension of the basic model do not accept any wage offer they obtain, and their expected unemployment duration depends on their net unemployment benefits. The resulting equilibrium unemployment $S(\bar{z}|H)$ is higher than the unemployment that would result if all firms would pay a wage equal to marginal productivity $S(\bar{z}|w = y)$.[23] In addition

[21] This is true, since $S(\infty) = S(\bar{z})$ is the amount of unemployed that would accept a wage offer of ∞. Since all unemployed individuals would accept such a wage offer, $S(\bar{z})$ is the amount of unemployed over all z-types.

[22] $L(w)$ is given by $L(w) = G(w)(N - S(\bar{z})) = \frac{\lambda \int_{\underline{z}}^{w}(H(w)-H(x))dS(x)}{(\delta+\lambda[1-H(w)])}$.
Using (2.12), $dS(z) = \left(\frac{\delta N}{\delta+\lambda[1-H(z)]}\right) dR(z)$ and $L'(w) = l(w)h(w) = (N - S(\bar{z}))G'(w)$ I find the above $l(w)$ (see Burdett and Mortensen (1998), p.265).

[23] That is always true if $\underline{w} < \bar{z}$.

equilibrium unemployment depends positively on $\frac{\delta}{\lambda}$, an indicator of the amount of frictions in the labor market (see Burdett and Mortensen (1998), p.267). If I assume that $\bar{z} < y$ and that $H(\bar{z}) > 0$, then every match is profitable in principle but not every match is formed when employers and employees meet. This is the case since firms commit ex-ante to pay some wage of the wage offer distribution and since it is optimal for a part of the firms to offer wages below $\bar{z}$.

Still the model implies a counterfactual wage density (see Van den Berg (1999), p.F299). It seems that different reservation wages do not strongly affect the wage distribution. A model allowing for different reservation wages has been estimated by Eckstein and Wolpin (1990). They estimate a model that allows n different z-groups and for heterogeneity across firms. The results of the estimation are not in favor of the model. Although the observed unemployment are accurately described in this modeling framework, the explanation of observed wages is too weak in this model (see Eckstein and Wolpin (1990), p.799f. and Bontemps, Robin, and Van den Berg (2000), p.307).

A labor union minimum wage has several effects. A binding minimum wage does not only change the lower bound of the wage distribution but also the upper bound (see Burdett and Mortensen (1998), p.267). However, since the minimum wage shifts the wage offer distribution to the right and since the reservation wage does in this case not depend on the wage offer distribution, the average unemployment durations will decrease, since on average they obtain more acceptable wage offers; that is unemployment decreases. This is the case since labor demand does not react, whereas job seekers accept job offers more often on average. To sum up, a labor union minimum wage has in this case the counterintuitive effect that unemployment decreases.

2.4.2 Heterogeneity across firms

Suppose now, that the other market side is characterized by heterogeneity: firms vary in their productivity. This subsection is divided in two parts. In the first part I will examine a market that is characterized by search frictions and an exogenous distribution of firm productivities. In the second part, firm productivity is chosen endogenously, e.g. as a decision over the capital equipment of a job.

A priori heterogeneity and endogenous wage dispersion

There exist several models with exogenous, heterogeneous productivity in the search framework. In a competitive setting with constant returns to scale this situation could not persist, since more productive firms would pay higher wages and employees would move immediately to the better paying firm. In a market with frictions however, this is not the case.

The model

The following derivations are based upon Bontemps, Robin, and Van den Berg (2000). I will assume that the assumptions (A0), (A1""), (A2"), (A3), (A4), (A5'), and (A6) hold, where:

- (A1""), as (A1"), but N identical individuals with productivity $\tilde{y}$ produce unequal amounts y of the good C. $y = \tilde{y}t(k)$ is assumed to hold, where $t(\cdot)$ is a positive function of k and displays the following properties: $t'(k) > 0$, $t''(k) < 0$. k can be interpreted as capital intensity in a firm.

- (A2"), as (A2), but there is an amount of M firms, whose capital intensity is distributed according to $\Gamma(k) = \Gamma(y)$. The constant, exogenous random variable K realizes before production starts and has a finite expectation. There is a unique realization of Y that corresponds to each realization of K. Realizations of Y are continuously distributed on the support $[\underline{y}, \bar{y}]$. It is assumed that $\underline{y}$ exceeds the common reservation wage of the employees or an eventually existing minimum wage.

- (A5'), as (A5), but the consumption good C is produced with labor and capital, and there are no depreciations.

Equilibrium unemployment is given by equation (2.8) $U = \frac{\delta N}{\delta + \lambda}$. The reservation wage of the U unemployed is given by equation (5.1) $w_R = z + (\lambda - \lambda_L)\int_{w_R}^{w^o} \frac{1 - H(w)}{r + \delta + \lambda_L(1 - H(w))} dw$, where w^o is the upper born of the wage distributions.

Describing the dynamics of employment in firms offering a wage above w ($w_R < w < w^o$), imposing stationarity and using equation (2.8) helps us deducing equilibrium employment $l(w)$ in firms offering w.

$$\frac{L(w)}{N - U} = G(w) = \frac{U}{(N - U)} \frac{\lambda H(w)}{[\lambda_L(1 - H(w)) + \delta]} = \frac{\delta H(w)}{(\lambda_L(1 - H(w)) + \delta)}, \tag{2.14}$$

as in the homogeneous model (equation 2.9). By the same arguments as above, the reservation wage (or minimum wage) is the lower bound of the wage offer distribution (see section 2.3.2). And thus:

$$l(w) = \delta(N - U) \frac{\delta + \lambda_L}{[\delta + \lambda_L(1 - H(w))]^2}. \tag{2.15}$$

Note that we must divide by M to obtain the average amount of employment in one firm offering w: $\breve{l}(w) = \frac{l(w)}{M}$.

Profit maximization

Firms maximize expected profits, which are given by profits per worker times the equilibrium employment in this firm:

$$\Pi(w|y) = (y-w)\breve{l}(w) = \delta(y-w)\frac{(N-U)}{M}\frac{(\delta+\lambda_L)}{[\delta+\lambda_L(1-H(w))]^2}. \tag{2.16}$$

Again, the firm faces the trade-off between the profit per employee and the equilibrium amount of employees. If $\lambda_L = 0$ the Diamond (1971)-solution is obtained, since in this case the employment of the firm in equation (2.15) does not depend on the wage. In general, the wage a firm pays might depend on its productivity y. However, facing the results of section 2.3.2 it is clear that it is possible that firms of an identical y-type pay different wages if different wages yield identical profits. If this is the case, then a firm of type y chooses a wage randomly according to $H(w|y)$. Let

$$K_y = \arg\max_w\{\Pi(w|y)|\max(w_R, w_{\min}) < w < y\}$$

be the entity of profit maximizing wages from which the y-firm draws one. Then, in the case of continuous productivity dispersion it can be shown that $K_y = K(y)$ is unique (see Bontemps, Robin, and Van den Berg (2000), p.315/350). For each firm of a given y-type there is only one optimal wage, which is in addition increasing with the productivity y of the firm throughout the support of Γ. This simplifies the analysis considerably since then the probability $H(w)$ that a firm pays a wage lower than $w = K(y)$ is determined by the probability $\Gamma(y)$ that a firm has a productivity below y. Since $K(y) = w$ and since $K'(y) > 0$ the inverse $y = K^{-1}(w)$ can be calculated. The share of firms that offer wages below w equals the share of firms, whose productivity is below $y = K^{-1}(w)$, or: $H(w) = \Gamma(K^{-1}(w))$.

The first order condition for the profit equation can be derived by differentiating (2.16) with respect to w:

$$\begin{aligned}\frac{\breve{l}'(w)}{\breve{l}(w)} &= \frac{l'(w)}{l(w)} = \frac{1}{y-w}, \text{ and} \\ -\delta-\lambda_L(1-H(w))+2(y-w)\lambda_L h(w) &= 0.\end{aligned} \tag{2.17}$$

The first line follows from using the first equality and the second line from using the second equality in equation (2.16). The second order condition is satisfied and thus the result is a profit maximum (ibid., p.316). The second line determines the optimal wage for each firm $w = K(y|H(\cdot))$ implicitly for wages above the reservation wage.

I can calculate for each firm equilibrium profits $\Pi(\cdot)$ and employment $\breve{l}(\cdot)$ as a function of y. Using this, an explicit expression for $K(y)$ can be obtained. It makes profits of $\Pi(y) =$

$(y-K(y))\breve{l}(K(y))$. Differentiating with respect to y yields $\Pi'(y) = (1-K'(y))\breve{l}(K(y)) + (y-K(y))\breve{l}'(K(y))K'(y)$. Using optimality and the envelope theorem, the following result is obtained:

$$\Pi'(y) = \breve{l}(K(y)). \tag{2.18}$$

Profits of the firms are increasing with productivity. If y increases the equilibrium amount of employees increases since the optimal chosen wage increases. Every worker produces more (because of the higher firm productivity) and obtains a higher wage. Now, think of an infinitesimal increase in y. From equation (2.17) it follows that, $w\breve{l}'(w) + \breve{l}(w) = y\breve{l}'(w)$. This means that the optimally chosen wage on the side of the firm, is chosen such that the wage bill for the newly attracted employees $w\breve{l}'(w)$ and the additional wage payments to the old stock of employees[24] $\breve{l}(w)$ equal the (value of the) production $y\breve{l}'(w)$ of the newly attracted employees, a standard result of monopsony theory (see Bontemps, Robin, and Van den Berg (2000), p.315). The additional production of the old stock of employees makes up the net profit increase of the firm if y increases.

Integrating equation (2.18) yields an explicit expression for $\Pi(y)$ (see appendix B.3). Using this and a suitable form of the equilibrium employment equation, I obtain the following expression for $K(y)$:

$$K(y) = y - [\delta + \lambda_L(1-\Gamma(y))]^2 \int_{\underline{w}}^{y} \frac{1}{[\delta + \lambda_L(1-\Gamma(\varrho))]^2} d\varrho, \tag{2.19}$$

where $\underline{w} = \max(w_R, w_{\min})$.

The wage offer distribution follows from $H(w) = \Gamma(K^{-1}(w))$. But, in general there is no closed form expression $K^{-1}(w)$.

The equilibrium wage offer distribution $H(w) = \Gamma(K^{-1}(w))$ uniquely determines the distribution of paid wages $G(w)$ in equation (2.14). It also determines the equilibrium profit of firms $\Pi(w|y)$ in (2.16) depending on y. Profit is maximized if firms choose the wage according to equation (2.19) and is given by equation (B.5). Equilibrium unemployment is given by equation (2.8).

The equilibrium relationships of G, H and Γ constrain the form of the admissible distributions of G and H. Because densities are nonnegative ($\Gamma'(y) \geq 0$), it follows that $h(w)[\delta + \lambda_L(1 - H(w))]$ decreases on $[\underline{w}, \bar{w}]$ (see Bontemps, Robin, and Van den Berg (2000), p.353ff.). If $h(w)$ is decreasing on the complete support, this condition is met. If λ_L is sufficiently large, $h(w)$ can also be increasing. The lower bound of the support is given by the reservation wage (minimum wage). If the lower bounds of y and of w are equal, there is a mass point at w. It can be shown that the upper bound of the support is finite, that it depends on the distribution of the

[24] More precisely, the additional wage payments to the old stock of employees is given by $(w+dw)\breve{l}(w) - w\breve{l}(w) = dw\breve{l}(w)$. So, $\breve{l}(w)$ are the additional payments to the old stock of employees if the wage increases by one.

productivity and that it increases with λ_L if a minimum wage constitutes the lower bound (ibid., p.319ff.).

Discussion

Wage dispersion is established as an equilibrium phenomenon in a model with continuous productivity dispersion. It arises as a result of the interaction of both search frictions and productivity dispersion. Productivity dispersion itself is not sufficient for wage dispersion, since in this case the Diamond (1971)-solution is obtained. On the other side it has already been shown that informational frictions alone with on-the-job search are a sufficient condition for wage dispersion. However, the integration of different productivities across firms seems an important ingredient, empirically. Second, it has been mentioned before that the homogeneous model implies counterfactual wage distributions and it is only able to explain part of the variance of wages between individuals. In this context, the resulting wage distributions depend on the productivity distribution. If for example a Pareto-distribution for the productivities is assumed, a realistic shape for the wage distribution can be obtained (see Bontemps, Robin, and Van den Berg (2000), p.321). In deed, the model is able to generate wage distributions that are in accordance with the data. This is astonishing, especially since the assumption of homogeneous workers has been retained.

Both ingredients, the frictions and the productivity dispersion determine together the shape of the wage distribution. This explanation for wage dispersion is richer than the explanation in the homogeneous model. In this model, more productive firms pay higher wages, make higher profits and are bigger than their less productive counterparts. This is confirmed by several empirical studies (see Bontemps, Robin, and Van den Berg (2000), p.319).

Since $K'(y) > 0$ an increasing variance of the distribution of the productivities, increases the variance of the wage distribution, whereas equilibrium unemployment remains unchanged. A labor union minimum wage affects also the upper bound of the wage distribution. As in the homogeneous model, equilibrium unemployment is in general not affected while the monopsony power of the firms is affected. It might be the case that the minimum wage causes relatively unproductive firms to leave the market. However, the missing demand of the low productive firms is absorbed by the more productive firms. However, the assumption that there is always a continuum of firms that demands labor is critical in that context.

Endogenous heterogeneity

The model of Acemoglu and Shimer (2000) assumes a production technology with decreasing returns to labor. This implies, because of a zero profit condition for the firms, that each firm has only one (normalized) vacancy.[25] The model is static. Therefore, equilibrium wage dispersion does not arise from on-the-job search, but from the fact that unemployed job seekers can, depending on their search intensity, sample more than one offer from the wage offer distribution. With the possibility to compare job offers, the Burdett and Judd (1983) condition for equilibrium price dispersion is met, if a positive share of the individuals (< 1) samples exactly one job offer and the rest samples more than one job offer (see Acemoglu and Shimer (2000), p.589f.). In general the model has three equilibria. One equilibrium corresponds to the Diamond (1971) solution, where all individuals sample only one offer and firms pay individuals their reservation wage. Another equilibrium is characterized by an equilibrium wage distribution and unemployed individuals are indifferent of sampling either one or two job offers (given the share of individuals that samples one or two offers).[26] Although the model is static, the tradeoff for firms is quite similar as in the dynamic models. A firm that offers a high wage has a high probability to fill its vacancy while a low wage firm has a low probability. This corresponds to high (low) expected employment in the dynamic models.

Like in most models with an endogenous and costly information decision, there is a free-rider problem. If part of the individuals are informed, the ignorant agents profit, too, since wages are dispersed and with that average wages rise. Partly this effect is internalized, since the informed agents obtain on average higher wage offers than the ignorant ones. Given the wage distribution in equilibrium, the expected utility of a well informed agent net of search cost must equal the expected utility of an ignorant agent (see Acemoglu and Shimer (2000), p.592).

If an endogenous capital decision is introduced in the model and if a zero profit condition is imposed, a unique connection exists between the capital choice and the chosen wage. This is the case, since firms pay their employees according to marginal productivity which depends positively on capital use. So, assuming marginal productivity pay, the problem of simultaneously choosing capital and wage can be reduced to choosing only the wage. This implies an endogenous distribution of productivities across firms if a positive share (< 1) of the unemployed samples two job offers (see Acemoglu and Shimer (2000), p.594f.). An increasing search intensity, i.e. an increasing share of informed individuals, increases the average capital stock of the firms. This is the case, since firms react with increasing wages on better informed individuals, which implies that the corresponding optimal capital stock rises. In an equilibrium with dispersed wages, unemployed individuals are indifferent sampling one or two job offers. A remarkable result however is that the stable equilibrium with a high share of individuals that samples more

[25] In this case the capital intensity is equal to the capital use of a firm. Therefore I use the two terms synonymous.

[26] In general there exist two such equilibria with wage dispersion, where one of the equilibria is characterized by a low share of individuals that samples twice and the other by a high share. The second is a stable equilibrium while the former is not. (see Acemoglu and Shimer (2000), p.593)

than one offer, comes relatively close to the result of a social planner (ibid., p.597f.). If search costs are comparatively low, although the capital choice of firms is made ex-ante, it is close to the optimal capital choice.

A dynamic version of the model uses a discrete time concept. So, unemployed job seekers can in principle sample more than one job offer at a time. There is no on-the job search and zero profit for the firms is imposed. The value equations have a similar form as in section 2.3.1. However, in this case, exogenous job destruction δ destroys also the capital stock the firm uses. In equilibrium[27] the capital distribution across firms is such that unemployed job seekers, given the share that samples two job offers, are indifferent of sampling one or two job offers. The lowest capital stock is chosen such that unemployed job seekers are indifferent between working or not (the reservation wage). From the value equations one calculates the average probability that a vacancy is filled and the average unemployment rate. The equilibrium wage offer distribution is given by the distribution of capital and follows from zero profit on the support.

Discussion

The model presented here, is, because of the assumed heterogeneity of firms, richer than the previous ones in that it allows wage distributions that are more realistic (see Mortensen (2000), p.289f. and Postel-Vinay and Robin (2002a), p.992). As far as the explanation of the variance of the wages is concerned both the model with endogenous and exogenous productivity dispersion bear the same advantages and disadvantages. However, an endogenous capital decision is a gain, since, at least in the long run, the capital use is a decision variable of the firm. In models with endogenous capital decision the crucial determinant of the form of the capital distribution is the link between capital use and wages. A further positive aspect of the presented model with endogenous capital decision is the fact that search intensity is also endogenous.

In the model with endogenous capital decision the decision over wage and capital is made simultaneously. On the other hand, in exogenous models the causality is by assumption from technology to wages. As Acemoglu and Shimer (2000) point out, there is empirical evidence that is in favor of a simultaneous decision or even that wages determine technology (see Acemoglu (2005)). The model of Acemoglu and Shimer (2000) implies in addition that wage dispersion does not vary with the age of the individuals. Both the homogeneous model and the model with exogenous wage dispersion, on the other hand imply that senior workers have changed jobs more

[27] In this version, too, there exist several equilibria. If I speak of the equilibrium, I refer to the equilibrium that is stable with a high average search intensity.

often, which implies both a higher average wage and a lower wage dispersion.[28] However, it seems to be the case that wage dispersion increases with age, which contradicts both theories.

In the model of Acemoglu and Shimer (2000) the rate of new jobs decreases with an increasing minimum wage. This implies that the unemployment rate increases as well. This is in contrast to the results of the other models discussed so far.

2.4.3 Heterogeneity on both sides of the market

If trying to explain the variance of paid wages between observationally equivalent workers, basically two components are required: first, there are firm effects on the wage and, second, there is an effect of the degree of frictions on wages. In addition, wages vary considerably between workers with different observed characteristics, controlling for firm characteristics and search frictions. Summing up, three factors are needed to explain empirical wage distributions: heterogeneous firms, heterogeneous workers and search frictions (see Bontemps, Robin, and Van den Berg (2000) and Abowd, Kramarz, and Margolis (1999)). So far, the presented models explain wage variation by search frictions (Burdett and Mortensen (1998), by search frictions and heterogeneity of the employees (Burdett and Mortensen (1998)), by search frictions and exogenous technology differences (Bontemps, Robin, and Van den Berg (2000)), by search frictions and endogenous technology differences (Acemoglu and Shimer (2000)). The model, I present thereafter integrates the three important factors for the explanation of an empirical wage distribution. The model is due to Postel-Vinay and Robin (2002b).

Assumptions

I will present the model in more detail since it deviates considerably from the baseline model à la Burdett and Mortensen (1998). Heterogenous productivity of the individuals is integrated in the model in the following way. A specific labor market for a more or less homogeneous employment group is considered (professor, mason, haircutter). All job seekers are assumed to have comparable characteristics (phd-degree, certificate of apprenticeship) and are therefore substitutable to a certain degree. However, individuals differ in their productivity (efficiency units of labor per time unit) as measured by an index ε. Before entering the labor market, individuals determine their productivity by drawing a value from the continuous productivity distribution $\Omega(\varepsilon)$ on an interval $[\varepsilon_{\min}, \varepsilon_{\max}]$ with density $\omega(\varepsilon)$. It is assumed that unemployed job seeker of type ε obtain a net unemployment income of $z(\varepsilon) = \varepsilon b$. w brings the individual the utility $\Xi(w)$ and individuals maximize the present value of their expected utility over an infinite

[28] This is true if $\lambda_L >> \delta$.

time horizon.[29] Leisure does not enter the utility function of the individuals, which implies that only risk aversion can be responsible for deviations of expected income maximization.

Each firm produces, using a technology (productivity, capital intensity) y, which follows a distribution function $\Gamma(y)$ with density $\gamma(y)$ on a bounded support $[\underline{y}, \bar{y}]$ and which is determined by an ex-ante random draw. A firm maximizes the present value of their expected profits over an infinite time horizon. It is assumed that the "home productivity" b exceeds $\underline{y}$. Marginal productivity of an efficiency unit of labor is constant given the y-type of the firm. That is, an individual of type ε and a firm of type y produce together an output $y\varepsilon$.

The sequential process of contacts between employers and employees is similar to that in standard models. Unemployed job seekers contact firms at rate λ, while employed job seekers contact firms at λ_L. The distribution of wage offers differs from standard models. Up to now, contacts were a random draw of the wage offer distribution. In this model it is assumed that each firm of type y makes wage offers to individuals with a specific probability that is identical over all ε-types. The contact probability for a type-y firm follows a distribution function $\Psi(y)$ with density $\psi(y)$. Postel-Vinay and Robin (2002b) argue that the relative frequency of contacts for a y-firm $\psi(y)/\gamma(y)$ is determined by the search intensity of this firm. There is, however, no microfoundation for the ratio of $\psi(y)$ and $\gamma(y)$. The wage formation process differs from the standard model as well. Upon a meeting, both sides have complete information about all relevant characteristics of the other agent. Therefore, the wage offer of the firm conditions on the type ε of the job seeker. In addition, if an employee gets an outside job offer from a competing firm, the employing firm can make a binding counteroffer. Implications of this assumption are detailed in Postel-Vinay and Robin (2002a). In a model with endogenous technology dispersion, they show that job-to-job transitions depend basically on the productivities of the competing firms. Before showing details of the derivation, I summarize the assumptions of the model. The assumptions (A0), (A1""'), (A2"'), (A3'), (A4), (A5") and (A6') are assumed to hold, where:

- (A1""'), as (A1'), but N individuals maximize their utility function $\Xi(w)$ and enter and leave the labor market at rate n. Newcomer enter the labor market as unemployed job seekers. Individuals differ in their productivity ε , according to a distribution function $\Omega(\varepsilon)$ on $[\varepsilon_{\min}, \varepsilon_{\max}]$. ε-type unemployed obtain $z = \varepsilon b$. $W_U(\cdot)$ ($W_L(\cdot)$) are the values of unemployment and employment, respectively. When a job seeker and a firm meet, the probability that the productivity of the firm is below y is $\Psi(y)$.

[29] Since the authors give their model a partial market interpretation, the discount factor must not correspond to the interest rate. This is especially important when estimating the model since the discount rate must be estimated along with the other parameters. For simplicity, r denotes the discount factor.

- (A2"'), as (A2), but firms differ in their productivity y, distributed according to $\Gamma(y)$ on $[\underline{y}, \bar{y}]$, with $\underline{y} > b$. Upon a meeting the firm observes both the type ε and the productivity y of the firm that employs the individual at the present.
- (A3'), as (A3) but firms condition their wage offer $w(\varepsilon, y, \cdot)$ that is nonnegotiable on the type ε of the individual and on the productivity y of the firm that employs the individual so far.
- (A5"): Specific labor market, where r is the discount rate in this market and where a homogeneous product is produced from heterogeneous agents. A type y firm and a type ε individual produce together the output $y\varepsilon$ of the homogeneous good. The price of the produced good is the numéraire.
- (A6'), as (A6), but matches dissolve at rate $\delta + n$, where δ is the job destruction rate and n is the rate at which individuals leave (and enter) the market.

The model

Let $W_U(\varepsilon, b, \varepsilon b) = W_U(\varepsilon)$ be the value of unemployment of an individual of type ε and let $W_L(\varepsilon, y, w)$ be the value of employment of the same ε-type, depending on the productivity of the employing firm and the paid wage. The value equation depends not only on the wage that the firm pays but also on the productivity of this firm. This is the case, since the productivity of the firm determines the career opportunities (in the sense of potential wage gains) in this firm. If an employed individual of type ε obtains a wage offer from a competing firm, the upper bound of the wage increase for the individual is determined by the productivity of the employing firm. To see this, notice that the maximal counteroffer that the employing firm can make is bound by its productivity. However, because of perfect information, the competing firm will choose its wage offer such that the individual is indifferent between changing the firm and not. Job seekers obtain always exactly their reservation wage upon engagement. For unemployed job seekers, it can be calculated from $W_L(\varepsilon, y, w_R) = W_U(\varepsilon)$, where $w_R = w_R(\varepsilon, y, z) = w_R(\varepsilon, y)$. The reservation wage of the unemployed job seekers, like the reservation wage of employed job seekers depends on the career opportunities in the firm, that makes the offer.

If a y'-firm with $y' > y$ makes an offer, it chooses the wage such that the individual is indifferent between the value of the highest wage $w = \varepsilon y$ he can get in his firm without career opportunities[30], and the value of the wage with the positive career opportunities if changing to the y'-firm. Let $w_w(\varepsilon, y, y')$ be the wage that makes the ε -individual indifferent between the firms

[30] Without career opportunities means that the employing firm pays marginal productivity and can therefore offer no higher wage.

y, y'. Than: $W_L(\varepsilon, y, \varepsilon y) = W_L(\varepsilon, y', w_w)$. If the competing firm has a lower productivity than the employing firm $y' < y$, than the firm is ready to pay at most $\varepsilon y'$. The counteroffer that is able to inhibit the individual from changing the firm is because of the better career opportunities smaller than $\varepsilon y'$ and given by $w_w(\varepsilon, y', y)$, where $W_L(\varepsilon, y, w_w) = W_L(\varepsilon, y', \varepsilon y')$ holds.

Value equations and reservation wages

The value of unemployment can be derived as usual from the No-arbitrage condition, where the instantaneous income has to be replaced by the instantaneous utility $\Xi(\varepsilon b)$. The value of a job offer is given by the value of unemployment since firms offer exactly the reservation wage to the individual. Future utility flows are discounted by the discount rate r plus the instantaneous mortality rate n. It follows $W_U(\varepsilon) = \frac{1}{1+(r+n)dt}\{\Xi(\varepsilon b)dt + \lambda dt W_U(\varepsilon) + (1 - \lambda dt)W_U(\varepsilon)\}$, or:

$$W_U(\varepsilon) = \frac{\Xi(\varepsilon b)}{r + n}.$$

The value of employment contains several components. If an ε-individual that is employed at wage w in a y-firm obtains an offer from a competing firm, three possibilities arise. First, if the productivity y' from the competing firm is so small that the employing firm could poach the ε-employee from the y'-firm for a wage $w_w(\varepsilon, y', y) < w$, nothing changes. Let the critical productivity of a competing firm for which $w_w(\varepsilon, \check{y}, y) = w$ holds, be $\check{y}(\varepsilon, y, w)$. Than the probability that the offer does not change anything is given by $\Psi(\check{y})$. The second possibility is that $\check{y} < y' < y$. That is, the competing firm cannot win the Bertrand-competition, but is able to offer the employee a higher value than it has in the current firm with his current wage. That is, the employee gets the wage increase $w_w(\varepsilon, y', y) - w$ and his new value of work is given by $W_L(\varepsilon, y', \varepsilon y')$. This happens with probability $\Psi(y) - \Psi(\check{y})$. The value equation must account for the expected value of labor over the productivities of the competing firms in this case. Finally, if the productivity of the competing firm y' is higher as the productivity of the employing firm y it wins the Bertrand-competition, the employee changes the firm and its wage changes by the amount $w_w(\varepsilon, y, y') - w$.[31] With the corresponding probability $(1 - \Psi(y))$ his new value of work is then $W_L(\varepsilon, y', w_w(\cdot)) = W_L(\varepsilon, y, \varepsilon y)$. The value equation summarizes all these possibilities:

$$\begin{aligned} [r + \delta + n + \lambda_L(1 - \Psi(\check{y}(\cdot)))]W_L(\varepsilon, y, w) &= \Xi(w) + \delta W_U(\varepsilon) + \\ \lambda_L[\Psi(y) - \Psi(\check{y}(\cdot))]E_\Psi[W_L(\varepsilon, x, \varepsilon x)|\check{y} &< x < y] + \lambda_L(1 - \Psi(y))W_L(\varepsilon, y, \varepsilon y). \end{aligned} \tag{2.20}$$

[31] The wage change can be both a wage increase and a wage cut. This depends on the wage the employee has earned in the old firm and on the productivities of both firms. If for example the employee earns already marginal productivity in his firm, the wage change is always a wage cut.

Evaluating this formula at $w = \varepsilon y$, I find that:

$$W_L(\varepsilon, y, \varepsilon y) = \frac{\Xi(\varepsilon y) + \delta W_U(\varepsilon)}{r + \delta + n}. \tag{2.21}$$

This is true, since $\check{y}(\varepsilon, y, \varepsilon y) = y$. Using 2.21 for the conditional expectation in 2.20 together with the conditional distribution $\Psi(x|\check{y} < x < y) = \frac{\Psi(x)}{\Psi(y) - \Psi(\check{y})}$, using in addition integration by parts, the fact that $W_L(\varepsilon, y, w) = W_L(\varepsilon, \check{y}, \varepsilon\check{y})$ and the relationship $\lambda_L \left(\frac{\Xi(\varepsilon y) - \Xi(\varepsilon \check{y})}{r+\delta+n} \right) = \frac{\lambda_L \varepsilon}{r+\delta+n} \int_{\check{y}}^{y} \Xi'(\varepsilon x) dx$, a new expression for the value of work is obtained.

$$(r + \delta + n) W_L(\varepsilon, y, w) = \Xi(w) + \delta W_U(\varepsilon) + \frac{\lambda_L \varepsilon}{r + \delta + n} \int_{\check{y}}^{y} (1 - \Psi(x)) \Xi'(\varepsilon x) dx \tag{2.22}$$

The (instantaneous) return to $W_L(\cdot)$ in the capital market must equal the return in the labor market. The return in the labor market can be decomposed in the instantaneous utility of the wage minus the loss in case where the job gets lost $-(\delta(W_L(\cdot) - W_U(\cdot)) + nW_L(\cdot))$ plus the instantaneous probability to get an offer of a competing firm times the expected discounted utility gain in this case.[32] Using that by definition $W_L(\varepsilon, y, w) = W_L(\varepsilon, \check{y}, \varepsilon\check{y})$ and equation (2.21) on the left hand side of equation (2.22), $\Xi(w) = \Xi(\varepsilon\check{y}) - \frac{\lambda_L \varepsilon}{r+\delta+n} \int_{\check{y}}^{y} (1 - \Psi(x)) \Xi'(\varepsilon x) dx$ is obtained. If a firm with $y' > y$ makes an offer to an employee, then the employee changes the firm and obtains the wage $w_w(\varepsilon, y, y')$. Plugging this in the last formula and using that $\check{y}(\varepsilon, y', w_w(\cdot)) = y$, one obtains an implicit characterization of the wage an individual obtains when changing job.

$$\Xi(w_w(\varepsilon, y, y')) = \Xi(\varepsilon y) - \frac{\lambda_L \varepsilon}{r + \delta + n} \int_{y}^{y'} (1 - \Psi(x)) \Xi'(\varepsilon x) dx \tag{2.23}$$

Analogously, I obtain the reservation wage of the unemployed job seekers at an offer from a y'-firm ($y' > b$) implicit by using $w_R(\varepsilon, b, y') = w_w(\varepsilon, b, y')$ and $\check{y}(\varepsilon, y', w_R(\cdot)) = b$.

$$\Xi(w_R(\varepsilon, b, y')) = \Xi(\varepsilon b) - \frac{\lambda_L \varepsilon}{r + \delta + n} \int_{b}^{y'} (1 - \Psi(x)) \Xi'(\varepsilon x) dx \tag{2.24}$$

Both wages are reservation wages in the sense that they correspond at the minimum wage that a type y'-firm must offer a ε-individual to induce it to work in this firm. In both cases this reservation wage depends on the current productivity, either of the employing firm or the home

[32] The expected utility gain from a job offer can be calculated as the integral over the probability that the offer stems from a firm, whose productivity is above x, where $x \in [\check{y}, y]$, times the marginal utility of the highest wage $x\varepsilon$ this firm can afford to pay. Putting $\frac{\varepsilon}{r+\delta+n}$ under the integral, the integral is the expected discounted utility gain from a wage offer of a firm with productivity $y' \in [\check{y}, y]$. This is true since all firms with productivity above $x \in [\check{y}, y]$ can afford to pay at least wage $x\varepsilon$ and therefore insures at least marginal utility $\Xi'(\varepsilon x)$ for the individual and since for values $x > y$ the value of employment remains unchanged.

productivity. Since a firm with $y' > y$ offers career opportunities, the wage $w_w(\cdot)$ it pays is lower than the maximal wage a y-firm can afford. The discounted value of the career opportunities is given by the second addend in equation (2.23). Therewith, the model generates voluntary job-to-job transitions under wage cuts. The analog holds for the reservation wage of the unemployed, it is lower than the value of their home production. In addition, the reservation wage does not depend on the job-offer rate λ since job offers exactly bring the reservation wage of the unemployed, which equalizes the value of employment and the value of unemployment. So, a job offer here means no value change (see Postel-Vinay and Robin (2002b), p.2304).

Paid wages are either the first wage $w_R(\varepsilon, b, y')$ or a wage that results from a Bertrand-competition between two firms y, y', that is $w_w(\varepsilon, y', y)$ mit $\check{y} < y' < y$ (or $w_w(\varepsilon, y, y')$, if $y' > y$). So there are always three components contained in the wage: individual productivity, firm productivity and chance. For a CRRA-utility function (as e.g. $\Xi(w) = \ln w$) the reservation wage from equation (2.23) can be decomposed additively in its three components, i.e. $\ln w_w(\varepsilon, y, y') = \ln \varepsilon + \ln w_w(1, y, y') = \ln \varepsilon + \ln y + \frac{\lambda_L}{r+\delta+n} \int_y^{y'} \frac{1}{x}(1 - \Psi(x))dx$ (ibid., p.2305). From this the decomposition of the variance of paid wages can be derived from which the model has been motivated (see appendix B.4).

$$var_w(\ln w) = var_\varepsilon(\ln \varepsilon) + var_y[E_{(y'|y)}(\ln w_w(1, y, y')|y)] + E_y[var_{(y'|y)}(\ln w_w(1, y, y')|y)]$$

The variance of wages can be decomposed in a component that is attributable to individual productivity differences (ε), a component that comes from different firm productivities (y) and in a component that comes from labor market frictions (see also appendix B.4).

Equilibrium and wage distributions

Before characterizing the equilibrium, some additional definitions must be made. Let $L(\varepsilon, y)$ be the share of individuals whose productivity is below ε and that are employed in firms with productivity below y. Then, $L_y(y) = \int_{\varepsilon_{\min}}^{\varepsilon_{\max}} L(\varepsilon, y)d\varepsilon$ is the share of individuals that are employed in firms with productivity below y. Let $l(\varepsilon, y)$ and $l_y(y)$ be the corresponding densities. Further let $G(w|\varepsilon, y)$ be the conditional distribution of paid wages. Equilibrium unemployment follows from $\lambda u = (1 - u)(\delta + n)$, or

$$u = \frac{\delta + n}{\lambda + \delta + n}. \tag{2.25}$$

This is the usual condition for unemployment, accounting however for the fact that there is turnover in the population.

The conditional wage distribution in equilibrium is characterized by the following. There are $G(w|\varepsilon, y)l(\varepsilon, y)N(1 - u)$ employees of type ε, who are employed in a type y-firm at wage below w. Employees of this category leave the class either because of job destruction δ, because of death n, or because they obtain an offer from a firm, whose productivity is above $\check{y}(\cdot)$. So, outflows amount to $(\delta + n + \lambda_L(1 - \Psi(\check{y})))G(w|\varepsilon, y)l(\varepsilon, y)N(1-u)$. Inflows come from the pool of unemployed $\lambda\psi(y)\omega(\varepsilon)$, since firms offer the reservation wage, which is always acceptable to the individuals.[33] On the other hand, y-firms can poach ε-individuals to a wage below w from firms, whose productivity is below $\check{y}(\varepsilon, y, w)$. The expected flow is given by $\lambda_L N(1-u)\psi(y)\int_{\underline{y}}^{\check{y}(\varepsilon,y,w)} l(\varepsilon, x)dx$. In equilibrium, using equation (2.25) and canceling out $N(1-u)$, it follows:

$$(\delta + n + \lambda_L(1 - \Psi(\check{y})))G(w|\varepsilon, y)l(\varepsilon, y) = \left[(\delta + n)\omega(\varepsilon) + \lambda_L \int_{\underline{y}}^{\check{y}(\varepsilon,y,w)} l(\varepsilon, x)dx\right]\psi(y). \quad (2.26)$$

Evaluating this equality at $w = \varepsilon y$, and using that $G(\varepsilon y|\varepsilon, y) = 1$ and $\check{y}(\varepsilon, y, w) = y$, $(\delta + n + \lambda_L(1 - \Psi(y)))l(\varepsilon, y) = \left[(\delta + n)\omega(\varepsilon) + \lambda_L \int_{\underline{y}}^{y} l(\varepsilon, x)dx\right]\psi(y)$ is obtained. The solution to this differential equation is (ibid., p.2341):

$$l(\varepsilon, y) = \frac{(1 + \kappa_L)\psi(y)}{[1 + \kappa_L(1 - \Psi(y))]^2}\omega(\varepsilon) = l_y(y)\omega(\varepsilon), \text{ mit } \kappa_L = \frac{\lambda_L}{\delta + n}. \quad (2.27)$$

Using the primitive $L(\varepsilon, y) = \frac{\Psi(y)}{1+\kappa_L(1-\Psi(y))}\Omega(\varepsilon) = L_y(y)\Omega(\varepsilon)$ and $l(\varepsilon, y)$ this is easily checked.[34]

Using (2.27), equation (2.26) can be solved for $G(w|\varepsilon, y)$. The conditional distribution of wages for ε-individuals in y-firms is given by:

$$G(w|\varepsilon, y) = \left(\frac{1 + \kappa_L(1 - \Psi(y))}{1 + \kappa_L(1 - \Psi(\check{y}(\varepsilon, y, w)))}\right)^2. \quad (2.28)$$

The equilibrium size of a y-firm can be derived by the equilibrium conditions as $N\frac{l_y(y)}{\gamma(y)} = \frac{N(1+\kappa_L)}{[1+\kappa_L(1-\Psi(y))]^2}\frac{\psi(y)}{\gamma(y)}$. The first term implies that the size of a firm increases with the productivity of the firm, since upon meetings they are more often capable of attracting individuals from competing firms than low productivity firms. The second term reflects by assumption the search intensity of a firm, which can increase or decrease with firm productivity. So, firm size does not uniquely depend on productivity (ibid., p.2308). Since the random variable ε does not depend on the random vector (y, y') and since this implies independence between ε and y, the conditional distribution of $(y'|y)$ can be derived. Let $y' < y$, then $G(w_w(\varepsilon, y, y')|\varepsilon, y) = G(\varepsilon y'|\varepsilon, y) = \frac{\Omega(\varepsilon)\breve{G}(y,y')}{\Omega(\varepsilon)L_y(y)} = \tilde{G}(y'|y) = \left(\frac{1+\kappa_L(1-\Psi(y))}{1+\kappa_L(1-\Psi(y'))}\right)^2$. This is true since $\check{y}(\varepsilon, y', w_w) = y'$.

[33] This is true because of the assumption $\underline{y} > b$.

[34] It is remarkable that $L_y(y)$ and $\Psi(y)$ are associated in the same way as $G(w)$ and $H(w)$ in the homogeneous model. This can be explained by the fact that $\Psi(\cdot)$ is as $H(\cdot)$ the distribution of wages if entering a job from unemployment, while $L_y(\cdot)$ as $G(\cdot)$ is the distribution of wages in across section after sorting to higher payed jobs.

Discussion

Summarizing, it is to be noticed that the model is able to integrate the three factors that are empirically important for explaining wage dispersion into a theoretical framework. This work is a significant contribution in the direction of a realistic, empirically valid modeling of the labor market. Obviously this has increased the complexity of the model. However, some simplifying assumptions were necessary to solve the model. It was assumed that the net income of the unemployed job seekers is proportional to the ε-type of the individual. The assumption can be justified by the fact that high productivity individuals are more productive in home production and that they might have lower search costs. On the side of unemployment benefits, however, this payment scheme is not very plausible, although it is true that the benefits might condition on the last wage. But, in frictional markets the wage is not perfectly correlated with the type of an individual. A further critical assumption is that there is perfect information at a meeting of the both market sides. On the side of the firms this assumption can be justified by the fact that job interviews serve to monitor the productivity of the individual. On the other hand, the literature has emphasized the argument that jobs have the character of an experience good: “that is, the only way to determine the quality of a particular match is to form the match and to ‚experience‘ it” (Jovanovic (1979), p.973). For the side of the job seekers, too, this assumption seems not very realistic since probably at a job interview there is little information revealed over the productivity of the firm. An additional ingredient in the model was the possibility of firms to make counteroffers, which enriches the basic model.

An attractive feature of the model is that it provides a rationale for voluntary job-to-job transitions under wage cuts, since this seems to be a phenomenon that is empirically important (see Fitzenberger and Garloff (2005a) and Pfeiffer (2003) for Germany). On the other hand, (real) wage cuts for job stayers seem to be empirically important, too (see Postel-Vinay and Robin (2002b), p.2313f. and Pfeiffer (2003), p.40ff.). Of course, this cannot be explained by the model.

A further interesting result is that ε and y are distributed independently, which implies that there is no sorting at least within professional groups. Although it is true that more productive firms prefer employing more productive individuals and although they can attract them if competing with low productive firms, firms can earn positive profits for each employee. Therefore in the model, they employ everybody and in equilibrium there is no sorting. The limitation to professional groups is important, since there is evidence for positive assortative matching in labor markets (see Van den Berg and van Vuuren (2006)).

The estimation of the model yields the decomposition of the variance in its components. Individual heterogeneity explains for the seven occupational groups, that are examined, an in the qualification increasing part of the wage variation. Taken together, the estimates are significantly smaller than 50% the result of the estimation of Abowd, Kramarz, and Margolis (1999). Postel-Vinay and Robin (2002b) interpret the fact that individual heterogeneity does not explain much for low-skilled individuals by the conjecture that productivity differences are smaller for the low-skilled. The difference to the results of Abowd, Kramarz, and Margolis (1999) are argued as stemming from market frictions, that are attributed wrongly to individual heterogeneity (see Postel-Vinay and Robin (2002b), p.2297). The estimated effect of search frictions is high and ranges between 45% and 60%. This documents the need to take search frictions into account. A further empirical finding is that the contact probability is consistent neither with random matching ($\psi(y) = \gamma(y)$) nor with balanced matching ($\psi(y) = l(y)$).[35] The already mentioned empirical result that larger firms pay higher wages is not warranted in the model. Productive firms in fact pay higher average wages and have a lower turnover. However, lower search efforts on behalf of highly productive firms can nullify that effect. Postel-Vinay and Robin (2002b) show empirically that the average effect of firm size on wages is positive but a second-order polynomial implies a bell-shaped distribution. That result can be interpreted as efforts on behalf of low-wage firms to compensate their low wages with high search efforts.

Introducing a binding minimum wage has multiple effects. Assume that $w_{\min} > \underline{y}\varepsilon_{\min}$. There is a set of matches that are not profitable anymore and are not performed. For workers with productivity $\varepsilon_{crit} < \frac{w_{\min}}{\underline{y}}$, i.e. workers that are affected by the minimum wage, the specific unemployment rate is higher. However, those workers that are still employed, earn higher wages. Let $y_{crit} = \frac{w_{\min}}{\varepsilon_{\min}}$ denote the productivity boundary, above which all matches are profitable. Then firms with $y < y_{crit}$ have less employees and make lower profits than in the absence of the minimum wage. For all other firms there is a number of matches that are in fact profitable, but which require the firms to pay the obligatory minimum wage instead of the reservation wage. This reduces profits of the firms but leads to higher average wages for the employees. Summarizing, in this model, the effects of a binding labor unions minimum wage on employment is negative, while rents are distributed from firms to workers.[36]

2.4.4 Production functions and marginal productivity

So far, the models discussed allowed for differences both on the side of the firms and on the side of the individuals. It maintained, however, the assumption that the productivity of an

[35] Similarly, theoretical objections against random matching have been discussed in the literature. Random matching implies that dividing a firm increases profits, which is a questionable result (see Burdett and Vishwanath (1988), p.1050).

[36] In the context of this model, the assumption that union influence on the wage distribution can be modeled as a minimum wage, is especially plausible. The reason is that the model is designed to be applicable only for a specific professional group, such that the assumption of one minimum wage seems more reasonable than for the whole labor market.

individual did not depend on the number of individuals employed. Yet, another possibility to introduce heterogeneity, is the assumption of non-constant marginal productivities. So far, there are only little attempts in the literature to incorporate this production function view in the search framework. One such attempt is Ridder and Van den Berg (1997), which draws on Manning (1993), Mortensen and Vishwanath (1993) and Mortensen and Vishwanath (1994). This model assumes a non-linear production function with one production factor, only. Introducing several skill groups and linking them over a production function is analytically very demanding. To the best knowledge of the author, there are only two models with several production factors linked over a production function: one is Holzner and Launov (2005) and will be discussed below. The other is chapter 5 of this thesis.

I start by discussing the model where one production factor is allowed to have non-constant marginal productivity in a production function, depending on its use. For the presentation, I refer to Ridder and Van den Berg (1997). Consider the framework as outlined in 2.3.2. As before, let $l(w)$ be the steady-state number of individuals employed in a firm that pay a wage w, and let $y(l(w))$ denote the output depending on the employment $l(w)$. Assume that y is concave $y'(l) > 0, y''(l) < 0$ and that $y(0) = 0$. Assume, in addition, that the job offer rate off-the-job and on-the-job are identical $\lambda = \lambda_L$.

The reservation wage is given by equation (5.1) and reduces to the monetary value of obtaining unemployment benefits net of search costs, because the option value of unemployment vanishes through the equality of job offer rates, i.e. $w_R = z$. Equilibrium unemployment is unchanged and follows from the steady state condition for inflows into and outflows from unemployment $u = \frac{\delta}{\delta+\lambda}$ since firms do not offer wages below the reservation wage. The objective function of the firms[37] is given by

$$\pi(w) = y(l(w)) - wl(w). \tag{2.29}$$

Concavity of y implies that there is a size $l(w)$ where $y'(l(w)) \leq w$. This implies that, at the upper bound of the wage distribution, we can obtain a mass point. In this case it is present both in the wage offer distribution $H(w)$ and in the distribution of paid wages $G(w)$. It arises since at the employment level where the wage equals marginal productivity every additional worker (even when obtained at that wage) would contribute a negative amount to the objective function and thus there is no incentive to pay a higher wage.[38] Still, firms paying a marginal productivity wage make positive profits because of the concavity.

[37] It is to be noted that the objective function given here is not equal to the expected profit because of the non-linearity of the production function. It can be justified, however, by a second order Taylor approximation (see below and Holzner and Launov (2005)).

[38] The incentive to pay a higher wage is the reason why mass points cannot exist in the homogeneous model. This mechanism is destroyed by decreasing marginal productivity.

Depending on the parameters this model has several possible solutions. One solution is an equilibrium where all firms pay a common wage, which can be either equal to the reservation wage or equal to marginal productivity and guarantees employment $\frac{N\lambda}{\lambda+\delta}$.[39] The reservation wage solution is obtained if marginal productivity in the symmetric equilibrium is below or equal to z, i.e. $y'(\frac{N\lambda}{\lambda+\delta}) \leq z$. In this case, it does not pay to deviate: paying a lower wage guarantees zero employees, whereas paying a higher wage increases the number of employees thereby decreasing marginal productivity. This makes the contribution of a an additional worker negative. So, deviating does not pay and this is an equilibrium if profits are positive. Otherwise, there is no production. A dispersed equilibrium cannot exist in this case. To see this, recognize, that for employment to be positive all wages must be above or equal to z. However, assume that z where the upper bound of the wage distribution (if it is higher, profits are even lower). Employment in the continuous part of the wage distribution is given by equation (2.10). Employment at the upper bound of the wage distribution is higher than in the equal wages equilibrium $l(w^o) = \frac{N\lambda}{\delta} > \frac{N\lambda}{\lambda+\delta}$. Thus marginal productivity is strictly lower than z. Firms paying wage z want to shrink. Thus, there is no such equilibrium.

Similarly, unique equilibria with dispersed wages or partly dispersed wages are obtained under the following parameter constellations. If the profit at z for a dispersed equilibrium is higher than the profit at a common wage equilibrium (which equals marginal productivity) $\bar{w} = y'(\frac{N\lambda}{\lambda+\delta}) > z$, then an equilibrium with dispersed wages is obtained, since deviating from the common wage to the reservation wage pays directly. Otherwise if

$$y\left(\frac{N\lambda}{\delta+\lambda}\right) - \bar{w}\frac{N\lambda}{\delta+\lambda} > y\left(\frac{N\delta\lambda}{(\delta+\lambda)^2}\right) - z\frac{N\delta\lambda}{(\delta+\lambda)^2} \tag{2.30}$$

the common wage equilibrium is obtained, since deviating does not pay (neither below, nor above).

Now, consider the dispersed equilibrium. Still, it is possible that there is a dispersed part and a mass point having a probability mass $\gamma = Prob(w = \bar{w}) < 1$. Steady-state employment in these firms can be calculated by equating in- and outflows.[40]

$$\lambda(N - \gamma l(\bar{w})) = \delta l(\bar{w}) \tag{2.31}$$

This yields $l(\bar{w}) = \frac{N\lambda}{\delta+\lambda\gamma}$ as employment in one firm that offers the wage at the mass point. Clearly, the wage at the mass point must correspond to the marginal productivity given the

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[39] The equal wage employment is given by the employment rate times the number of employees N divided by the number of firms 1.

[40] The equation can be derived by recognizing, that $l(\bar{w})$ per assumption is the employment in one firm that offers $\bar{w}$ and that the measure of firms is 1.

employment, i.e. $y'(\frac{N\lambda}{\delta+\lambda\gamma}) = \bar{w}$.[41] Paying the mass point or being in the continuous part must yield identical profits and thus:

$$y\left(\frac{N\delta\lambda}{(\delta+\lambda)^2}\right) - z\frac{N\delta\lambda}{(\delta+\lambda)^2} = y\left(\frac{N\lambda}{\delta+\lambda\gamma}\right) - y'\left(\frac{N\lambda}{\delta+\lambda\gamma}\right)\frac{N\lambda}{\delta+\lambda\gamma}. \tag{2.32}$$

If there is a value between 0 and 1 for γ that solves this equation, then a mass point is obtained. Otherwise there is no mass point in the wage distribution.

For the general case (unspecified production), it is not possible to obtain a closed form solution for H and G. Note however, that the counterfactual shape of the wage density does not get lost. On the contrary, to compensate for the decreasing profit per worker because of a decreasing marginal productivity, employment must grow even faster with the wage than in the linear model.[42] Then, equation (2.10) implies that the density is even steeper.

Increasing minimum wages might change the equilibrium obtained and compress the wage distribution. The probability of obtaining a mass point at the *upper bound* of the wage distribution increases. In general, however this does not result in lower employment, since all equilibria but one yield the same employment. If minimum wages have employment effects however, that means shifting from an equilibrium with production to an equilibrium where there is no production at all. Clearly, this is not a very realistic possibility.

An extension of the baseline model to a production function with several skill groups i each of size q_i with $\sum q_i = N$ and heterogeneous production technologies as indexed by j is due to Holzner and Launov (2005). Note that this is the most general model we discuss in this paper: it allows for differences between firms employing different technologies and for differences in workers that vary in productivity a priori and depending on their use. I need to introduce first some notation. w_{ij} is the wage offer a firm of type j offers to an individual of type i. Let H_{ij} be the wage offer distribution for firms that produce with a technology j for skill group i. Ie, $H_{ij}(w_{ij})$ is the amount of type-j firms that offers a wage below w_{ij} for type-i individuals. H_i is the wage offer distribution for skill group i aggregated over all firm types, i.e. the distribution individuals care about, when looking for a job. Finally, H_j is the I-dimensional wage offer distribution of type-j firms to all skill groups. Similarly, $l_i(w_{ij})$ gives the employment of skill group i in a type j firm that offers w_{ij}, while $l(w_j)$ is the I-dimensional employment of all skill groups in this firm.

[41] If the wage was higher, firms would want to employ less. If the wage was lower, the usual argument that increasing the wage by a small amount increases profits holds.

[42] With decreasing marginal productivity, there are two effects that drive the profit per worker down, when employment is growing: first, to attract more worker the wage must increase and even with linear production the profit per worker decreases. Second, with increasing employment the marginal productivity decreases, driving down the other component of the profit per worker.

The reservation wage w_i^R for individuals of skill group i is given by equation (5.1) and is indexed by i. Skill-specific unemployment is given by equality of in- and outflows and determined by the skill-specific friction parameter λ_i.[43] In addition, the dynamics for each skill group is similar as in the standard model, meaning that equation (2.10) holds for each skill group, indexed by the index i, except for the following modification. In the denominator $(\delta + \lambda_L(1 - H(w)))^2$ must be replaced by $(\delta + \lambda_L(1 - H_i(w_i)))(\delta + \lambda_L(1 - H_i(w_i^-)))$. The modification follows from the fact that H_i is allowed to contain mass points and thus $H_i(w_i) = H_i(w_i^-) + \gamma_i(w_i)$. If there are no mass points, the original employment equation is obtained. Recognize that λ_L, δ are assumed identical across skill groups.

Firms with production technology j maximize their expected profit by choosing the wage vector $w_j = (w_{1j}, w_{2j}, ..., w_{Ij})$, $j = 1, ..., J$ i.e.:

$$\pi_j = \max_{w_j} E[y_j(l(w_j)) - w_j' l(w_j)]. \tag{2.33}$$

Using a second order Taylor-Approximation, $E[y_j(l(w_j)) - w_j' l(w_j)]$ can be rewritten as $y_j(E(l(w_j))) - w_j' E(l(w_j))$. Note that, due to tractability reasons, it is assumed that firms do not react on short-run variations in employment, implying that firms specify their wage policy at the outset and do not change it. Holzner and Launov (2005) assume complementarity between the production factors (supermodularity) in the production function y_j. This guarantees, provided a continuous distribution, that (type j) firms cover exactly the same position in the wage offer distribution of each skill group.[44] As above, if there exists a mass point, it exists at the upper bound $\bar{w}_{ij}$ of the skill-specific wage distribution H_{ij} for firms with technology j. At this point, marginal productivity given the employment at that wage equals the wage $y_j'(l_{ij}(w_{ij})) = w_{ij}$.

It is assumed that firms profits differ according to the technology j employed. In this case, firms sort according to their profitabilities in the skill-specific wage offer distributions meaning that more profitable firms pay higher wages. Thus, the share of firms that offers wages below the upper bound $\bar{w_{ij}}$ of a skill-specific wage offer distribution of firms of type j equals the share of firms s_j with technology j and less profitable $H_{ij}(\bar{w}_{ij}) = s_j$. The resulting skill-specific wage offer distributions H_i have no holes (connected support) and the reservation wage (of skill group i) is the lower bound of the wage offer distribution (of skill group i) as in the standard model.

[43] Firms do not offer wages below the reservation wage of the individuals. This can be justified by assuming for the production function that each skill is essential in production and is implied by the supermodularity assumption made below.

[44] Intuitively this is the case, since under supermodularity in production a firm that has high employment in each skill group and a firm that has low employment in each skill group together produce more output than any two firms that produce with any other combination of these employments. Note that this characteristic carries over to the profits of the firms.

Excluding mass points, Holzner and Launov (2005) are able to derive an analytical form for the wage offer distribution. They show that depending on the degree of homogeneity of the production function, the model is able to generate increasing or decreasing skill-specific wage offer densities h_{ij}.[45] That means that they do not require differences in technologies to generate a well-shaped wage density, as opposed to the models discussed so far. In addition, they show that for higher wages decreasing densities are more likely.

Introducing a binding minimum wage has the following effects. Assume that a binding minimum wage is introduced for one skill group only. This compresses the wage distribution for this skill group from the left. In addition, the *complete* skill-specific wage distribution H_i is shifted to the right. This follows from the fact that the upper bound of the skill specific wage offer distributions $\bar{w}_{ij}$ for each technology j depends positively on the lower bound. As long as the skill-specific wage offer distribution does not contain a mass point, the other wage offer distributions remain unchanged and firms still cover the same position in the wage distributions for each skill group. It is possible however, that the increase of the binding minimum wage leads to a mass point. Increasing the minimum wage above marginal productivity of the most unprofitable technology would make it optimal for the firms to employ less individuals. This is however not allowed for by the model. It is possible that the minimum wage increases to a level where firms with the most unprofitable technology make negative profits and thus are driven out of the market.

Independently of the precise effects on the wage distribution, employment effects of increasing a minimum wage are zero, since labor demand as represented by λ_i does not react, even when firms go bankrupt. The reason is that λ_i does not depend on the measure of active firms nor does it depend on the profitability of the use of a specific skill group (as long as the productivity of this skill group is high enough to guarantee some employment). Thus, the minimum wage redistributes rents from firms to workers and might eliminate unprofitable technologies but does not increase unemployment. Introducing a binding minimum wage for all skill groups simultaneously is similar in its effects, with the modification that the point where a technology becomes unprofitable is attained faster. Clearly, the model allows decomposing wage variation in a part that is due to differences in skills and into a part that is due to search frictions. It would be interesting to analyze this empirically. In addition, it could be very interesting to incorporate skill-biased technical change in this model and to analyze the according changes in the different types of wage inequality caused by the skill bias and to see what the model can contribute to the literature on changing inequality.

[45] Intuitively, with increasing returns to scale there is a factor which counteracts the effect of decreasing profits per employee from the standard model. To insure constant profits, this implies that employment must grow more slowly as compared to the linear production case. A decreasing wage offer density guarantees employment growth to be slowly.

Note that the existence of mass points in the wage distribution makes it reasonable to think about rationing of jobs (see Ridder and Van den Berg (1997)), because there are cases where profits at the mass point are higher with lower employment. The model of Holzner and Launov (2005) does not account for this possibility which must be seen as a drawback. Chapter 5 of this dissertation removes this drawback, by endogenizing λ.

2.5 Conclusion

The aim of this paper is twofold. On the one hand, it presents models of the labor market that give ample consideration to the frictional character of the labor market. A number of models that explicitly take account of the incompleteness of information and the process of acquiring information are introduced. In the basic model, an equilibrium wage distribution is derived for ex-ante homogeneous employees and employers. In extensions to the model, the impact of differences on the employer and employee sides on the resulting equilibrium wage distribution are examined. Because heterogeneity of the actors in the labor market is seen as an important factor, it is sensible to study models that explicitly model heterogeneity on both market sides and that are still analytically tractable. All these equilibrium search models are seen to be able to generate residual wage dispersion, which is an important component of wage dispersion as a whole (see e.g. Juhn, Murphy, and Pierce (1993) and Katz and Autor (1999)). Thus, this models contribute to our understanding of wage inequality and its changes.

On the other hand, the impact of unions on wages is considered in this paper, since in the German context their influence is considered especially important. It turns out that the union compression hypothesis, i.e. the assumption that union wage compression leads to higher unemployment, is not supported by all models analyzed. I obtain all sorts of employment effects: positive, zero, and negative ones. For example, in the case of continuous search costs, a minimum wage can lead to a reduction of unemployment. Where I obtain zero employment effects this stems from the fact that search frictions guarantee firms a monopsonistic position on the labor market. A minimum wage then restricts the monopsony power of firms and redistributes rents from firms to workers. Labor demand effects do not occur or only in the unlikely case where the minimum wage increases so strong that *all* matches (for a certain skill group) become unprofitable. Two of the proposed models support the union compression hypothesis: the model with endogenous technology decision, and the model with heterogeneity on both sides of the market. In the first case the reason is that the measure of firms decreases as the minimum wage increases and that therefore the contact frequency declines. In the second model, this is the case, since the minimum wage makes a part of the matches unprofitable and thus not every meeting does result in a match. A further possibility to incorporate labor demand effects in a reasonable way in a model with search frictions is to endogenize λ. This is done in Fitzenberger and Garloff (2007b). Summarizing, in the search context, no definite answer is available to the question of union influence on unemployment. In the spirit of Koning, Ridder, and Van den Berg (1995), one could argue that as long as the minimum wage is not too high, there are no employment effects of minimum wages and these only redistribute rents. However, considering the labor market as an ensemble of segmented specific labor markets, as they do, suggests that a too high minimum wage could make a whole segment unprofitable. In this case there are pronounced employment effects. Note that when search frictions or more general monopsonistic structures are important, it can be desirable to introduce or increase a minimum wage in order to redistribute rents from firms to workers without incurring the cost of increasing unemployment (see e.g. Manning (2003a)).

In sum, it can be concluded that search approaches offer a good alternative and complement to neo-classical model frameworks. It provides a basis for a better understanding of labor market mechanisms in a world of imperfect information. It adds to our understanding as far as labor market dynamics is concerned and as far as the determinants of residual wage dispersion are concerned. It thereby provides an alternative framework, for evaluating labor market policies, as for example minimum wages. It turns out from our analysis above that the impact of labor unions is complex. Further theoretical and empirical work is necessary to decide on the issue of employment and wage effects of labor unions bargaining power.

3 Employment, wages and frictions: The role of job–to–job transitions

3.1 Introduction

This chapter deduces, discusses and tests empirical implications of search theory for the German labor market and is based on Fitzenberger and Garloff (2007b).

For a long time, the literature in economics has concentrated on a static perspective of the labor market. Since Stigler's seminal paper (1961) on the effect of imperfect information in goods markets, a huge literature on price dispersion for identical products and the decision problems for either side of the market has developed. By nature, the process of acquiring information is time-consuming and therefore dynamic. We conduct an empirical analysis on labor market dynamics and wages based on this theoretical background, which is now seen as 'the canonical framework for the analysis of labor markets' in parts of the literature (Moscarini (2003)). This paper attempts to give a comprehensive empirical overview on wages and employment dynamics in the labor market without a priori restrictions on the data. We investigate differences in transition rates and in the wage structure over time and across individuals with specific characteristics. Our results cannot be used to discriminate between competing theories of the labor market in a strict sense. Nevertheless, for a number of aspects, the results allow to assess whether theoretical predictions are consistent with the data.

The motivation for considering labor market transitions and wages together builds on equilibrium search theory (see Mortensen (2003) for an overview). In their seminal work on equilibrium wage dispersion for homogeneous workers Burdett and Mortensen (1998) show that the amount of frictions determines the extent of wage dispersion for homogeneous workers in a labor market. Frictions themselves can be measured by labor market transitions. To see this, recognize that frictions persist because there is imperfect information in the labor market. Individuals do not know their outside wages and have to acquire this information in a time-consuming process. Once they have acquired the information, they process it and take the optimal decision based on a standard optimization problem. This implies, for instance, that individuals climb the wage ladder slowly, and that wage differentials diminish over time. Since jobs do not last forever, but also end for reasons beyond the control of firms and workers, the process does not converge to a single wage, and an equilibrium cross-sectional wage distribution exists.[1] This argument identifies two important friction parameters in search theory: the job offer rate and the job destruction rate.

[1] Note, that the above argument also implies that the distribution of wages in a cross section of workers is not the same as the distribution of wages in a cross section of newly created jobs.

The first can be viewed as reflecting informational frictions, being the result of the process of acquiring information. The second parameter represents the amount of turbulence and shocks in the economy (see e.g. Mortensen and Pissarides (1994)). Because of the importance of frictions for the wage distribution, we scrutinize the changes in these friction parameters over time and across demographic groups.

Human capital theory assumes that the wage growth of individuals over time is mainly caused by the acquisition of human capital while working in a given job. Search theory suggests that the main source of wage growth over the course of an individual's career is the wage growth caused by (voluntary) job–to–job transitions. This leads us to examine the wage growth associated with job–to–job transitions. Since it might be the wage-tenure profile instead of the level of wages which influences the decision to change the job, we also investigate the wage growth of job movers and stayers (see e.g. Postel-Vinay and Robin (2002b), Burdett and Coles (2003) and Stevens (2004)). Finally, we take a closer look at the determinants of changing the relative position in the wage distribution to analyze the factors determining the relative success in the labor market and the importance of job–to–job transitions in this respect.

There exists a large empirical literature that deals with labor market frictions, labor market transitions and the connection between wages and transitions. Such literature strands include the literature on empirical equilibrium search models (see, e.g., Van den Berg and Ridder (1998),Bontemps, Robin, and Van den Berg (2000) and Postel-Vinay and Robin (2002b)), the literature on returns to seniority (see, e.g., Abraham and Farber (1987), Topel (1991) and Dustmann and Meghir (2005)), the related literature on worker displacement (see, e.g., Fallick (1996), Kletzer (1998), Burda and Mertens (2001), and the literature on search frictions (see Ridder and Van den Berg (2003), Jolivet, Postel-Vinay, and Robin (2006) and Van den Berg and van Vuuren (2006)). We analyze wage mobility, i.e. changes in the relative wage position of a worker as in the study by Buchinsky and Hunt (1999) for the US, which has so far been a neglected issue in the literature for Germany.

Ridder and Van den Berg (2003) comes closest to our approach. They estimate friction parameters for France using two different methods. One method relies on the relationship between the cross-sectional distribution and the wage offer distribution which is implied by an equilibrium search model, while the other does not. Using OECD data, they also obtain estimates for Germany. Contrary to our approach, they assume that the job-offer rate on the job is identical to the job-offer rate for unemployed. Because of the disaggregate nature of our dataset, clearly, our results are interesting and complement their results. In addition, we use no constraints for estimation. Our results for annual transition rates differ considerably from theirs. Especially our estimate of the job arrival rate for the unemployed λ and the job arrival rate for the unemployed λ_L) is much higher than theirs. λ in our dataset is around 25% and our job-changing rate, which can serve as a lower bound for λ_L is around 8% and therefore around factor 3 higher than the estimate of Ridder and Van den Berg (2003).

The outline of the paper is as follows. Section 2 states the results of search theory, that motivate our analysis. Section 3 describes the data set used. In section 4, we state some facts about stocks and flows (normalized as rates), their differences across groups, and their cyclical behavior. Afterwards, we investigate in some detail the job–to–job transitions and their impact on wages for different groups. Finally, we estimate determinants of changes in the relative position of the wage distribution. The last section concludes.

3.2 Theoretical background

Starting with Stigler's (1961) seminal contribution, the early literature on informational frictions was concentrating on the search problem of individuals when confronted with different prices for a homogeneous product. It was shown that under certain circumstances the search problem can be interpreted as an optimal stopping problem, where the solution is characterized by a reservation wage/price (see DeGroot (1970)). The other side of the market was rarely analyzed in detail, i.e. it remained unclear why price/wage dispersion emerges. The matching literature (see e.g. Pissarides (2000) as a major contribution to this literature) suffers from this shortcoming. On the one hand, the motivation for the existence of an informational imperfection is argued to come from heterogeneous prices for homogeneous products. On the other hand, in this literature, there is generally just one price for homogeneous matches in equilibrium, so that it is difficult to argue why informational frictions exist. In addition, the focus of the matching literature lies on worker flows and on phenomena related to the business cycle.[2] In light of these limitations, we focus on the equilibrium search literature as an explanation of wage dispersion among potentially homogeneous workers.

Stigler's contribution already shows that the amount of information imperfection is related to the degree of price dispersion for a homogeneous product in the market. Burdett and Mortensen (1998) formalize the idea in the context of labor markets. Their model resolves the Diamond-Paradox (1971), which states that under a Poisson-assumption for job offers and wage setting by firms, a non-degenerate price dispersion for homogeneous workers cannot be an equilibrium.[3] Under Diamond's assumptions, firms have the whole bargaining power over the rent resulting from the market imperfection. In equilibrium, identical workers with identical reservation wages

[2] We thank an anonymous referee for pointing out this fact.

[3] A theoretical paper by Albrecht and Axell (1984) that implies an equilibrium wage distribution with two mass points was an earlier attempt to resolve this paradox.

are all offered their reservation wage by firms. The crucial difference in the paper by Burdett and Mortensen (1998) is that workers are allowed to search on–the–job for a better–paying job. This guarantees that the Burdett and Judd (1983) condition for equilibrium price dispersion is met, i.e. that one part of the individuals (here: the employed) is able to compare wages. This yields a trade-off in firms' wage policy, since a higher wage attracts more workers and causes the firms to lose fewer workers to competitors. This essential point of the model guarantees the existence of a non-degenerate equilibrium wage distribution among identical individuals and firms. In equilibrium, high-wage firms have higher employment, and make less profits per employee compared to low-wage firms.

The amount of wage dispersion observed in this model is directly linked to the possibility of individuals changing jobs. The more often they change jobs, the faster they climb the wage ladder towards their marginal productivity. Hence, the market imperfection is weaker and the wage dispersion is smaller. If jobs never ended, except through job–to–job transitions, unemployment would converge to zero and the wage dispersion to the marginal productivity of the individuals. So, the second determinant (and a necessary condition) for wage dispersion is the frequency at which jobs end for reasons not related to the individuals decision to change a job (called "job destruction"). If they end more often, equilibrium unemployment and therefore the inflows into low-wage firms will rise. Accordingly, the frequency of exogenous job destruction acts to increase wage dispersion.[4]

More formally: consider the model as outlined by Burdett and Mortensen (1998). Let λ_L denote the rate at which employees receive offers from competing firms (job offer rate). Further, let δ denote the rate at which jobs end for exogenous reasons. y denotes the marginal productivity and w_R the reservation wage of the individuals. Then the resulting equilibrium wage offer distribution is[5]

$$H(w) = \begin{cases} 0 & \text{for } w < w_R \\ \frac{\lambda_L+\delta}{\lambda_L}\left(1 - \sqrt{\frac{y-w}{y-w_R}}\right) & \text{for } w_R \leq w < w^o \\ 1 & \text{for } w \geq w^o \end{cases} \tag{3.1}$$

Hence, the wage distribution is determined by the two frictional parameters λ_L and δ, the marginal productivity and the reservation wage. However, what is observed in the data is not the wage offer distribution but the distribution of paid wages. The distribution of paid wages

[4] Both statements are only correct under some parameter restrictions. See Van den Berg and Ridder (1993).

[5] A derivation of this formula can be found in Garloff (2003).

$G(w)$ is determined by the wage offer distribution and just the parameters λ_L and δ. The variance of the actual wage distribution is given by (see Van den Berg and Ridder (1993), p.48ff.)

$$var_G(w) = 1/3(y - w_{min})^2 \eta(1-\eta)^2, \tag{3.2}$$

where $\eta = \frac{\delta}{\delta+\lambda_L}$ is a frictions indicator often used in the search literature, and w_{min} is a minimum wage (when there is not minimum wage then w_{min} corresponds to w_R). This shows more formally our motivation to deal with labor market dynamics and therefore with the transition rates when thinking about wages. The above formulas imply that informational frictions are an important determinant of the observed wage structure.

There are two major objections against this model. First, an important drawback is that the model assumes homogeneous individuals and firms. It is difficult to argue that, even after a market segmentation, individuals are homogeneous or at least not distinguishable from the point of view of the firm. For instance, Abowd, Kramarz, and Margolis (1999) find a strong individual component in the determinants of wages. Second, the resulting distribution of actual wages $G(w)$ is skewed to the left.[6] This is at odds with observed wage distributions which are typically skewed to the right. Even after a segmentation of the labor market in (more or less) homogeneous segments, e.g. in age-education cells as in Fitzenberger and Garloff (2005b), or in age-education-profession-industry cells as in Van den Berg and Ridder (1998), (German and Dutch) wages are not skewed to the left.[7]

In reaction to these objections, several extensions have been discussed including exogenous or endogenous heterogeneity on the side of the firms (see e.g. Bontemps, Robin, and Van den Berg (2000), Acemoglu and Shimer (2000)), exogenous or endogenous heterogeneity on the side of the workers (see e.g. Burdett and Mortensen (1998), Moen (1999)) or exogenous heterogeneity on both sides of the market (see e.g. Postel-Vinay and Robin (2002b), Teulings and Gautier (2004)). However, all these models have in common that wages are determined partly by search frictions. So the fundamental insight of the basic model is robust: there is a close relationship between labor market dynamics and the wage distribution along the arguments of equilibrium search theory.

Let us summarize our theoretical section by stating empirical implications of search theory.

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[6] Intuitively, the fact that both wage distributions have an increasing density means that the trade off between the number of employees and the profit per employee generated by on the job search is so strong that not only the employment over all firms increases with the wage, which would also be the case if there was the same amount of firms offering each wage. But, the effect is so strong that there are even more of these bigger firms offering the higher wage.

[7] On the contrary, Gautier and Teulings (2006) conclude in their application for six OECD countries, including Germany, that the theoretical prediction of a left skewed wage distribution is in accordance with the data.

- There is a close relationship between wages and labor market frictions. Labor market frictions in the sense of this paper are informational imperfections and, basically, constitute barriers to mobility. They cause economically motivated labor market transitions not to take place immediately. Labor market transition rates are indicators of labor market frictions.

- Transitions between unemployment and employment depend on the job offer rate when unemployed, job–to–job transitions depend on the job offer rate when employed. Both rates depend both on macroeconomic conditions (e.g. labor market tightness) and on individual behavior (e.g. search intensity).

- Transitions from employment to unemployment depend on the exogenous job destruction rate and therefore on the business cycle.

- The job–to–job transition rate depends on the wage earned in the current job because the probability that an i.i.d. offer from the wage offer distribution exceeds the current wage declines with the level of the current wage. By the same argument, the job–to–job transition rate also depends on age, since individuals climb the wage ladder as time progresses.[8]

- The simple equilibrium search model is a model for homogeneous individuals and therefore does not make any predictions how the different rates vary with education, sex, nationality, marital status, professional status, or sector. However, when interpreting the model as a model for homogeneous market segments, it is important to take account of these differences. In contrast, the displacement literature (Burda and Mertens (2001)) emphasizes that individuals, who loose their jobs involuntarily, loose human capital, and experience wage cuts even if they find employment again.

- Job–to–job transitions are the crucial determinant of wage growth in an individual's career. From the point of view of the simple equilibrium search model presented above, they occur exclusively because of wage gains.

- Average wage gains through job–to–job transitions decrease with the earned wage and with age, since older individuals earn more on average.

- The share of job–to–job transitions involving wage gains decreases with age, since the number of job–to–job transitions that are economically motivated in the sense discussed above decreases, holding other noneconomic reasons that cause job–to–job transitions constant.

[8] This holds true only if $\lambda_L > \delta$. In our application, this condition is met (see table C.3).

3.3 Data and definitions

The empirical analysis is based on the IAB employment sub-sample (IABS), a large administrative data set for Germany for the time period 1975 to 2001, see Hamann (2004). The IABS contains information from two sources. The first source are the employment statistics based on the integrated notification procedure for health insurance, social security, and unemployment insurance. This way, employers are required to report employment under the social security system which covers about 80% of all employees. Civil servants, self-employed, helping family, students, and employees earning less than a certain low threshold income are not covered by the system. The second source for the IABS are the transfer payments to the unemployed.

The two sources are merged together for a two percent random sample of employees from the social security records. Therefore, by construction, the data set is representative regarding employment covered by the social security system but not regarding the stock of unemployment. The information on timing (daily!) of being in one labor market state (spells) and on the gross daily wage (rounded to DM/Euro) are exact, except for the wage being censored at the upper social security threshold. Typical panel data problems like panel mortality or commemoration error do not arise. In addition, the data set is large (about 21 million observations) and (depending on the interpretation) representative for all persons who have been employed at least once in a job that is part of the compulsory notification procedure during the observed 27 years (more than 80% of all workers). We observe the three labor market states: employed (E), recipient of transfer payments (i.e. unemployment benefits, unemployment assistance and income maintenance during participation in training programs, BR), and out of sample (OOS).[9] Unfortunately, none of the two last categories corresponds exactly to the economic concept of unemployment. The second state is likely to approximate unemployment better than the third one, since every person being recipient of transfer payments is indeed unemployed from an administrative point of view.[10] On the other hand, there are persons who are registered unemployed but who are not entitled to receive transfer payments. During this time, these people are not recorded in the IABS. Thus, they cannot be distinguished from self-employed, civil servants, people being out of labor force and others (see above) who are at least once employed in a recorded job during the time period under investigation.

[9] In addition, we could distinguish between people being out of sample between two spells of different states and between people who are at one point in time not in the data set, but where there is no spell either before or afterwards (broad definition). As an extreme case, the latter might include persons who are dead, whereas the former does not. For most analyses, we use the narrow definition of the third state, i.e. only out of sample spells where there are spells of different states both before and afterwards. Although then, the state OOS is not representative any more, this narrow definition seems more appropriate for our analysis.

[10] With the exception of participants in a training programme. We basically view them as being unemployed since the goal of the programme is to improve the reemployment chances in the future.

We calculate transition rates between the three states, excluding individuals that have been employed at least once in East Germany, individuals who had a minor employment after 1998 and workers who had parallel employment spells at least once.

These restrictions reduce our sample to 12.2 millions observations. Annual transition rates are based on the labor market state on January 1st of each year.[11] Transitions from employment to receiving transfer payments are interpreted as transitions to unemployment,[12] since the benefit entitlement period is six months after an employment spell of six months, and it increases to one year after a two year spell.[13] In addition, the correlation between the administrative unemployment rate and the share of benefit recipients in our sample is near one. In contrast, transitions from unemployment into employment are not that easily approximated by transitions from receiving transfer payments to employment. Long–term unemployed, whose benefits are exhausted, might find a job, and there might be people shifting from the state receiving transfer payments to the state out of sample by becoming a civil servant or by becoming self–employed. Therefore, in the empirical section, we use different definitions of unemployment to check for consistency of the results.

As wage information we use daily gross wages given in the data set, which are censored from above at the upper social security threshold. Since the censoring threshold is not precise in the data, we observe wages which are slightly above the social security threshold and a clustering of wage observations below this threshold. In addition, for data reasons, there exists another category (wage 400) in the data which indicates censoring. Where we need the wage information, we censor the wages slightly below the social security threshold and replace the censored value by a conditional expectation from a Tobit regression. Thus, we assume that log-wages in every cross section (after conditioning for demographic characteristics) are normally distributed.[14] There is also a lower bound in the wage distribution which stems from the fact that, below a certain salary threshold, jobs are not subject to social insurance contributions (i.e. the wage distribution is truncated from below).[15] About 0.6% of the employment spells fall into this category. We

[11] The yearly structure implies that our sample is a stock sample, which itself implies a length-biased sampling problem when estimating transition rates. Both short employment and unemployment spells are underrepresented in the data set.

[12] The largest group of workers not contained in the data set are civil servants who are typically tenured ($\equiv$ no risk of unemployment).

[13] However, we have to note that at least for the US, it is known that most new jobs end early. Farber (1999) finds that in the US about one third of all new full-time jobs end in the first six months, while about two thirds end within the first two years.

[14] We censor slightly below the threshold because of the clustering around the threshold and since we suspect that there is no real clustering around the social security threshold (see Fitzenberger and Reize (2002)). In the case of clustering, Tobit estimates based on the rounded official daily threshold yield unsatisfactory results, since the estimator tries to fit a fairly high density slightly below the threshold.

replace the censored value for part-time employees and apprentices by a conditional expectation from Tobit regressions.[16] Around 74% of these censored spells involve apprentices, whom we typically exclude from our analysis of wage mobility. Part-time employment, which accounts for further 8% of these censored values, is also excluded from most of our analysis on wage mobility. For benefit recipients, we replace the wage by their last inflation (≡CPI) adjusted wage. For about 5% of the employment spells, the wages are not available because of data errors (wage 0). For the analysis of wages, we exclude these spells. There is a second problem with missings in the wage data. Namely, there are benefit recipiency spells which are extrapolated backwards before the first employment spell of an individual. Again, we exclude these spells for the analysis of wages. Finally, there exists a structural break for wages between 1983 and 1984. Since 1984, but not before, one-time wage payments and non-monetary benefits are covered by the wage variable. We use a time trend and/or year dummies to control for this institutional change. When using wage dispersion measures, we calculate them from the cross sections of employees on January 1st.

For the analysis of wage mobility, we construct three skill groups from the education information: The first category corresponds to persons who have neither a completed vocational training nor a university degree (low-skilled). The second category consists of people who have finished a vocational training degree but have no university degree (medium-skilled). The third group corresponds to persons who have a university degree or a degree from a technical college (high-skilled). Note that the education information in the IABS is not always consistent across time so that we corrected the education information based on the simple rule that a degree obtained cannot be lost.

3.4 Empirical results

This section first provides a broad description of stocks and flows as the background for our subsequent analysis. Then, we investigate job–to–job transitions and associated wage changes. Finally, we analyze the wage distribution and examine determinants of wage mobility. All tables and figures can be found in the appendix.

[15] The data set records such jobs only since 1998 but even before 1998 there are wages below this threshold which are therefore censored and set to 1 in the data set. This is due to the fact that there are both wage and working time criteria for a job not to be subject to social insurance contribution.

[16] For other employees we suspect that the low wage notifications are incorrect and therefore we set the censored wage values to missing.

3.4.1 Stocks

Figure C.1 and table C.1 describe the stocks in different labor market states over time and across different socio–demographic groups. Since most findings are as expected, we only briefly discuss these results. Table C.1 shows a benefit recipiency rate of about 7% and a rate of 12% of individuals being out of sample (narrow definition, see footnote 9). About 81% of the individuals are employed. Figure C.1 show the development of the benefit recipients and people being out of sample over time. The number of individuals being out of sample shows a hump-shaped trend over time. This is caused by the sampling design of the data set, see section 3.3.[17] Higher unemployment and institutional changes (such as a prolongation of unemployment claims) are reflected in the higher share of individuals that are registered as benefit recipients at the end of the 90s. The rate of benefit recipients shows a stepwise increase, analogous to the widely discussed ratchet effect for the trend in the unemployment rate (Franz (2006)). Employment growth is positively correlated with the real (West-German) GDP growth (correlation coefficient 0.50), whereas the growth rate of benefit recipients is negatively correlated to real GDP growth (correlation coefficient of -0.67). The growth rate of persons being out of sample is weakly negatively related to real GDP growth (correlation coefficient -0.24).[18] The rate of benefit recipients in our data set shows a strong positive correlation with the official unemployment rate (0.95) and a strong negative correlation with the inflation rate.

Table C.1 shows that by far the biggest professional group are clerks (more than 40%), whereas the smallest group are foreman (less than 2%). Apprentices account for almost 7% of all employees. Unskilled workers show the highest benefit recipiency rate (12.7%). The lowest benefit recipiency rate is found for clerks (4.6%), apprentices (3.8%), and part-time workers who work less than half of the normal time (1.5%). Foremen have the lowest rate of persons being out of sample (5.3%), while part-timers that work less than half of normal time have the highest rate (34.9%). Regarding education, the benefit recipiency rate decreases as expected with the educational level. The rate is 9.4% for persons who do not have any degree and it is 3.6% for polytechnic and university graduates. Foreigners account for 8% and they show a slightly worse labor market performance than Germans. As expected, males are overrepresented in the data compared to females because sampling is based on employment. The benefit recipiency rate among females is slightly lower and the out of sample rate is considerably higher than among males. Regarding age, the benefit recipiency rate increases strongly with age and the out of sample rate shows a hump shaped pattern between 16 and 61 years.

[17] Out of sample observations at a certain point of time in the middle of the observation period are more likely to be sampled compared to observations close to the boundaries of the observation period.

[18] The data for the business cycle are based on Statistisches Bundesamt (2000) until 1991 and own calculations for GDP growth in West Germany, based on the data available for the West-German "Länder" (www.destatis.de).

3.4.2 Flows

There exists a large literature on worker and job flows in the labor market.[19] The literature mainly focuses on the forces behind and on the regularities of worker and job flows, e.g. their cyclical behavior. Our data allow us to identify worker flows, i.e. job–to–job transitions associated with a change in establishment.

Based on table C.2 about 8% of the previously employed change jobs, about 3% become benefit recipients, and a further 3% move out of sample. About 3% leave the data set (e.g. because of retirement, death, or business start–ups), while more than 82% stay with the same employer or experience recalls. Hence with only about 18% of all workers leaving their current job per year, the German labor market exhibits higher employment stability than the US labor market where this number is about 37%. Between one and two percent of the about 90% who remain employed in two consecutive years have an intervening benefit recipiency spell and another one to two percent have an intervening spell out of sample (not in the table). Once individuals are benefit recipients, they are employed again in the next year at a rate of 24%. Similarly, about 24% return to employment when they are out of sample. About 48% of the benefit recipients are benefit recipients in the next year, while about 13% change to the state out of sample and another 14% leave the data set. Individuals that are out of sample remain in more than 64% of the cases in this state in the following year, while about 10% become benefit recipients (probably with an intervening employment spell) and 3% leave the data set (with an intervening spell of either employment or benefit recipiency).

Turning to the cyclical behavior of transition rates, figure C.2 shows the percentage of individuals who changed their job during one year relating to all individuals employed at the beginning of the year. There is a weak cyclical structure for job–to–job transitions and the rate is positively related to real GDP growth (correlation coefficient 0.33), whereas the correlation between the rate of persons who remain in the same establishment with the business cycle is a bit stronger (0.41).[20] Allowing that last year's growth might influence today's job changing rate shows that after one year the positive correlation is about the same (0.33). Figure C.3 reveals that the

[19] For a comprehensive overview, see Davis and Haltiwanger (1999). A recent paper by Bachmann (2005) analyzes the cyclical behavior of labor market transition rates in West Germany based on the IABS. His results differ from our results. A major difference lies in the definition of the transition rates. While we investigate transitions on a year-to-year basis (there is at most one transition per year), Bachmann (2005) includes multiple transitions in the calculation of transition rates, i.e. individuals with multiple transitions in a year have a higher implied rate. Our definition focuses on transitions into labor market states which are sustained for some time, thus not giving strong weight to cases with many transitions during a short amount of time.

[20] Fallick and Fleischman (2001) conclude for the United States, that job–to–job transitions are not pro-cyclical. Our numbers and theirs, however, are not directly comparable, since we relate the flows to the size of total employment, which might be responsible for the cyclical behavior.

transition rate from employment to benefit recipiency is strongly counter-cyclical, as confirmed by the negative correlation coefficient (-0.86). This negative correlation is weaker if we allow for a lag, i.e. the transition rate to benefit recipiency is correlated with the growth rate of the previous year (-0.38). After two years the correlation has vanished. This negative correlation is in accordance with the literature (see e.g. Burda and Wyplosz (1994) for four European countries and Davis and Haltiwanger (1999) for the US). Transitions from benefit recipiency to employment are not strongly related to GDP growth (0.36). The lagged transition rate shows a weaker positive correlation with GDP growth (0.30), which almost disappears after two years. The correlation of the business cycle with the outflow rate from benefit recipiency is almost zero (0.01).[21] It seems that layoffs and/or quits with a subsequent benefit recipiency spell are counter-cyclical in contrast to hirings being pro-cyclical (all transitions to employment). The outflow rate from employment is counter-cyclical as indicated by a correlation coefficient of -0.82, thus the probability to remain employed is pro-cyclical (see table C.4). The fact that we have the counter-cyclical structure for job separations is in accordance with the view that a downturn might have a cleansing effect in the sense that unproductive jobs are destroyed. Note that job–to–job transitions may as well serve as a means to improve match quality, but job–to–job transitions are higher in an upturn compared to a downturn.

Table C.3 shows differences across demographic groups.[22] We observe three states and four transitions for each of the three states, since there is one state that indicates that an individual has left the data set and that he does not return any more. In addition, for the employed we also report the transition rate from job to job.

Search theory argues that individuals draw i.i.d. wage offers from some wage offer distribution at a constant rate. When individuals earn higher wages, wage offers exceed their earned wage more rarely, i.e. the job changing rate decreases with wage. This argument is confirmed in table C.3, which measures the wage position by the tercile of the wage distribution. The risk of becoming benefit recipient or changing to the state out of sample shows similar patterns and declines with age. Likewise, the frequency at which individuals stay with the same employer strongly increases with the wage. The transition rate from benefit recipiency to employment is highest for low wages, while the rate of remaining benefit recipient is highest for high wages. While individuals with low wages comparatively often change to the out of sample state, high-wage individuals

[21] Here, Burda and Wyplosz (1994) and Davis and Haltiwanger (1999) conclude for the outflows from unemployment that they are counter-cyclical. Again, the differences to our results might come from the fact that we normalize by the number of unemployed, which might be responsible for the weakly pro-cyclical behavior in our data set.

[22] Note that the (weighted) mean of the transition rates for those demographic characteristics which can change over time is not necessarily equal to the transition rate over all individuals, since we include in our analysis only individuals that maintain the same characteristics in two consecutive years.

often leave the data set completely once they are benefit recipients. The transition rates from out of sample to other states also differ considerably.

Table C.3 shows pronounced differences in transition rates across age groups. Economic theory predicts that older individuals are on average in a better position in the wage distribution so that they accept wage offers from competitors more rarely. Therefore, we expect that the job changing rate declines with age. This is confirmed by the data.[23] Suitably, the frequency with which individuals stay with the same employer increases from age 26 to age 50 and declines afterwards. The benefit recipiency risk is high for young individuals up to 30 years and for elderly people from 56 onwards. The risk of moving out of sample is highest for individuals aged 21 to 25 and decreases afterwards, while obviously the probability of leaving the data set is very high for people aged 56 and older. The transition rate from benefit recipiency to employment is highest for individuals between 21 and 25 and decreases monotonically with age afterwards. The frequency at which individuals remain unemployed in two consecutive years increases from 44% for the 21 to 25 age group to 63% for the 51 to 55 age group and then decreases rapidly. The transition probability to the state out of sample is high until age 35 and decreases afterwards, while the probability of leaving the data set starts to increase from age 36 onwards. The outflow rate from the state out of sample to employment decreases continuously with age, while the probability to remain out of sample decreases from age 20 onwards. The inflow rate from out of sample to benefit recipiency increases monotonically up to age 60 and the probability to leave the data set is particularly high for the elderly. Since unemployment–to–job transitions are rarer for older individuals, search frictions seem to be higher for this group, while the job destruction rate declines at least up to age 50 indicating less frictions.[24]

Education is an important determinant of economic outcomes. However, simple equilibrium search theory does not make clear predictions on the effect of education on transition rates. Table C.3 shows that the job changing rate increases with educational attainment. While medium-skilled individuals are most likely to stay with the same employer, high-skilled individuals are more likely to change jobs. Clearly the benefit recipiency risk and the risk of moving out of sample is highest for low-skilled individuals and decreases with educational attainment. For benefit recipients, the job finding rate increases with education as well. Individuals without any degree have by far the highest probability to remain unemployed in two consecutive years. If

[23] Farber (1999) finds that the job–to–job transition rate declines with tenure. This is consistent with our observation on the behavior of this rate with age if older persons have on average longer tenures, which is always true if the job offer rate for unemployed is higher than the job offer rate on the job plus the job destruction rate.

[24] In Fitzenberger and Garloff (2005b), we distinguish transition rates for prime-age working males by age and education. There are pronounced differences across age and education groups which are mostly in accordance with the search-theoretic framework.

individuals are out of sample, their transition rate to employment increases with education, while the transition rate to benefit recipiency decreases with education. Summing up, as expected, the situation is more favorable for the high-skilled, which means, in terms of search theory, that there are less frictions for the highly educated.

Regarding gender differences, women stay more rarely with the same employer over two consecutive years, while all other transition rates are a bit higher. If women are benefit recipients, they remain less often in this state than men (42% versus 51%), because they move out of sample more frequently. From out of sample, women remain there more often than men (67% versus 61%) with all other rates being lower. Germans seem to be better off in the labor market exhibiting a higher probability to change jobs as well as to remain in the same job and lower probabilities to move to benefit recipiency, out of sample, or to leave the data set. For benefit recipients, the differences are not large, but Germans are more likely to return to employment. In the state out of sample, foreigners have a lower probability to remain there for another year. They move more often to the state benefit recipiency and disappear more often from the dataset.

Regarding the professional status, especially clerks often change jobs. This might be due to scale effects of markets, since clerks are the biggest group and since therefore it might be easier to get in contact with a new job. In contrast, foremen are the least mobile full-time group and they stay most often with the same employer. Unskilled workers (and home workers) have the highest benefit recipiency risk, while clerks have the lowest full-time risk. Apprentices and part-time employed most often change to the state out of sample. Part-time employed also leave the data set fairly often. The highest transition rate from benefit recipiency to employment is found for clerks. Again, this might be due to scale effects.[25] Unskilled workers are most likely to remain unemployed in two consecutive years, while clerks have the lowest probability. Foremen show the highest propensity to leave the data set and most frequently return from the state out of sample to employment (besides home-workers), while they remain rarely in this state in two consecutive years.

Concluding, we find clear differences in almost all characteristics that we have looked at. Some differences are consistent with economic theory, whereas others are not. It is important to take account of these differences. Differences across characteristics indicate differences in the degree of frictions, which can explain differences in economic outcomes.

[25] Petrongolo and Pissarides (2002) find in their analysis for the UK that scale effects are reflected in higher wages and not in more matches, since the reservation wage of the individuals reacts to a higher job-offer rate.

3.4.3 Wage changes following job-to-job transitions

This section explores the effect of job–to–job transitions on wages. This is important for several reasons and there exists a large body of literature on the effect of seniority on wages (see e.g. Dustmann and Meghir (2005)) and on the effect of voluntary and involuntary mobility on wages (see, e.g. Burda and Mertens (2001)). It is often argued that due to accumulation of specific human capital wages increase with tenure.[26] An alternative view argues that tenure effects are the result of shifts in the composition of employment. High-wage jobs are more likely to survive, so that we observe that long tenures and high wages are correlated (sorting bias). Third, from the search-theoretic perspective, with increasing experience individuals have received on average more job offers from competing firms, which might lead as well to job–to–job changes associated with wage gains (see Burdett and Mortensen (1998) for a theoretical model) or to higher wages in the specific firm if firms can counter wage offers from competing firms (see Postel-Vinay and Robin (2002a)).[27] So the fact that we observe less job–to–job transitions and higher wages as people age might stem from the fact that they have acquired a lot of specific human capital which they would loose when changing jobs or from the fact that they simply have higher wages because of more offers from competing firms, so that on average job offers rarely exceed their wage. Note that, from this perspective, job–to–job transitions are the central source of wage growth and that they play a critical role in equilibrium search models. Most of the existing equilibrium search models that derive an endogenous wage distribution depend critically upon the fact that workers can search on the job.[28]

Both the effect of seniority on wages and effects of mobility on wages have been discussed intensively in the literature. The literature on mobility, though, is often motivated from a more geographical perspective. Regarding the interaction of mobility, human capital, and wages the literature is more narrow. Examples for studies addressing this problem in a non-structural way are Antel (1986), Light and McGarry (1998) and Zwick and Kuckulenz (2005). In the following, we analyze in detail the wage changes associated with a direct job–to–job transition, defined as a transition from one establishment to another within 15 days. In addition, we condition on the fact that the previous job and the new job last for at least three months.[29] Recall that the average annual job-changing rate lies around 8%. This does not exactly reflect the job–to–job

[26] This argumentation can be traced back to Becker (1964).

[27] In addition, there might be a match-specific component that does not result from higher productivity but from better information about the match (see e.g. Moscarini (2003)).

[28] For an exception, see e.g. Acemoglu and Shimer (2000) where the decision problem is not sequential, and Teulings and Gautier (2004).

[29] Alternative definitions consider individuals that have changed jobs without long phases of interruption or simply individuals that are known to have changed the job within a year (analogous to the definition in the previous subsection). We give numbers for these alternative definitions as well.

changes we define here, since there are individuals who change jobs and return to the previous employer afterwards (recalls) or individuals who change jobs and then become benefit recipients or move out of sample afterwards. Furthermore, there are individuals who change jobs more than once within one year and individuals that change jobs with longer phases of interruption. However, we constrain ourselves to these selection of individuals to avoid that multiple trippers, as e.g. artists, with huge income swings affect our results.

Overall, we observe about 714,000 direct job–to–job transitions over the 27 years and the development over time is similar to the normalized measure in figure C.2. Among the 570,000 direct job-to-job transitions within the full-time category (excluding apprentices), 65% of the individuals gain from a job–to–job change, whereas 28% experience wage cuts.[30] Average gains for the 65% that have wage increases are quite high with an average gain of 27% (median 14%) relative to their previous wage. The average loss of the individuals suffering a wage cut is about 16% (median 11%). Among the 225,000 individuals (within the full time category) that have exactly one job-to-job transition within a year with a break of a maximum of 14 days, about 63% experience a wage gain, while 28% experience a loss. The average gain among the winners is 29% (median 18%) compares to an average loss of 14% (median 10%) among the losers. Additional roughly 34,000 full-time employed individuals have more than one job-to-job transitions (without long breaks) within a year, but including them does not change the picture. Following the approach in subsection 3.4.1 and considering all full-time employed individuals that have changed the employer throughout the year, we observe about 348,000 such individuals, where about 62% win (33% on average, median 18%) and 30% loose (18% on average, median 13%).[31] These results are broadly consistent with the wage change being a crucial determinant of the decision to change a job, as purported by search theory. In general, individuals gain considerably from job–to–job transitions. But, even within the category of full-time employees, there remains a significant proportion of job changers with wage cuts. This is difficult to reconcile with standard search theory, although more advanced theoretical models are able to explain this (see Jolivet, Postel-Vinay, and Robin (2006) or Postel-Vinay and Robin (2002b)).[32] The evidence is of course

[30] This number is roughly comparable to the numbers that are found by Jolivet, Postel-Vinay, and Robin (2006) using the ECHP. Note, that it is possible that our estimator for the direct wage gains (losses) slightly overestimates (underestimates) the real wage changes because the wages are averaged for each spell. It is possible that the wage at the time when the spell ends is higher than the one reported (or the one at the beginning of the spell), while the wage at the beginning of the next spell can be lower (or higher) than the one reported. Major wage changes within a firm however are likely to be reported, because in general they will be linked to a change in the position. In addition, (major) wage changes within the firm will decrease the probability that the individual moves.

[31] For some of these calculations we use different definitions of the censored wages to check for consistency (see appendix C.4). Since the differences are not big, we use in the following the first wage definition (wage A) where we replace censored wages by their conditional expectations from Tobit–estimates.

consistent with a sizeable share of workers being displaced (Burda and Mertens (2001)), an issue we will discuss further below.

Table C.6 shows the differences across movers within categories. If we omit apprentices (and home-workers and the missing category) from the analysis of transitions within the group of full-time employees and conditioning on the fact that both the previous and the current job last at least three months, the share of winners is markedly higher and the share of losers is lower than for all full-time employed individuals. The share of winners is around 71% and the share of losers is only 22%, while about 7% do not experience a wage change when changing jobs (probably in many cases censored values). The average relative gain of the winners decreases clearly from about 27% (table C.6) to about 20%. So does the average relative loss of the losers which decreases from around 16% (table C.6) to around 13%. The overall gain amounts to just under 12%. Among part-timers, who work less than half of the regular time, there are only few winners, while in the group of more than half part-time employed this is not the case.

Next, we separate job–to–job changes by terciles (see table C.7 of the conditional distribution of the initial wages (on age, education and year) for full-time employed West-German prime-age males. As predicted by search theory, the share of winners is highest (78%) in the low wage tercile, and much lower in the upper wage tercile (60%), while the middle wage tercile is somewhere in between (69%). However, adding the share of individuals without a wage change shows that differences might be smaller, because in the upper tercile, where censoring is a severe problem, about 15% do not experience a wage change, while in the other terciles this amounts to a maximum of 4%.[33] The share of losers increases with the wage tercile, while the middle wage tercile exhibits the highest losses. The average gain of the winners is - as expected - the highest in the lowest wage tercile (around 26%), while it is 13% or less for the two higher wage terciles. The average loss of the losers is higher for employees from the upper tercile compared to the two lower terciles.[34] Overall, the evidence is in accordance with search theory.

[32] In the first model, they introduce a new sort of shocks, so called reallocation shocks, which force individuals to change jobs irrespective of the wage offer they get. The basic idea in the second model is that people change jobs since they have better career opportunities in the new establishment, which makes them accept wage losses. In the literature, the empirical findings for the share of individuals who accept wage losses are quite different. Van den Berg and Ridder (1998) find a very small number for the Netherlands (about 11%; OSA-panel) which they interpret as measurement error, while Postel-Vinay and Robin (2002b) find a much larger number (between 36% and 55%, DADS-panel) for France.

[33] Job changes for individuals whose wages are censored before will very often result in a censored wage observation afterwards indicating no wage change, see section 3.3 for the imputation of wages in the case of censoring.

[34] If job–to–job changes under wage cuts are interpreted as reallocation shocks, as in Jolivet, Postel-Vinay, and Robin (2006), then the higher wage loss for higher wage categories is the wage ladder effect, since after being reallocated, individuals obtain offers from the same wage offer distribution which means that the loss for high-wage individuals is higher.

Across age categories, the share of winners for full-time working individuals (excluding apprentices) declines from about 79% for the youngest age group (16-20) to about 51% for the oldest age group (61-62). For the share of losers the trend is reversed. The share of losers increases from 17% for the youngest age group to 31% for the oldest age group. Relative gains are quite high for the youngest age group and then decline more or less monotonically with age from about 56% to 12%. The losses lie between 15 and 12%. Controlling for the position in the wage distribution partly eliminates this effect. It disappears for the high and the middle tercile, while it is still present for the low-wage tercile (results are omitted here).

Next, we summarize differences through regressions focusing on prime-age (25-54 years) working males and again conditioning on the fact that both the previous and the current employment spell last for at least three months. Table C.9 shows how the share of winners and losers varies by age and education. The share of winners decreases with educational attainment and is lower for some older age groups.[35] The share of losers is lower, the higher the educational attainment, while there is no clear age effect. But the share of losers is on average lower for older individuals than for younger individuals. Both the relative gain of winners and the relative loss of the losers are not significantly correlated with the share of winners and the share of losers, respectively. From this, we conclude that age seems to have at least for some age groups a significant impact on the motivation for a job–to–job change decision, with wage gains losing importance as individuals age. Table C.10 summarizes the relationship between the relative gain of the winners and the relative loss of the losers, by age and education. We find that high-skilled individuals have significantly higher gains and lower losses than low-skilled; maybe because voluntary job–to–job changes in this category are more frequent. The medium-skilled do not differ significantly from the low-skilled in the average gain but have significantly lower losses. The relative gain of the winners decreases with age, which is in accordance with search theory, but there is no significant age effect on the relative loss. The latter indicates that job–to–job changes under wage losses are not driven by economic reasons. After job displacement, a new random offer from the wage offer distribution would imply that the relative loss should increase with age. The share of winners is positively correlated with the relative gain of the winners, while the share of losers is positively related to the relative loss of the losers.

Now, we include the tercile position in the conditional wage distribution in the regressions (tables C.11 and C.12).[36] The position in the wage distribution has the expected effect on the shares and the relative gain/loss and seems to affect the effect of education and age. Based on search

[35] The regressions summarizing the correlations are simple OLS regressions with age-education cells as observation unit. Note that the share of winners is likely to be too low for the upper tercile, see footnote 33.

[36] Again, we use simple OLS regression techniques to summarize the correlations. We group individuals within age-education cells according to the wage tercile before the job change in the conditional wage distribution for the respective age-education-year cell.

theory, age should not show an independent effect on the share of winners and in fact and in fact, controlling for the wage position leaves almost all age dummies insignificant. The average age effect instead is negative for the share of losers. For the relative gain, as expected, we find that it is lower for individuals in higher wage categories and that it is higher for high-skilled individuals. As before, age has on average a negative effect on the relative gain and almost no effect on the relative loss.

Furthermore, we examine wage changes after an intervening benefit recipiency spell and categorize their duration into five intervals (again using the three months condition, see table C.8). First, most unemployment spells are very short, i.e. shorter than 3 months, or very long, i.e. longer than a year. The share of winners as compared to their last deflated wage decreases with benefit duration. But, the share of winners is similar for the shortest and the longest benefit recipient duration. Accordingly, the share of losers increases with benefit duration. Surprisingly, however, the relative gain of winners is highest for the longest benefit recipiency duration, while being similar and slightly increasing for the other groups. The relative loss of losers, on the other hand, differs less. Regarding the relative gain of winners, longer search duration seems to slightly improve the match quality, which again is in accordance with predictions from search theory. While the average change after a job–to–job transition for all individuals decreases with benefit duration, this is not the case for the long-term unemployed. Here, the longer search period leads to a higher average wage in the job after the benefit phase.

Finally, we investigate the wage changes for individuals who changed jobs (within 15 days) and compare their wage growth in the following four years with individuals without a job–to–job transition in the first year (table C.13). The results are not clear cut. From 1977 to 1982, the wage growth for changers is higher than for stayers in the first year but the differences are small afterwards. Two years after the job change, there is no difference left. After 1983, however, job changers are not in a better position anymore. In some years it even seems that job changers are in a worse position than job stayers, possibly reflecting compositional effects.

Summing up, wages seem indeed to play a crucial role for job–to–job changes, in accordance with search theory. On average, almost all changes involve remarkable average wage gains. Notwithstanding non-monetary motives, job–to–job changes appear to advance one's career through higher wages. However, a significant proportion of job–to–job changes are associated with wage losses. While job displacement associated with finding a new job immediately might account for part of these wage losses, it is unlikely that such a high share of wage losses can be attributed to this effect alone or to measurement error (as in Van den Berg and Ridder (1998)). We find some evidence against the displacement hypothesis. Here, an investment motive based on the anticipation of later career opportunities as in Postel-Vinay and Robin (2002b) or in Burdett and Coles (2003) provides an alternative explanation which needs to be explored in future research.

Furthermore, there are pronounced differences between different demographic groups (which we do not discuss here), that are not easily explained by economic theory, and there are differences between full-time and part-time. Thus, noneconomic factors are likely to influence the decision to change a job. In accordance with search theory, the frequency and the size of wage gains are highest for workers in the lower part of the wage distribution conditional upon age, education, and year.

3.4.4 Wage distribution and wage mobility

This section analyzes the wage distribution for different groups and the determinants of changes in the relative wage position. First, figure C.4 and C.6 show the distribution of log-wages in a cross section of individuals on 1 January 1986 for all full-time employed individuals (including apprentices, figure C.4) and for clerks only (figure C.6). For comparison, figures C.5 and C.7 display the distribution of log-wages for clerks in 1976 and 1996. The distribution of log-wages does not appear (censored) normal because of the thin left tail. Kolmogorov-Smirnov-tests confirm this: for each partition of the sample, we reject the hypothesis that log-wages are normally distributed.

Here, the analysis is restricted to individuals who are employed in two successive years. Our interest is on career advancements and its determinants, especially job–to–job transitions. We take such employees, define their position in the wage distribution in the first year (measured in deciles) and observe which decile position they hold in the next year, depending on their characteristics. For each (age-education) group of individuals, a 10x10-Matrix captures the transitions in the decile position. Then, we aggregate this information in an ordered Probit model and obtain for each individual one of the three outcomes upward, no change, or downward mobility in the decile position. If an individual's wage is censored, we observe the individual in the decile of the wage distribution where we observe censoring for the first time coming from below, i.e. when the sixth decile is the first censored decile (that is, more than 40% of the wages are censored, which is often the case for the high-skilled group aged 31-33), all individuals are observed in this decile. If an individual's wages are censored in two consecutive years, we will observe no wage change if the first censored decile is the same in the two consecutive years (the most plausible case). In the case where the first censored decile is lower (higher) than in the previous year, say the fifth, we interpret this as wage cuts (increases) for all censored individuals.

We start with the ordered Probit model in table C.14 based on those individuals who are employed in two consecutive years. The dependent variable is 1 if an individual moves up by one or more deciles of the wage distribution, it is 0 if the individual stays in the same decile, and it is -1 if the individual moves down by one or more deciles. For this analysis, we include only prime-age males in the age group 25 to 54 years, disaggregated in three year age intervals. Among others, the set of covariates in table C.14 includes the interquartile range in wages, the rate of job changes, and the stayer rate in employment by age-education cell, as well as a dummy for a job–to–job transition at the individual level (different employers in the two consecutive years).

The age-education cell with the lowest age and the lowest education level and the year 1975 are chosen as omitted categories. The probability of climbing the wage ladder decreases significantly in age and is higher for the two higher skill levels. This result is in accordance with search theory. The dummy variable for job–to–job transition is also highly significant and positive, thus job–to–job transitions involve upward wage mobility as predicted by search theory.[37] The impact of the cell-specific variables, the wage dispersion measure (iqr), the transition rate from job–to–job, and the retention rate in employment is difficult to predict. On the one hand, it seems plausible that higher wage dispersion is favorable for upward wage mobility because the return to search is higher. On the other hand, if wage dispersion is high, this means that search frictions are large and we observe little (upward) wage mobility. This effect works through a low job–to–job transition rate and a high job destruction rate. Our results support neither of the arguments; the effect of the wage dispersion measure on mobility is positive but not significant. The job–to–job transition rate is not significant, thus rejecting the above argument. The retention rate in employment (≡(1-job destruction rate)) has a small but (weakly) significant negative effect on upward wage mobility. With an increasing probability of remaining employed, individuals seem to be more willing to accept wage cuts which contradicts our argument and which seems consistent with the investment motive mentioned above.

Table C.15 shows a similar analysis replacing the year dummies with a linear time trend and allowing for interactions between job–to–job changes and age. The effects of age group and education category are similar in magnitude and significance. The job change dummy effect is now somewhat larger and job–to–job changes have a smaller effect on the probability for wage increases as individuals age. This is in accordance with search theory, since older individuals have on average a better position in the wage distribution, and therefore their propensity for upward wage mobility through job–to–job transitions decreases. As argued before, it might be that a bigger share of job–to–job transitions are not economically motivated as individuals age.

Separate analysis for the different education groups and for job changers and stayers, the results do not differ much (see tables C.16 and C.17). However, for high-skilled workers we find that the effect of age on upward wage mobility is not significant for the younger age groups and then negative, which can be due to university graduates entering the labor market later. Furthermore, the effect of age on the propensity for upward wage mobility shows a similar pattern for

[37] Of course, the job change indicator is endogenous. However, from a search-theoretic perspective, it is irrelevant whether the job change takes place because the individual obtains a higher wage offer or whether the individual obtains a higher wage because he changes the job.

all education groups and for changers and stayers. It becomes more pronounced with higher education. For example, in the group of stayers, the coefficients for age range from -0.07 (28 to 30 years) to -0.27 (52 to 54 years) for the low-skilled and from -0.09 (28 to 30 years) to -0.83 (52 to 54 years) for the high-skilled. Interestingly, the effect of wage dispersion is positive for changers and stayers in the two lower education groups, while it is negative for the high-skilled, however, the latter results might be questionable because of censoring. These results seem to be offsetting when pooling the three education groups. For the stayer rate in employment, a similar pattern is found. While the coefficient for changers and stayers is negative for the two lower education categories, it is smaller or close to zero for the high-skilled. When pooling the education category, the overall effect is negative. The effect of the job–to–job transition rate is insignificant for all education groups.

Finally, we classify the group of individuals with transitions from unemployment to employment by the positions of their wage in the contemporaneous wage distribution before and after unemployment (see table C.18). Based on these data, we perform the same analysis as before. The age profile shows a similar pattern as before for low-skilled and medium-skilled individuals. For the high-skilled, no such clear pattern is found and only few coefficients are significant. The wage dispersion measure and the transition rate from employment to benefit recipiency are not significant (at the five percent level) in either model.

Summarizing our findings, job–to–job transitions are strongly related to wages. We find that age shows a strong negative effect on upward wage mobility. Elderly individuals are less likely to experience wage gains. The same holds for older individuals changing jobs: they gain less than their younger counterparts. This is in accordance with job search theory. Furthermore, education has a strong positive effect on upward wage mobility. A possible explanation could be that the informational situation is better for the high-skilled. Cell-specific macro variables apparently do not have the same effect on the three education groups with different effects for the high-skilled. The partial correlation of the stayer rate in employment and the upwards wage mobility is positive for the low-skilled and the medium-skilled. For the high-skilled, this correlation is negative. Similar results are observed for other macro variables.

3.5 Conclusion

Using equilibrium search theory as the theoretical background, this paper presents a descriptive empirical analysis exploring labor market dynamics and the wage structure in Germany. We find considerable differences in labor market transition rates over the business cycle and across demographic groups, which can partly be explained by search theory. Our analysis also explores the wage structure and determinants of wage changes. Wage changes following job–to–job transitions are quite remarkable and most job changes involve wage gains. There exists a considerable number of individuals who do not gain from job–to–job changes, which is unlikely to be explained solely by the displaced workers, who quickly find a new job, or by measurement error. Nevertheless, this finding contradicts the simple equilibrium search model, as outlined in the theoretical section.

Further findings are that, first, part-time employees gain less from job–to–job changes than full-time employees, which we can not explain easily by economic theory. Second, job–to–job changes in the low-wage group often involve wage losses. We show that wages are neither log-normally distributed for either group we looked at, nor that the wages for a homogeneous age-education group are skewed to the left. This can be taken as prima facie evidence against equilibrium search theory, implying a wage distribution skewed to the right. Regarding upward wage mobility, age (negative) and job–to–job transitions (positive), as well as the interaction between the two (decreasing with age) show the expected relationship. Also, education effects appear to be in accordance with theoretical considerations. The effect of cell specific macro variables appear to vary across the education groups. High-skilled workers differ somewhat from the other groups.

Clearly, the non-structural approach taken here does not suffice to evaluate a complex set of theories. Nevertheless, our comprehensive descriptive analysis provides some clear insights. As a crucial part of equilibrium search theory, job–to–job transitions show a close relationship with wages and the wage distribution, mostly in accordance with theoretical considerations. In contrast, job displacement seems to play at most a minor role in explaining this relationship.

4 Employment, wages and frictions: Testing between frictional and neo-classical theories of unemployment

4.1 Introduction

This chapter deduces antagonistic hypotheses from search theory and from neo-classical theory and tests them for the German labor market. It is based on Fitzenberger and Garloff (2005b).

It is commonplace in the debate on Germany's labor market problems to argue that low wage dispersion as an indicator of low wage flexibility is a major reason for the high unemployment rate, see Sachverständigenrat zur Begutachtung der Gesamtwirtschaftlichen Entwicklung (2005) and OECD (2006). In international comparison, wage inequality in Germany is small and remained stable until the late 1990s, see Prasad (2004). According to the Krugman (1994) hypothesis, the increase of wage inequality in the US and the increase of unemployment in Germany are two sides of the same coin, namely, the response to the pertinent skill bias in labor demand. Accordingly, wage rigidities caused by wage bargaining institutions (unions) have prevented wage inequality to rise in Germany thus resulting in higher unemployment. The rationale for this argument is that if wages are set above the marginal productivity of workers, firms do not employ some of the least productive workers.

Given the production technology and the skill bias, human capital theory explains wage differentials by concentrating on the role of individual, productivity-relevant traits (human capital). If individuals are paid as in a competitive human capital model, we expect that wage differentials stem only from differences in individual traits. Wages, however, differ between observationally equivalent workers. We call these differences residual wage dispersion and postulate that, if the human capital approach to wages is correct, the residual wage dispersion is explained by unobserved productivity differences. From an empirical point of view, one can control for a part of this residual variation if allowing for effects that come from specific firms ("high wage firms", see Abowd, Kramarz, and Margolis (1999)) or from specific industries. This observation challenges the neo-classical human capital model which assumes perfect competition and which allows neither for firm-specific differences nor for industry-specific effects, except for the case that the unobserved productivity differences of the individuals are correlated with firms or specific industries.[1]

[1] In the neo-classical framework, high wage firms might have attracted high ability individuals. However, empirical evidence does not seem to support this. Abowd, Creezy, and Kramarz (2002) and Gruetter and Lalive (2004) find that person and firm effects are *negatively* correlated.

Search theory offers both an interesting alternative and complement to marginal productivity theory and human capital theory by focusing on search frictions as an explanation for wage differences among workers with identical marginal productivity. The basic idea of search theory is that under imperfect information, there is a match-specific rent because of opportunity costs of waiting for a better match. Then, the wage is not unique and does not necessarily correspond to the marginal product. Equally productive workers face different possible wages (or even a whole distribution) for which they could work. Under this perspective, the reason why firms pay different wages is that search frictions lend them monopsony power, which they can exploit to different degrees. On the one hand, there might be high-wage firms that have to pay high wages in order to assure their high employment. On the other hand, there might be low-wage firms that employ only a small number of employees since they lose them at a fast rate to their better paying competitors. Wage decompositions that try to identify the effect of search frictions on the basis of search equilibrium models attribute a considerable amount of the wage variation to search frictions.[2] Search equilibrium models themselves predict a close association between wages and labor market transitions. When implementing these models empirically, a lot of identifying and non-testable assumptions typically have to be imposed on the data (see e.g. Bontemps, Robin, and Van den Berg (2000), or Van den Berg and Ridder (1993)).

We follow a slightly different approach here. Starting with the Krugman (1994) hypothesis that the relatively small wage dispersion in Europe might be the reason for the high unemployment in European countries, we distinguish two types of wage dispersion. We distinguish wage dispersion between groups of individuals with the same observable (productivity relevant) characteristics ("between wage dispersion") and wage dispersion within such groups ("within wage dispersion") because, from a theoretical point of view, the reasons for the two might differ.[3] Since in the empirical application, we are not able to control perfectly for differences in marginal productivity, we refer to residual wage dispersion as the empirical counterpart of within wage dispersion.

Regarding between wage dispersion, there is empirical evidence for Germany that wages are compressed across groups of different human capital endowments (as a proxy for marginal productivity) and that this compression has led to high unemployment, especially for the group of low-skilled (see among others Fitzenberger and Kohn (2006)). Although this view that the compressed wage structure in European countries has led to high unemployment seems to be the conventional wisdom among economists, it has not remained unchallenged for various reasons (see the discussion in chapter 1, sections 1.1 and 2.1).

[2] By search equilibrium models, we refer to a class of models based on search frictions which explicitly model the decision problem of both sides of the labor market and which imply an endogenous wage distribution.

[3] Note, that we refer to the empirical counterpart of within wage dispersion as residual wage dispersion.

The focus of this paper is on within wage dispersion and its relationship to employment. Here, we attempt to fill a research gap. Starting from search theory on the one hand and from productivity theory on the other hand, we discuss competing hypotheses with respect to the relationship between labor market transitions and within wage dispersion. On the one hand, neo-classical theory based on marginal productivity determining factor prices predicts that wage dispersion is determined by individual heterogeneity. Thus, empirically, within wage dispersion reflects unobserved productivity characteristics. When within wage dispersion decreases in response to institutional changes (such as a rise in union bargaining power or higher levels of public assistance) unemployment increases. On the other hand, search theory predicts an opposite relationship between the two variables. Here, a small amount of search frictions is responsible for the low within wage dispersion. At the same time, low search frictions lead to a low unemployment rate.

To our knowledge, this paper is the first attempt in the literature to test between the different empirical implications of the two theoretical approaches.[4] We use a large administrative labor market data set for West Germany, the IAB–Beschäftigtenstichprobe (IABS), which covers the time period 1975 to 1997 and which contains precise information on wages and the timing of changes in employment status. We define cells in which individuals are homogeneous with respect to age and education. Using this dataset, we first describe labor market transitions and wage changes following a job–to–job change, one of the key determinants in job search models. Then, we look at the wage structure and ask for the determinants of changes in the relative position in the wage distribution. Finally, we estimate how the rates at which labor market transitions take place and unemployment depend on the dispersion of the wage distribution and vice versa. Our results are more supportive for the search-theoretic hypothesis than for the neo-classical theory based on marginal productivity determining factor prices, although some implications of the former hypothesis are rejected. However, one remarkable and stable result in favor of a search-theoretic view of the labor market persists: we find that there is no negative relationship between the unemployment rate and wage dispersion. This result, which is surprising for Germany, contradicts the hypothesis that labor unions compress wages within each cell, thereby causing high unemployment.

The structure of the paper is as follows: First, we discuss the two competing theories. Then, we describe the data and we present descriptive evidence on labor market transitions and the wage structure. As the main part of the empirical analysis, we use competing predictions of the two theories to test them against each other. The last section concludes and appendix D provides the precise definition of variables used in the empirical analysis.

[4] This idea is also used by our associated paper Fitzenberger, Garloff, and Kohn (2003), however, the scope of the analysis in that paper is much more limited compared to this paper.

4.2 Theoretical background

From the neo-classical point of view, wages are equal to the marginal product of labor which is determined by the human capital endowment of a person and other productivity relevant characteristics after controlling for differences in physical capital usage. In a competitive market, there is no room for pure firm (size) or interindustry wage differentials, when controlling for all productivity relevant individual characteristics, nor is there room for unemployment. However, when researchers can only control for observed characteristics, unexplained wage differentials might reflect differences in unobserved productivity relevant characteristics.[5]

Search and Matching theories provide an alternative explanation for within wage dispersion as the outcome of search frictions and monopsony power of employers. The textbook models view the competitive model as the limit case of search and matching models when frictions and monopsony power disappear (Cahuc and Zylberberg (2004)). However, because of productivity relevant unobserved characteristics we view the two models as nonnested alternatives in empirical work.

In addition to accounting for unobserved heterogeneity and frictions, the competitive textbook model has to be modified because of the importance of impact of unions on wage setting in Germany. In a standard wage bargaining model with right–to–manage assumption, wages still correspond to the marginal product of labor. Unions in Germany bargain with employers over a schedule of minimum wages for different types of jobs. The so-called "to–the–worker's–advantage" principle ("Günstigkeitsprinzip") allows firms to pay more but not less than the wage that is agreed upon by unions' and the employers' association. We do not model the objectives of labor unions explicitly in this paper, but simply assume that unions set binding minimum wages both in order to increase effective wages paid and to reduce wage inequality.

Separate union contracts exist for different professional groups and different industries. We expect that there is in general more than one binding minimum wage for individuals with identical observed human capital endowment since they might be employed in different industries or they might be grouped into a different professional group. However, a smaller wage dispersion among individuals with identical observed human capital endowment can, ceteris paribus, be interpreted as originating from higher minimum wages set by labor unions.[6]

[5] For example, ability sorting could in principle provide an explanation for firm size wage differentials (see footnote 1).

[6] See Fitzenberger and Kohn (2005) for evidence that unions compress wages in Germany. Obviously, this raises the question why labor unions set wages too high. One possible reason is that at least some of the low wage employees gain from the minimum wage if they are still employed and paid a higher wage rate. E.g. Pfeiffer (2003) discusses further reasons for compressed wages within the productivity framework.

In the following, we discuss the heterogeneity hypothesis and the friction hypothesis as alternative theoretical rationales for wage inequality among observationally equivalent workers, which are not necessarily exclusive. We argue that the two approaches imply simple testable differences in their predictions for the descriptive relationship between wage inequality and unemployment, as well as transition rates between different labor market states in a world with sluggish adjustment. These theoretical predictions involve the relationship between endogenous outcomes assuming that the correlations in the data result from plausible economic assumptions about the data generating process. Note that we do not attempt to estimate structural relationships.

4.2.1 Heterogeneity hypothesis

Basic neo-classical theory assumes that markets are in a competitive equilibrium. If there is indeed a competitive market for labor, the same efficiency unit of labor will be paid the same wage, irrespectively of where it is employed. Human capital theory argues that the efficiency unit of labor is determined by the amount of (general) human capital that an individual has acquired. Wage dispersion results from differences in the human capital endowment. Wage dispersion among identical individuals is hard to explain from this point of view, unless one acknowledges unobserved productivity relevant characteristics.

Wage dispersion within groups can be explained by firms employing different capital stocks or technologies. But this situation should not persist in competitive markets. A second reason for wage dispersion within groups arises if there is specific human capital. In this case, even if we are able to measure true human capital[7] endowment, the wage is not uniquely determined by the amount of human capital but can be negotiated between the firm and the worker, since rents exist due to the specific capital not being of use in other firms (see Cahuc and Zylberberg (2001), pp. 193ff.).

Further important sources of residual wage dispersion relate to measurement issues. First, we might not be able to measure human capital correctly because of data restrictions. Second, there might be unmeasurable qualities of individuals, like ability, that affect marginal productivity and that are (partially) observed by the employer.[8]

Suppose, now, that a union and an employer association agree upon increasing the minimum wage for a group of observationally equivalent workers. If the minimum wage is binding then some employees will lose their job. The reason is, that residual wage dispersion is explained by

[7] We define human capital as all individual traits which influence the (marginal) productivity of an individual.

[8] Residual wage dispersion can also be the result of compensating wage differentials among observationally equivalent workers. For the purpose of this paper, they can be treated in the same way as differences in marginal productivity.

unobserved productivity differences and that the minimum wage truncates the distribution of the marginal productivities at some point. This makes some jobs unprofitable who were previously profitable.

We also consider the dynamics of the labor market as reflected by transition rates between different labor market states. Since markets need time to adapt to equilibrium values, it is realistic to assume that unemployment does not react immediately to a change of the binding minimum wage. This is implied by the dynamic theory of labor demand with adjustment costs (Hamermesh (1993)). We expect that, as a reaction to an increase of a binding minimum wage, more labor contracts will end and firing rates slowly increase. Conversely, we observe fewer transitions from unemployment to employment since the potential match between employee and employer will become less profitable. Hiring rates are expected to react immediately since jobs are only filled if they are profitable.

We assume that the variation in the data stems from two sources, namely (partly) exogenous changes in the binding minimum wages and shocks to the distribution of marginal productivity within groups of workers. The following hypothesis summarizes the empirical implications on the implied relationship between residual wage dispersion and labor market transition rates.

Heterogeneity Hypothesis: Consider a cell of observationally equivalent workers. When the residual wage dispersion decreases (because of an increase in the minimum wage or a downward shift of the distribution of marginal productivities), then the cell-specific unemployment rate increases, the transition rate from unemployment to employment declines, and the transition rate from employment to unemployment increases, possibly with a lag. Labor market transition rates react with a lag because of adjustment costs (dynamic labor demand). There is no clear relationship between job–to–job changes and wage dispersion. Transition rates do not affect future wage dispersion.

4.2.2 Friction hypothesis

As a benchmark, this section assumes that after controlling for observable productivity relevant characteristics employers consider individuals to be identical in their marginal productivity (Burdett and Mortensen (1998), Mortensen and Pissarides (1999)). Furthermore, imperfect information exists on both sides of the labor market, since there are opportunity costs (of time) for the employers to search for new employees and for the workers to find a job. After a match is formed, there is a rent to be divided between employer and employee (a match-specific rent).

We consider both off–the–job and on–the–job search with possibly different job arrival rates (Cahuc and Zylberberg (2001)). We assume that the wage is posted by the employer, as a “take it or leave it" offer for the employee.[9] In equilibrium it pays for the ex-ante identical firms to choose different strategies and to offer different wages. The reason for this is that in equilibrium large and small firms coexist. Large firms will pay high wages in order to attract many individuals working at competing firms and to lose only little staff to competitors. The high employment comes at the cost of small profits per employee. Firms that pay low wages, on the contrary, will have high profits per employee but only low employment. Burdett and Mortensen (1998) show the existence of a continuous distribution of wages in equilibrium. Residual wage dispersion then merely reflects search frictions rather than differences in productivity.[10]

To be more precise, the variance of the wage distribution is determined by two frictional determinants (see Van den Berg and Ridder (1993)). The first determinant is the job offer rate for employed job seekers. It is intuitively clear that the more often individuals are able to change jobs because of wage differences, the more difficult it is for firms to pay low wages since then they quickly lose their staff. This means that the variance of wages decreases with the job offer rate. The second determinant of the variance of wages is the job destruction rate. The higher this rate, the more frequently employees lose their jobs and become unemployed. Hence, the search friction is higher and the variance of the wage distribution is larger. This is the case, since the trade-off for low-wage firms improves through higher inflows from unemployment.[11] Note, however, that search frictions themselves also affect the equilibrium unemployment rate, thus predicting that higher search frictions lead to higher wage dispersion and to higher frictional unemployment.

Now, assume that a labor union sets a minimum wage truncating the wage distribution at this point. Thus, the minimum wage constitutes the lower bound of the wage distribution. But, the whole distribution including the upper bound reacts as well. In the new equilibrium, all firms still have the same profits but the level of profits is lower than before, while employment remains the same.

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[9] Other rent sharing mechanisms are explored in Mortensen and Pissarides (1999). Although this mechanism might lead to situations where possibly profitable matches do not take place, this is "consistent with how many labor economists view the wage setting process"(ibid., p. 2607).

[10] The term search friction summarizes the facts that unemployed individuals cannot find a job immediately, that employed individuals cannot change their job immediately, and that jobs can end for exogenous reasons.

[11] Van den Berg and Ridder (1993) show that the variance of the cross-sectional wage distribution is increasing in the job destruction rate and decreasing in the job arrival rate if and only if the ratio between the job offer rate on–the–job is less than twice the job destruction rate. We consider this to be a natural condition to hold, since in Germany job–to–job changes occur less frequently than transitions from employment to nonemployment (see tables C.2 and C.3 in appendix C). Assuming that this condition is satisfied in the data allows us to test empirically between the two theoretical approaches.

We assume that the variation in the data is caused by differences and changes in job arrival and destruction rates effectively reflecting changes in labor demand. The empirical implications can be summarized as follows.

Friction Hypothesis: If the job offer rate on–the–job increases or the job destruction rate declines, then the residual wage dispersion decreases and the cell–specific unemployment rate declines. There is no clear relationship between the job offer rate off–the–job and wage dispersion, but unemployment decreases with an increase in the job offer rate off–the–job. Wage dispersion itself does not affect transition rates. A minimum wage is not affecting the unemployment rate and the transition rates between unemployment and employment.

4.3 Data

The empirical analysis is based on the IAB employment sub-sample, 1975-1997, a large administrative data set for Germany, see Bender, Haas, and Kloose (2000). Since most data features correspond for the IABS 1975-1997 and for the IABS-R01 used in the previous chapter 3, we only state differences. The IABS 1975-1997 is a *one* percent random sample of employees from the social security records. The dataset contains about 8 millions observations and is representative for all persons who have been employed at least once in a job that is part of the compulsory notifying procedure in the observed 22 years (more than the 80% in a cross section of workers).[12]

We calculate transition rates between the three states. Transitions from employment to receiving transfer payments are interpreted as transitions to unemployment,[13] since already a short employment spell results in a renewal of benefit entitlement. E.g. after an employment spell of twelve months, the benefit entitlement period is six months. In contrast, transitions from unemployment into employment are not that easily approximated by transitions from receiving transfer payments to employment. Long–term unemployed, whose benefits are exhausted, might find a job, and there might be people shifting from the state receiving transfer payments to the state out of sample by becoming a civil servant or by becoming self–employed. Therefore, in the empirical section, we use different definitions of unemployment to investigate the robustness of the results.

For our empirical analysis, we use only full–time working men who are between 25 and 54 years old and who are residents in West Germany. This sample is grouped into cells by age, education, and year. We define three education groups: The first category corresponds to persons who

[12] For a more extensive treatment of the data, the reader is referred to chapter 3, section 3.3.

[13] The largest group of workers not contained in the dataset are civil servants who are typically tenured ($\equiv$ no risk of unemployment).

have neither a completed vocational training nor a university degree. The second category are people who have finished a vocational training but have no university degree. The third group corresponds to persons who have a university degree or a degree from a university of the applied sciences ("Fachhochschule").[14] We also group the individuals by their age in ten three-years-intervals (25-27, 28-30, etc.) to proxy for potential experience. For the descriptive analysis, we use the cells for all 22 years (1975–1997). For the explicit empirical test of the two hypotheses, we restrict ourselves to the 17 years 1980-1997, since there are concerns that the transition rates cannot be estimated consistently for the seventies (see Bender, Haas, and Kloose (2000)). Annual transition rates are based on the labor market state on January 1st of each year. The within wage dispersion is calculated for the cross section of workers in each age–education cell for the 22 (17) years. When wages are censored from above, we replace the censored value by the predicted value from a Tobit regression (run separately for every age–education cell in every year) assuming that log-wages are normally distributed in a cell.

4.4 Empirical analysis

We first present descriptive evidence on labor market transitions and the wage structure. Then, we scrutinize the testable predictions of the heterogeneity hypothesis and the friction hypothesis.

4.4.1 Descriptive evidence

First, we calculate the transition rates between the three labor market states and the rate of job–to–job changes for each of the thirty cells by year. Further detailed results can be found in chapter 3 and appendix C of this thesis.

Several testable hypotheses regarding the relationship between theses rates and age or education are plausible. Since search efficiency increases and mobility costs decrease presumably with higher education, the friction hypothesis implies that the job changing rate increases with higher education. Since individuals sort themselves in better paying jobs as time progresses, we expect that job changing rates decrease with age. As far as the job finding rate is concerned, one might argue that people who are older have higher reservation wages because they had higher wages before (see e.g. Christensen (2003)). Again, with higher education the knowledge about job opportunities improves.[15] According to the heterogeneity hypothesis, it is not clear whether job changes increase with higher education. For older workers, we expect less job changes due

[14] Notice that the education information in the IABS-dataset is not always consistent over time so that we corrected the education information based on the simple rule that a finished degree cannot be lost. For a more sophisticated correction procedure, see Fitzenberger, Osikominu, and Völter (2005).

Table 4.1: Regressions of transition rates for different age-education-groups

Variable	E-OE	E-E	E-ES	BR-E	BR-BR	OOS-E	OOS-OOS
medium-skilled	2.567**	2.415**	-0.2	12.082**	-10.085**	2.747**	-3.4**
	(0.323)	(0.219)	(0.326)	(1.177)	(1.240)	(0.630)	(0.705)
High-skilled	3.42**	1.658**	-2.207**	17.022**	-21.35**	-3.502**	4.582**
	(0.422)	(0.252)	(0.525)	(1.584)	(1.871)	(1.325)	(1.453)
28-30 years	-1.193	1.619**	2.735**	3.505	-2.817	-0.596	0.738
	(0.754)	(0.69)	(0.773)	(4.986)	(3.788)	(2.18)	(2.45)
31-33 years	-2.339**	2.538**	4.756**	1.394	-2.88	-4.37**	4.648**
	(0.74)	(0.752)	(1.072)	(3.55)	(3.629)	(1.734)	(2.125)
34-36 years	-3.437**	3.19**	6.471**	-0.438	1.02	-7.083**	7.53**
	(0.578)	(0.706)	(0.799)	(3.641)	(2.512)	(1.617)	(2.008)
37-39 years	-4.376**	4.143**	8.319**	-4.124	4.954**	-8.85**	9.382**
	(0.462)	(0.684)	(0.646)	(3.768)	(1.966)	(1.623)	(2.005)
40-42 years	-5.269**	4.789**	9.85**	-6.815**	6.075**	-9.217**	9.766**
	(0.433)	(0.681)	(0.558)	(3.693)	(2.049)	(1.63)	(2.010)
43-45 years	-5.72**	5.204**	10.693**	-8.063**	9.905**	-9.998**	10.279**
	(0.473)	(0.691)	(0.590)	(3.819)	(2.682)	(1.666)	(2.025)
46-48 years	-6.231**	5.143**	11.183**	-8.599**	12.547**	-8.838**	9.094**
	(0.592)	(0.675)	(0.724)	(3.748)	(3.073)	(1.643)	(2.030)
49-51 years	-6.494**	4.708**	11.053**	-5.366	8.703**	-7.764**	7.824**
	(0.565)	(0.665)	(0.648)	(3.563)	(2.146)	(1.649)	(2.041)
52-54 years	-7.087**	4.119**	11.104**	-11.081**	10.54**	-7.76**	7.734**
	(0.931)	(0.706)	(1.075)	(3.722)	(2.095)	(1.815)	(2.164)
Time	0.105**	-0.007	-0.082**	-0.685**	1.258**	-0.431**	0.438**
	(0.012)	(0.015)	(0.025)	(0.145)	(0.132)	(0.093)	(0.096)
Unemployment rate	-0.395**		0.207**			-3.258**	3.361**
	(0.041)		(0.078)			(0.475)	(0.528)
Intercept	-198.454**	103.069**	241.595**	1382.322**	-2442.76**	882.043**	-797.314**
	(24.454)	(30.026)	(48.080)	(288.069)	(261.808)	(185.199)	(191.771)
N	660	660	660	618	618	660	660
R^2	0.78	0.563	0.747	0.306	0.355	0.329	0.344

Significance level: $*$: 5%. Standard errors are robust with respect to correlations within groups (panel adjusted).
E-OE: job–to–job changes for different age-education-groups; E-E: Probability of remaining employed
E-ES: Probability of remaining in the same job; BR-E: Receiving transfer payments to employment
BR-BR: Probability of remaining recipient of transfer payments; OOS-E: Out of sample to Employment
OOS-OOS: Probability of remaining out of sample; all rates in percent

to a higher level of specific human capital at risk. The same holds true for the transitions to unemployment since their high dismissal protection (see Franz (2006), chapter 6.2) makes firing them more unlikely. Based on the heterogeneity hypothesis, we expect the reemployment probability for those who receive transfer payments to decrease in age for institutional reasons since the length of benefit entitlement increases in age.

Table 4.1 summarizes the transitions between the three states and their variation with age and education using simple OLS-regressions. The reference category consists of employees with lower education, aged 25-27. Job changes are more frequent for higher educated individuals than for lower educated individuals and they occur less frequently as individuals get older.[16] Likewise, the probability of remaining employed increases with higher education and with age. Similar to other studies (see e.g. Lauer (2003)), we observe the highest job stability for individuals with a vocational training degree, but not for university graduates. The probability of staying at the same job decreases with higher education and increases with age. The probability for returning from receiving transfer payments to employment increases with the education level and decreases with age, while likewise the probability of remaining transfer recipient increases with age and decreases with higher education. Finally, once out of the sample, individuals return more often to employment when they hold a vocational training degree and more rarely as university graduate. This probability first decreases with age but then shows a minimum at the age of 40 to 45. Finally, individuals with a vocational degree stay less often out of sample while university graduates stay more often out of sample.[17] The probability of remaining out of sample increases with age and shows a maximum in the 40s.

We conclude that most findings discussed so far are consistent with both hypotheses of the labor market, as put forward above, although the heterogeneity hypothesis does not cover job–to–job transitions. Since job–to–job changes are a crucial aspect in equilibrium search theory, we explore them in more detail. We defined job–to–job changes as a change of the employer with an intervening out–of–sample spell lasting not longer than 15 days.[18]

[15] A related argument of why the job finding rate might be higher for high-skilled individuals is given in Moen (1999). Here the basic idea is that there might be several job applicants for one vacancy and thus queuing for jobs and that the person with the highest skill will get the job.

[16] As a quantitative example, having a university degree as compared to having no degree at all is associated with a 3.4% higher rate of job change.

[17] Reasons might be that a university degree often is a prerequisite for becoming civil servant and that university graduates more often become self–employed.

[18] We restrict our analysis to direct job–to–job changes (new job starts within 15 days after end of old job), since we are interested in the wage effects of voluntary transitions. For an analysis of wage effects of job–to–job transitions on an annual basis, see Pfeiffer (2003). His main findings that the wages of job changers are more dispersed than the wages of job stayers are in accordance with our results.

Table 4.2: Job-to-job transitions and wages

	total	share winners	share losers	no change
full-time to full-time	282644	0.638	0.289	0.073
part-time 1 to part-time 1	13375	0.643	0.291	0.066
part-time 2 to part-time 2	2217	0.549	0.289	0.162

	relative gain of the winners	relative loss of the losers	overall wage change
full-time to full-time	0.268	-0.152	0.127
part-time 1 to part-time 1	0.205	-0.143	0.09
part-time 2 to part-time 2	0.268	-0.162	0.101

part-time 1: working hours are more than 50% of regular working hours
part-time 2: working hours are less than or equal to 50% of regular working hours

We consider wages before and after job change, distinguish winners and losers, and calculate the mean gain or loss from the job–to–job change. Table 4.2 shows remarkable gains and losses. On average, winners earn about 25% more, while losers still earn around 15% less. Almost two thirds have an effective gain from changing jobs while more than 25% lose. Further results, which are available upon request, show that the more highly educated show higher average wage increases, even though the share of winners is smaller. The relative wage gain decreases with age, but at the same time the share of losers decreases as well. Overall, the high gains and the high share of winners point to the central role of wage changes in understanding job–to–job changes.[19] On the other hand, there is a remarkable share of persons with losses. This result is difficult to reconcile with search theory, unless one acknowledges that workers expecting displacement start searching early and are willing to accept wage cuts to avoid unemployment. Still, the decreasing gains from such changes with age can be understood as sorting processes into higher paying jobs. The fact that relative losses do not increase with age is difficult to reconcile with the notion that specific capital should be more important at a higher age as a proxy for tenure and experience. As far as the relationship between education and shares of winners/losers as well as relative gains or losses are concerned, the hypotheses discussed above do not allow to completely rationalize our findings.

Finally, we investigate all persons in one cell who are employed in two consecutive years. They were classified by deciles of the wage distribution each year resulting in a 10×10 transition matrix for each education-by-age cell and each year. To summarize the information, we analyze the determinants of changing the relative position in the wage distribution. We estimated an

[19] Similarly, Fitzenberger and Spitz (2004) find that on average occupational mobility is associated with wage increases.

ordered Probit model where the options were moving one or more deciles up, remaining in the same decile or moving one or more deciles down. Since replacing year dummies by a linear time trend did not change our results, table D.1 in the appendix only reports the latter results.

Table D.1 shows that upward wage mobility decreases with age and increases with education. As expected, job–to–job changers have a higher probability to move up the wage distribution. As individuals age, upward wage mobility is considerably less likely, even when changing jobs which also occurs more rarely. Finally, the interquantile range (iqr) between the eighth and the second decile (in logs) exhibits a negative impact on upward wage mobility, i.e. the higher the wage dispersion the lower is the probability of moving up the wage ladder. Still, the findings, that job changers have better career opportunities and that older individuals fare worse, are consistent with the friction hypothesis.

4.4.2 The relationship between transitions and wages

After presenting some basic descriptive evidence, we now turn to a test whether residual wage dispersion is related to heterogeneity or to labor market frictions. We start by restating the central ideas of both hypotheses. On the one hand, if wages are basically determined by residual heterogeneity under the heterogeneity hypothesis, we expect that lower wage dispersion indicates stronger union influence, which results in higher unemployment, higher entry rates into unemployment, and lower exit rates out of unemployment. On the other hand, the friction hypothesis postulates that wages in one cell are determined by the amount of search frictions. If wage dispersion is low, then both search frictions and unemployment are low as well. The direct effect of search frictions works via the job destruction rate which is positively related with wage dispersion and unemployment. An indirect effect originates from the fact that the job offer rate on–the–job (which negatively affects wage dispersion) and off–the–job (which negatively affects unemployment) are likely to be positively correlated.

Regarding the heterogeneity hypothesis, the relevant variables can be directly measured. We regress transition rates and the unemployment rates on a measure of wage dispersion. For the friction hypothesis, the relevant variables are not observable. First, we do not observe the job offer rate on–the–job but only the job–to–job transition rate. Under the assumptions of the search model, individuals change jobs if the wage offer exceeds the current wage (see Mortensen and Neumann (1988)), i.e. the probability of changing a job is given by the product of the job arrival rate and the probability that the wage offer exceeds the current wage. If the wage offer distribution were constant, the transition rate would be proportional to the job offer rate. However, the wage offer distribution varies with the job offer rate. An increase in the latter shifts the wage offer distribution towards the marginal productivity of the individuals, thus typically reducing the wage dispersion. In the following, we assume that the direct effect dominates, i.e. an increase in the job offer rate results in a higher job–to–job transition rate. The second variable which determines the wage dispersion is the job destruction rate. Again, it is not possible to distinguish between voluntary quits and job destructions due to exogenous reasons.[20] However, as often done in the literature, the entry rate into unemployment is used to proxy exogenous job destruction (see e.g. Van den Berg and Ridder (1998)). As a robustness check, we use different definitions when calculating the entry rate into unemployment.

As measure of wage dispersion, we use the interquantile range (iqr) between the eighth and the second decile of log wages. This is a more robust measure compared to the sample variance (or its Tobit estimate) in a cell because of the censoring in the wage data. For medium and low-skilled worker, iqr is not affected by censoring for the vast majority of cells. However, for high skilled workers censoring is quite prevalent at the eighth decile and, therefore, we omit high-skilled worker from the analysis in this section.[21] According to the heterogeneity hypothesis, a smaller iqr reflects a stronger wage compression by the unions. Then, the unemployment rate, either measured by recipients of transfer payments or by these plus individuals being out of sample, is high, while we observe few transitions from receiving transfer payments to employment and a lot of transitions out of employment. Based on the friction hypothesis, we predict that an increase in job–to–job transitions or a reduction in transitions from employment to receiving transfer payments result in a smaller iqr. Correspondingly, the share of recipients of transfer payments or the share of recipients of transfer payments plus individuals being out of sample should decline.

The empirical analysis is based on a panel of 20 education–by-age cells which are observed over 17 years. Using fixed–effects estimation techniques, we allow for cell-specific effects in wage dispersion, transition rates, and unemployment. It is quite likely that these cell–specific effects are both correlated with the dependent variable and the regressor variables, thus precluding estimating a random–effects model. However, two reasons for endogeneity are particularly noteworthy since they might not be addressed completely by estimating a fixed–effects model. First, endogeneity problems arise from the very fact that each transition from and to employment affects the wage distribution depending upon the type of selectivity of the transition with respect to the position in the wage distribution. This is an issue when individuals in a cell are heterogeneous in their productivity (heterogeneity hypothesis). However, the sign of the empirical correlation between changes in transition rates and the wage dispersion measure should not differ from the sign of the causal effect because of the likely reaction of unions to changes in employment prospects.[22]

[20] This includes every reason which makes the previous job unprofitable which is beyond the influence of the employer or the employee. This precludes, however, the voluntary decision to become unemployed or the decision of the employer to lay off somebody who is enduringly unproductive.

[21] We also performed the analysis including high-skilled workers (the eighth decile relies on our Tobit estimates) which did not alter the main results. These results are available upon request.

A second reason is that the two theories postulate a different direction of the relationship between transition rates and wage dispersion.[23] In the following, we try to address this by using the time structure of the data for identification. The wage dispersion measure refers to one point in time (1st January each year), while the transitions rates refer to the period from January, 1st until December, 31st. This means that, when estimating the impact of transition rates on wage dispersion, we use the rates from year $t-1$ to year t to measure the impact on wage dispersion in year t and vice versa. Even in the absence of this timely structure, the endogeneity, coming from the direct reverse causation of the theories, is not harmful to our approach because of the following. Suppose that either the heterogeneity or the friction hypothesis holds. Suppose further that we empirically reject, for instance, the heterogeneity hypothesis. Then, rejection implies endogeneity as well as a rejection of the heterogeneity. On the other hand, we cannot err by accepting the heterogeneity hypothesis because endogeneity is consistent with the friction hypothesis. The latter implies a different direction of correlation. To illustrate this argument with an example: Assume that we regress the job destruction rate on iqr. The heterogeneity hypothesis predicts a negative sign. Suppose that according to the friction hypothesis the true sign is positive. Then, it is not possible to find a negative sign because of the endogeneity from the friction hypothesis, since this implies a positive correlation between iqr and jdr and therefore the bias would go into the opposite direction.

To circumvent problems stemming from the fact that both the transition rates and the wage dispersion measure have bounded support, we use positive monotone transformations of these variables on the left hand side that are unbounded. That is, we use the transformation $liqr = log(iqr)$ for the interquantile range, and the transformation $tr = log(rate/(1-rate))$ for the transition rates.

We estimate the model as a fixed-effects feasible GLS-model (FEGLS), see Wooldridge (2002, chapter 10.5.5).[24] Consider the following model estimated to test the heterogeneity hypothesis:

$$tr_{it} = \alpha + \beta iqr_{it} + d_t + c_i + u_{it} \tag{4.1}$$

[22] Take the following example: Consider a positive productivity shock, then employment prospects will improve and therefore transition rates into employment increase, it typically follows that wage dispersion increases, as a first order effect, for given union contract wages. In response, unions will raise contract wages effectively reducing wage dispersion. If unions trade off average wages and employment in their utility function, then both wage dispersion and transition rates into employment (and correspondingly the employment rate) are still higher in the end compared to the situation before the exogenous increase in transition rates. This follows from standard textbook models of wage bargaining.

[23] Strictly speaking, the heterogeneity hypothesis focuses on λ and the friction hypothesis on λ_L. However, they are likely to be strongly positively correlated.

[24] We started with implementing both the standard fixed–effects estimator and the estimator in first differences. Typically, both variants seemed inefficient since the associated error terms after the fixed–effects and the first–differences transformation, respectively, still showed considerably autocorrelation and the precision of the estimates was quite low. The results for fixed effects and first differences are available upon request.

Table 4.3: Heterogeneity hypothesis – FEGLS-regressions of the transition rates on the interquantile range

Dependent variable	Coefficient estimate β	Standard error	Expected sign
jdr1 (E-BR)	0.0259	0.1198	-
jdr2 (E-BR|OOS)	-0.0595	0.0683	-
jdr3 (E-NoE)	-0.1265*	0.0478	-
jfr1 (BR-E)	-1.7274*	0.2782	+
jfr2 (BR|OOS-E)	-0.8449*	0.2159	+
jcr (E-OE)	0.2516*	0.0400	0

*indicates that the coefficient is significant at the 5% significance level. See appendix D for the definition of the variables. The results for the year dummies have been suppressed from the table. The estimation is based on 340 observations. Further explanations are given in the text. The transition rates are transformed to insure unboundedness. iqr is measured at the beginning of the respective time period.

for cells $i = 1, ..., 20$ and year $t = 1980, ..., 1996$. iqr_{it} is the interquantile range, tr_{it} is the transformation $log(rate_{it}/(1 - rate_{it}))$, with $rate_{it}$ being the transition rate from t to $t+1$, α the intercept, c_i the unobserved heterogeneity, which is assumed constant over time, and u_{it} represents the unsystematic error component. In addition, equation (4.1) includes fixed year effects d_t to control for business cycle effects.[25] Estimation proceeds in two steps. First, we estimate equation (4.1) by fixed effects. We then calculate the empirical covariance matrix of the fixed effects residuals. After omitting one equation, since the covariance matrix of the fixed-effect-residuals does not have full rank (see Wooldridge (2002), chapter 10.5.5), the remaining covariance matrix is used for the GLS transformation. Second, we estimate the transformed model. Table 4.3 shows the GLS estimates.[26]

The signs for different definitions of the job destruction rate ($jdr1$-$jdr3$) confirm in two out of three cases the heterogeneity hypothesis. It is significant, however, only for the broadest definition of entries into unemployment. From this it is not clear, whether an increasing wage dispersion indeed reduces transitions from employment to unemployment, as predicted by the heterogeneity hypothesis. The estimated coefficients for both definitions of the job finding rate ($jfr1$,$jfr2$) are significantly negative and contradict therefore the heterogeneity hypothesis. We expected that a higher wage dispersion would imply that the unemployed find jobs faster, since there are more jobs that fit the marginal productivity of the searching individuals. This seems not to be the case in Germany. The wage dispersion was not expected to have any effects on the job changing rate (jcr). The data, however, contradict this view as well. The higher the wage

[25] See Wilke (2004) for the importance of business cycle effects on transition rates in Germany.

[26] Note that estimating equation (4.1) as a system of equations would not result in an efficiency gain, since we use the same regressors in all equations (Wooldridge (2002), chapter 7.3).

Table 4.4: Heterogeneity hypothesis – FEGLS-regression of unemployment on the interquantile range

Dependent variable	Coefficient estimate (Standard error)	Expected sign
u	0.0629 (0.0796)	-
$\tilde{u}$	0.0658 (0.0804)	-

The Estimation is based on 320 observations. See appendix D for the definition of variables. Further explanations are given in the text.
iqr is measured at the beginning of the respective time period.
u is transformed to insure unboundedness.

dispersion the higher is the job changing rate. Finally, we also explore directly the relationship between unemployment and wage dispersion, which is the focus of the heterogeneity hypothesis. For the narrow definition of unemployment (recipients of transfer payments only) u, we find a positive sign, but it is not significant. Also including the state out of sample (variable $\tilde{u}$) increases slightly the size of the effect, however, it remains insignificant. For both definitions the sign contradicts the heterogeneity hypothesis since higher wage dispersion is associated with higher nonemployment (or with no change in unemployment at all). In light of our previous findings, this implies that the negative effect of the wage dispersion on the job finding rate dominates other effects that drive (equilibrium) unemployment. Thus, the heterogeneity hypothesis is rejected regarding this important relationship. Though not being significant, the positive coefficient estimates are in accordance with the friction hypothesis.

Next, considering the friction hypothesis directly, we investigate whether the transition rates affect the (logarithm of the) interquantile range in the expected direction. Our estimated model is specified as

$$liqr_{it} = \alpha + \beta rate_{i,t-1} + d_t + c_i + u_{it}, \tag{4.2}$$

where $i = 1, ..., 20$, and $t = 1981, ..., 1996$. Again, fixed year effects are included to control for business cycle effects. The model is estimated by FEGLS. Table 4.5 contains the results for estimating equation (4.2) regressing the transformed interquantile range on the transition rates.

The friction hypothesis purports that the job destruction rate (jdr1-jdr3) should have a positive influence on wage dispersion. This is supported by the data since we find positive signs which are always significant. Obviously, a higher job destruction rate is associated with higher wage dispersion, from the point of view of the friction hypothesis because higher job destruction increases the monopsony power of the firms via its effect on unemployment. The second prediction concerns the job changing rate (jcr). Here, an increase in the job–to–job transition rate should reduce wage dispersion. The signs found in the data are well in accordance with this hypoth-

Table 4.5: Friction hypothesis – FEGLS-regressions of the interquantile range on the transition rates

Coeff. estimate (Stand. error)	jdr1 (E-BR)	jdr2 (E-BR|OOS)	jdr3 (E-NoE)	jcr (E-OE)	jfr1 (BR-E)	jfr2 (BR|OOS-E)
liqr	0.9106*					
	(0.1099)					
		0.7693*				
		(0.0907)				
			0.6094*			
			(0.0887)			
				-0.0351		
				(0.1557)		
					0.1143*	
					(0.0214)	
						0.1946*
						(0.0252)
	0.9099*			-0.1806		
	(0.1100)			(0.1420)		
	0.9140*			-0.2849*	0.1199*	
	(0.1042)			(0.1257)	(0.0181)	
Exp. sign	+	+	+	-	0	0

See appendix D for the definition of the variables. Estimation is based on 320 observations. iqr is log-transformed. We use the transition rates between $t-1$ and t as explanatory variables.

esis. However, we find a significantly negative effect only when controlling for transitions from employment to unemployment and for transitions from unemployment to employment. Obviously, if people change jobs more often wage dispersion decreases or remains unchanged. Finally, we suspected that the job finding rate (jfr1, jfr2) bears no influence on wage dispersion. This implication is not confirmed. Instead, we find a positive influence of the job finding rate on wage dispersion which always proves significant. When individuals find jobs faster, this seems to increase wage dispersion.

As a second evaluation of the friction hypothesis, we regress the (logarithm of the) wage dispersion measure on the lagged unemployment rate and on the lagged friction indicator, as defined in Van den Berg and Ridder (1993), i.e. $\eta = \frac{jdr}{jdr+jcr}$ (using the job–to–job transition rate jcr as a proxy for the job offer rate on the job). Various regressions were run using different definitions of jdr and u, respectively. Table 4.6 indicates that the coefficient of η does not show the expected sign. The friction hypothesis predicts that wage dispersion rises with stronger market frictions η. Empirically, however, a higher value for η is associated with lower wage dispersion. This must be interpreted as evidence against search theory. Especially, in light of the previous estimation results this is astonishing, since we find that both factors influencing η, that is, jdr and jcr show the correct sign from the point of view of the friction hypothesis. The results for the two definitions of unemployment are in favor of search theory. Overall, one should be cautious not

Table 4.6: Friction hypothesis – FEGLS-regressions of the interquantile range on frictions indicator and unemployment

Coefficient estimate (standard error)	η	$\tilde{\eta}$	u	$\tilde{u}$
iqr	-0.0012 (0.0171)	-0.5367* (0.1608)	0.1943 (0.1099)	0.3842* (0.1116)
Expected sign	+	+	+	+

The Estimation is based on 320 observations. Year dummies are included as regressors. See appendix D for the definition of the variables.
iqr is log transformed.
The RHS variables are measured from $t-1$ to t .

to overemphasize these results, in particular, since our empirical measure for jcr is only a proxy for the job offer rate on–the–job.

Summing up, we conclude that both the heterogeneity hypothesis and the friction hypothesis are only partly consistent with the data. In a strict sense, both hypotheses are rejected by the data. However, the friction hypothesis seems to perform better than the heterogeneity hypothesis. Regarding the starting point of our discussion, namely the relationship between wage dispersion and unemployment, our results favor search theory and contradict the Krugman hypothesis regarding residual wage dispersion.

4.5 Conclusion

This paper attempts to discriminate between different theories on the relationship between unemployment and residual wage dispersion. We develop two hypotheses which exhibit different empirical implications. One view, which we denote heterogeneity hypothesis, is that wages are determined entirely by marginal productivity so that residual wage dispersion corresponds to residual productivity dispersion. To account for the institutional setting in Germany, we allow labor unions to compress wages from below by imposing different minimum wages for different groups of worker. Differences in residual wage dispersion might stem from union influence differing in strength. Accordingly, unemployment results because the minimum wage is higher than the marginal productivity of the unemployed. The alternative view, which we denote the friction hypothesis, is based on search theory. It states that after having controlled for age and education, residual individual heterogeneity is not sufficiently strong to account for the considerable residual wage dispersion. Instead, the residual wage dispersion is determined by the amount of search frictions. If search frictions are high, we will observe a high wage dispersion because search frictions lead to monopsony power for the firms resulting in higher wage dispersion. Accordingly, unemployment is not caused by minimum wages set by labor unions, but is a result of search frictions. Our empirical analysis tests these opposing hypotheses. We obtain panel estimates that are based on the comovement in transition rates, unemployment, and wage dispersion within age–education cells. The results are more supportive for the friction hypothesis than for the heterogeneity hypothesis, although some implications of the former hypothesis are rejected as well. Especially, regarding the relationship between unemployment and residual wage dispersion, the friction hypothesis seems to perform better. Thus, regarding residual wage dispersion, our results contradict the Krugman hypothesis. A compression of the residual wage dispersion does not seem to be associated with an increase in unemployment. So far, we have said nothing concerning the relationship between wage dispersion between cells and unemployment. However, recognize that, when the Krugman hypothesis between cells is valid, it is likely that we find this phenomenon within the cells as well. To see this, note that a wage compression from below would both reduce the wage dispersion between groups and the wage dispersion within groups and thus we should find this relationship both between and within groups

There are a number of critical issues which should be mentioned to put this study into perspective. First, the two hypotheses are complementary in a broad sense. They become mutually exclusive in the sense that the heterogeneity hypothesis postulates 'observable' residual heterogeneity while the friction hypothesis does not, once productivity related heterogeneity is accounted for. Second, the data do not perfectly match the data requirements. For instance, it would be interesting to investigate whether our (imperfect) wage dispersion measure is correlated with the relative strength of the union membership in a cell. Descriptive evidence in Fitzenberger and Kohn (2005) suggests that a higher union density in fact reduces within wage dispersion. Third, at this level of analysis, we cannot use the primitive variables, which search theory is built upon, e.g. the job offer rate while employed instead of the actual rate of job changes. Rather, our analysis operates at a descriptive level based on observable transition rates. However, this has the advantage that it does not require the strong assumptions typically invoked to estimate structural models of search equilibrium.

5 A synthesis: Modelling different types of unemployment and wage dispersion together

5.1 Introduction

This chapter combines an equilibrium search framework for heterogeneous labor with a production function approach and endogenous job offer rates to analyze the effects of minimum wages on employment and wages when unemployment is both frictional and structural. It is based on Fitzenberger and Garloff (2007a).

This combination allows us to analyze wage dispersion within and between skill groups in a unified framework. We obtain analytical solutions for equilibrium wage distributions for individuals with identical skills. For a more general class of models we simulate wage distributions often containing mass points at the upper bound of the distribution. We calculate the effects of minimum wages on structural unemployment and on the two types of wage dispersion. We find that labor unions minimum wages cause structural unemployment when firms labor demand reacts.

"Structural" reasons are often identified when discussing the high unemployment in European countries. This is surely correct, because the term is not very well defined and used for very different things. Structural in the sense of this paper refers to a situation where unemployment results from the market power of labor unions, setting wages too high. This type of structural reason for the high unemployment is not as easily agreed upon. In addition, it is not seen as being equally important in all European countries. However, a big part of the literature on unemployment in Europe argues that labor unions influence is an important factor in explaining the situation, at least in Germany (see, e.g., Krugman (1994), Krueger and Pischke (1998), Fitzenberger and Franz (2001), Puhani (2003), Blau and Kahn (2002) and Pfeiffer (2003)).[1] We take up that point and model this explicitly.

But, economists would generally agree that even in countries where structural reasons are said to be very important, frictional unemployment is present. Frictional in the use of this paper means that individuals look for "good" jobs and they do not know where the good jobs are located. This process is time-consuming, generating waiting phases in "frictional" unemployment and potential market power for firms. We take up this idea as well and explicitly model frictional unemployment in this paper.

[1] Note, however that there is a literature that is more critical about this explanation, see e.g. Nickell (1997), Gregg and Manning (1997), Freeman and Schettkat (2000), Beaudry and Green (2003) and Möller (2004).

So far, the interplay between frictional and structural unemployment has largely been ignored in the micro literature.[2] Both strands of the literature are largely parallel and have not inspired each other. With our approach to commonly model the two types of unemployment in an equilibrium search context, we fill this research gap. One of the few exceptions in the literature dealing with both types of unemployment in this context is Koning, Ridder, and Van den Berg (1995). Contrary to our approach, they assume however, that the labor market consists of a number of separate submarkets, which do not interact. Structural unemployment in their model means that in one submarket there is no production at all, because the value of leisure exceeds the (constant) marginal productivity of the individuals. We avoid this strong assumption in our model, where heterogeneous agents interact on one labor market.

A big part of the literature on unemployment differentials between the US and Europe focuses on the diverging experience in unemployment *and* wage dispersion. Skill-biased technological change and other factors are said to have increased the demand for high-skilled labor as compared to low-skilled labor and have therefore altered the wage structure. Numerous studies point to the fact that wage dispersion between groups increased as a reaction at least in the US (for overviews, see e.g. Gottschalk (1997), Katz and Autor (1999) or Acemoglu (2002)). Because wage regressions generally only explain little of the wage variation however (Mortensen (2003)), recently the literature has become interested in the development of wage differentials within groups with comparable attributes. These literature has been stimulated by the seminal paper of Burdett and Mortensen (1998) (BM hereafter). Empirical studies show that first, much of the increase in overall inequality is due to an increase in residual inequality (see Juhn, Murphy, and Pierce (1993), Violante (2002)) and that second the development of wage inequality between different skill groups and within different skill groups is not parallel (see, e.g., Katz and Autor (1999), Fitzenberger (1999)).[3] Clearly, this poses the question of understanding the development of both types of wage dispersion in a unified framework.

Again, the literature on wage differentials between groups and within groups are largely parallel.[4] Our model corresponds to the challenge of understanding the development of wage dispersion within and between groups in one framework. In addition, it allows to understand the development of the unconditional wage distribution as resulting from the interplay of the development within and between groups as analyzed, e.g. for Germany, in Kohn (2006) or Gernandt and Pfeiffer (2006).

[2] The macro literature, namely the matching-literature does allow for the two types of unemployment. However, the matching literature does not allow for residual wage inequality.

[3] Prasad (2004) argues based on the GSOEP that the developments are parallel for groups defined by education, experience and tenure. Lemieux (2005) argues that much of the residual wage inequality is data noise and that its importance is overstated.

[4] A notable exception is e.g. Acemoglu (2002).

We extend an equilibrium search framework that naturally generates frictional unemployment and residual wage inequality to allow for wage inequality between groups and structural unemployment. Model building is complicated by the fact that in order to be able to explain different unemployment rates for different skill groups and to generate wage dispersion between groups, we allow for heterogeneous labor. Under strong assumptions, we obtain analytical solutions for the wage distributions of the skill groups. These are similar in shape to the Burdett and Mortensen (1998) solution.[5] For more general model settings, we simulate solutions. Endogenous job offer rates allow us to introduce labor demand effects in this framework. Comparatively weak assumptions are required to obtain a unique negative effect of a binding minimum wage on employment. Analytical results for effects of a binding minimum wage on the wage distribution and its moments are not easily obtained, since in equilibrium the complete distribution reacts.[6]

The plan of the paper is as follows. First, we discuss some related literature. Second, we present the model to discuss afterwards an analytical solution and extensions. Then, we give simulation results and finally introduce a labor union. The last section concludes.

5.2 Literature

There are two separate strands of literature dealing with wage inequality and employment. On the one hand, there is the labor supply and demand literature. This literature relates the average wage for a skill group to its employment. Typically, within a labor supply and demand framework only a small number of skill groups can be distinguished (see Hamermesh (1993)). The most advanced analyses distinguish up to 3 education and 6 age categories in the empirical implementation (see, e.g., Fitzenberger and Kohn (2005)). However, the interpretation of the empirical relationship between average wages and employment is not easy, because aggregation over presumably heterogeneous workers is problematic (see, Fitzenberger, Garloff, and Kohn (2003)). Further, wages and employment are endogenous quantities with respect to each other and output effects exist and are endogenous; thus empirical operationalization is difficult (see Fitzenberger (1999)). In addition, even when distinguishing a relative huge number of skill groups, the residual wage inequality is still considerable (see, Fitzenberger, Garloff, and Kohn (2003)). A part of the literature argues that the residual wage inequality reflects unobserved productivity differences (see, e.g., Katz and Autor (1999), Acemoglu (2002) and Lemieux (2005)). An interesting alternative, and the second literature strand that relates wages and employment,

[5] When we speak about a BM-type wage distribution, we refer to a wage density that is increasing and where the wage distribution has no mass points.

[6] Recognize that this seems to be a stylized fact of minimum wages, see Koning, Ridder, and Van den Berg (1995).

is offered by the equilibrium search theory. This literature shows that search frictions can cause both unemployment and wage inequality for identical workers.

Most of the literature on search equilibrium is based on the paper of Burdett and Mortensen (1998). It is the first paper that generates frictional unemployment and continuous residual wage dispersion in a model. The paper has two main shortcomings. First, individuals are homogeneous with respect to all relevant characteristics, especially in their marginal productivity, which is in addition assumed constant. Second, most commentators criticize the equilibrium wage distribution, that the model generates, with the argument that the increasing density is counterfactual. Part of the critique, however, seems to be a misunderstanding of the model in so far as it does not generate an unconditional wage distribution. Some part of the literature argues that the form of the conditional density does not contradict stylized facts (see e.g. Gautier and Teulings (2006)).

Several attempts have been made to respond to these challenges. Heterogeneity has been incorporated in the model both on the side of the individuals and on the side of the firms. On the side of the firms heterogeneity was integrated as different productivities that are either exogenous or endogenous (see Burdett and Mortensen (1998), Mortensen (2000), Bontemps, Robin, and Van den Berg (2000)). These extensions seem to be capable of producing wage densities that have a long right tail as required for empirical wage densities (see Bontemps, Robin, and Van den Berg (2000)). On the side of the workers, heterogeneity has been introduced with respect to leisure preferences by Burdett and Mortensen (1998). Van den Berg and Ridder (1998) consider individuals that are different with respect to their marginal productivities, but assume that the labor market is completely segmented. Ridder and Van den Berg (1997), building on Manning (1993) and Mortensen and Vishwanath (1994), consider the case where marginal productivity of the individuals varies with the amount of labor employed in a particular firm, i.e. a production function with one production factor. Postel-Vinay and Robin (2002b) model jointly productive heterogeneity on the side of the employers and on the side of the employees. Their assumptions somewhat differ from the standard BM-case. Still, they maintain the assumption that marginal productivity of the individual does not depend on the employment.[7]

The first attempt of modelling several skill groups jointly and to link their employment in firms via a production function in the equilibrium search context is Holzner and Launov (2005). In addition, they allow for heterogeneous firm productivities. To solve their model they have to assume supermodularity in production. In addition, their model does not allow for labor demand effects. Since their model entails several skill groups it generates wage inequality within and

[7] For surveys on new developments in the search literature, compare Garloff (2007), Rogerson, Shimer, and Wright (2005) and the book of Mortensen (2003).

between groups. In addition, it is able to generate a long right tail for the wage density. Our model extends their results by allowing for labor demand effects via endogenous job offer rates, by employing different assumptions for obtaining an analytical solution and by giving simulation results.

5.3 An equilibrium search model with heterogeneous labor

We consider a labor market, where there is a huge amount of workers of two skill groups ($i = 1, 2$ of masses N_i and firms (of mass 1). Individuals are maximizing their expected lifetime income, while firms maximize an approximation of expected profits. The labor market is frictional in the sense that finding a job requires time, and in the sense that jobs are destroyed from time to time. This is reflected in the job offer rates for unemployed individuals (λ_i) and for employed individuals ($\lambda_{i,L}$) on the one hand and by the job destruction rate (δ_i) on the other hand.

5.3.1 Individuals behavior

We now derive the optimal behavior of the individuals. In this environment, the optimal behavior of the individuals is characterized by an optimal stopping property, i.e. a reservation wage.

Proposition 1: Individual behavior and therefore the reservation wage depends only on the marginal wage offer distributions.

Proof: See appendix E.1.

The reservation wage is given by the wage w_i for individuals employed at wage w_i (see Mortensen and Neumann (1988)). For unemployed individuals of the two skill groups ($i = 1, 2$), assuming that there is no mass point at w_i, it is determined by the value equations and given by:[8]

$$w_{i,R} = z_i + (\lambda_i - \lambda_{i,L}) \int_{w_{i,R}}^{w_1^o} \frac{1 - H_i(w_i)}{r + \delta_i + \lambda_{i,L}(1 - H_i(w_i))} dw_i. \tag{5.1}$$

$w_{i,R}$ is the reservation wage for an unemployed individual of skill group i, w_1^o is the upper bound of the respective wage offer distribution, z_i is the alternative income of the unemployed, i.e., unemployment benefits net of search cost, and $H_i(w_i)$ is the (marginal) wage offer distribution for skill group i.[9]

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[8] Given that individuals care in their decision only about the marginal distributions, the derivation of the reservation wage is standard and can be found in Cahuc and Zylberberg (2004).

[9] This is the distribution from which an individual draws, when it receives a job offer according to the respective job offer rate. The probability of drawing a job offer paying a wage above w_i is $(1 - H_i(w_i))$ irrespectively of whether or not an individual is employed and where it is employed.

The reservation wage completely characterizes the decision of an individual. The unemployed (employed) individual accepts all job offers that pay wages above $w_{i,R}$ (w_i) and rejects otherwise.

Given this optimal behavior, we can describe the employment dynamics for firms. Consider the collection of firms that pay wages above a wage w_i, assuming that at w_i there is no mass point. Let $K(w_i) \equiv N_i - U_i - L_i(w_i)$ be the employment in these firms, where U_i is the number of unemployed and $L_i(w_i)$ is the number of employed in firms paying wages below w_i. Their employment evolves according to:

$$\dot{K}_i(w_i) = (\lambda_i U_i + \lambda_{L,i} L_i(w_i))(1 - H_i(w_i)) - \delta_i K_i(w_i). \tag{5.2}$$

Under stationarity, we have $\dot{K}_i(w_i) = 0$ and from this we can calculate the connection between the cross-sectional wage distribution $G_i(w_i) = \frac{L_i(w_i)}{(N_i - U_i)}$ [10] and the wage offer distribution $H_i(w_i)$ [11]. It is given by:

$$G_i(w_i) = \frac{\delta_i H_i(w_i)}{\lambda_{i,L}(1 - H_i(w_i)) + \delta_i}. \tag{5.3}$$

Now, consider skill group $i = 1$. Imposing stationarity $\dot{K}_1(w_1) = 0$ and twice differentiating the resulting condition with respect to w_1 yields:

$$\frac{l_1'(w_1)}{l_1(w_1)} = \frac{2\lambda_{1,L} h_1(w_1)}{(\lambda_{1,L}(1 - H_1(w_1)) + \delta_1)}. \tag{5.4}$$

This is the central equation characterizing the dynamics of employment in a firm that offers a wage w_1 depending on the wage strategies of all other firms and the frictions. This dynamics follows from the optimal behavior of individuals.

We can calculate $l_1(w_1)$ from $L_1'(w_1) = l_1(w_1) h_1(w_1)$ as

$$l_1(w_1) = \frac{(N_1 - U_1)\delta_1 \left(\lambda_{1,L} + \delta_1\right)}{\left(\lambda_{1,L}(1 - H_1(w_1)) + \delta_1\right)^2} \tag{5.5}$$

and $l_1'(w_1) > 0$.[12] Note that this equation gives an expression for the *expected* employment or equilibrium employment depending on the parameters.

Next, we consider optimal behavior of firms.

[10] The distribution of wages when randomly sampling an employed individual.

[11] The wage distribution when randomly sampling a firm. These are different because firms differ in size.

[12] This equation is a special case of equation (5) in Holzner and Launov (2005) for the case of no mass point at w_i. If there is a mass point at w_i, we must adopt the more complicated form of them.

5.3.2 Firms behavior

Firms maximize the profits at the expected employment, an approximation of the expected profits (see Holzner and Launov (2005)), which are given as

$$\Pi(w_1, w_2) = y(l_1(w_1), l_2(w_2)) - w_1 l_1(w_1) - w_2 l_2(w_2), \tag{5.6}$$

by choosing an optimal wage-vector w. Recognize that this is similar to saying that firms choose an optimal employment level, because the wage uniquely determines the employment level (see equation (5.5)). Recognize that Proposition 1 implies together with the above derivations that the employment for skill group 1 only depends on the wage for skill group 1 and not on w_2. This justifies that we do not need to allow for a dependence of l_1 (or equivalently h_1, g_1) on w_2 in the above profit function and vice versa.[13]

Firms optimal choice of w_1 implies

$$\begin{aligned} \frac{\partial \Pi(w_1, w_2)}{\partial w_1} &= \frac{\partial y()}{\partial l_1}\frac{\partial l_1}{\partial w_1} - l_1(w_1) - w_1 \frac{\partial l_1()}{\partial w_1} = 0 \\ \frac{l_1'(w_1)}{l_1(w_1)} &= \frac{1}{\left(\frac{\partial y()}{\partial l_1} - w_1\right)} = \frac{1}{y'(l_1) - w_1} \end{aligned} \tag{5.7}$$

a condition describing a connection between the relative change of the employment density of skill group 1 with w_1 and the profit per worker.

5.3.3 Equilibrium

To solve the model, we now equate the conditions (5.7) and (5.4) yielding the following condition of optimality.

$$2h_1(w_1)\left(\frac{\partial y()}{\partial l_1}(H_1(w_1), H_2(w_2)) - w_1\right) + H_1(w_1) - \frac{\lambda_{1,L} + \delta_1}{\lambda_{1,L}} = 0 \tag{5.8}$$

In this equation we have substituted $H_1(w_1)$ for $l_1(w_1)$ as arguments in the production function. We must specify the production function in order to be able to characterize the form of the solution of this differential equation. Moreover, in this form the equation looks like a partial differential equation. We will argue below that it is not a partial differential equation but only

[13] Notice, that we assume that firms care about expected employment and do not adapt their wage policy on short run variations in employment.

an ordinary one. Assume for the moment a Cobb-Douglas form $y = A l_1^{\alpha_1} l_2^{\alpha_2}$. We can rewrite the central differential equation as

$$h_1(w_1) = \frac{-H_1(w_1) + \frac{\lambda_{1,L}+\delta_1}{\lambda_{1,L}}}{2\left(\alpha_1 A \left(\frac{(N_1-U_1)\delta_1\left(\lambda_{1,L}+\delta_1\right)}{\left(\lambda_{1,L}(1-H_1(w_1))+\delta_1\right)^2}\right)^{\alpha_1-1}\left(\frac{(N_2-U_2)\delta_2\left(\lambda_{2,L}+\delta_2\right)}{\left(\lambda_{2,L}(1-H_2(w_2))+\delta_2\right)^2}\right)^{\alpha_2} - w_1\right)}. \tag{5.9}$$

This equation looks very involved. Recognize however, that the solution $H_1(w_1)$ to this differential equation does not depend on w_2 but on w_1 only. If there is a functional connection between w_1 and w_2 this holds true. Therefore, we assume that the optimal choice of w_1 determines the optimal choice of w_2, i.e. $w_1 = z(w_2)$ and that, in addition, $z' > 0$.

This considerably simplifies the problem, since it makes clear that we only have to solve an ordinary differential equation. We can replace $H_1(w_1)$ for $H_2(w_2)$ in the above equation since firms cover the same position in the wage distributions of the two skill groups. Still, the above equation is sufficiently involved such that we could not find a closed form analytical solution for this non-linear, non-autonomous, ordinary differential equation.

5.4 Solving the model

5.4.1 An analytical solution

For an analytical solution to this problem, we now constrain ourselves to a special case with parameter restrictions. We discuss some other solution strategies in appendix E.2. Let us first assume that the production technology has constant returns to scale, i.e. $\alpha_1 + \alpha_2 = 1$.[14] Second, we assume that the ratio of job destruction rate and job offer rate on-the-job is identical for both skill groups:

$$\frac{\delta_1}{\lambda_{1,L}} = \frac{\delta_2}{\lambda_{2,L}}. \tag{5.10}$$

This means that the average job duration is strictly shorter for one skill group than for the other or, in other words, that there is higher turnover from both sources for one skill group. It is conceivable, for example, that high-skilled jobs involve more specific capital which means that job destruction is more seldom and job-to-job transitions occur less often. For the Dutch labor market Van den Berg and Ridder (1998) show that this assumption is in accordance with the data. The empirical findings of Van den Berg and Ridder (1998) even allow for a stronger assumption, since they note that it is "... important to allow for unobserved heterogeneity in λ but not necessarily in λ_L or in δ." (p.1213)

[14] For evidence on constant returns to scale, see e.g. Hamermesh (1993).

We obtain:

$$h_1(w_1) = \frac{-H_1(w_1) + \frac{\lambda_{1,L}+\delta_1}{\lambda_{1,L}}}{2\left(\alpha_1 A \left(\frac{(N_1-U_1)\delta_1\left(\lambda_{1,L}+\delta_1\right)}{\left(\lambda_{1,L}(1-H_1(w_1))+\delta_1\right)^2}\right)^{\alpha_1-1}\left(\frac{(N_2-U_2)\delta_2\left(\lambda_{2,L}+\delta_2\right)}{\left(\lambda_{2,L}(1-H_1(w_1))+\delta_2\right)^2}\right)^{\alpha_2} - w_1\right)}. \tag{5.11}$$

This differential equation looks nice and can be solved using separation of variables (see appendix E.3).

We get a closed form solution for the wage distribution of skill group 1 and by symmetry for skill group 2:

$$H_i(w_i) = \frac{\delta_i + \lambda_{i,L}}{\lambda_{i,L}}\left(1 - \sqrt[2]{\frac{(\alpha_i A(\lambda_{i,L}+\delta_i)^{\alpha_i-1}(N_i-U_i)^{\alpha_i-1}(\lambda_{j,L}+\delta_j)^{1-\alpha_i}(N_j-U_j)^{1-\alpha_i} - w_i)}{\left(\alpha_i A(\lambda_{i,L}+\delta_i)^{\alpha_i-1}(N_i-U_i)^{\alpha_i-1}(\lambda_{j,L}+\delta_j)^{1-\alpha_i}(N_j-U_j)^{1-\alpha_i} - w_i^R\right)}}\right)$$

$i = 1, 2$. A steady state labor market equilibrium solution to this model is completely characterized by H_1, H_2, w_1^R, w_2^R, where individuals maximize expected lifetime income and firms maximize expected profits. This is the solution to an equilibrium search model with two skill groups which are linked via a Cobb-Douglas production function, where both firms and individuals behave rationally with respect to their preferences.[15]

Of course, the resulting mixture wage distribution of the two skill groups is of special interest, since it allows to decompose the variance of the wage distribution into a component that is due to the variance within a skill group (i.e., because of frictions), and to a component that is due to the variance between skill groups (i.e., because of human capital differences).

Using that $H_2(w_2) = H_1(z^{-1}(w_2))$, the function z is determined by the above equation. We obtain

$$z^{-1}(w_2) = C + \frac{\left((\alpha_1 A(\lambda_{1,L}+\delta_1)^{\alpha_1-1}(N_1-U_1)^{\alpha_1-1}(\lambda_{2,L}+\delta_2)^{1-\alpha_1}(N_2-U_2)^{1-\alpha_1} - w_1^R\right)}{\left((1-\alpha_1)A(\lambda_{2,L}+\delta_2)^{-\alpha_1}(N_2-U_2)^{-\alpha_1}(\lambda_{1,L}+\delta_1)^{\alpha_1}(N_1-U_1)^{\alpha_1} - w_2^R\right)} w_2, \tag{5.12}$$

where $C = \alpha_1 A(\lambda_{1,L}+\delta_1)^{\alpha_1-1}(N_1-U_1)^{\alpha_1-1}(\lambda_{2,L}+\delta_2)^{1-\alpha_1}(N_2-U_2)^{1-\alpha_1}$

and

$$\frac{dz^{-1}(w_2)}{dw_2} > 0.$$

[15] Recognize that differences in marginal productivity of these two skill groups stem from differences in the equilibrium unemployment rate, from the friction parameters, and from differences in their α parameter.

We checked that the solutions satisfy the original differential equations (i.e., equation (5.11) is satisfied). Recognize that the equilibrium wage distributions cannot contain mass points, since wages are strictly below marginal productivity (see below).

5.4.2 Properties of the solution

Increasing wage densities

The wage offer density from the model is given as:

$$h_1(w_1)=\frac{\delta+\lambda_L}{2\lambda_L}\sqrt[2]{\frac{1}{(\alpha_1 A(N_1-U_1)^{\alpha_1-1}(N_2-U_2)^{1-\alpha_1}-w_1)(\alpha_1 A(N_1-U_1)^{\alpha_1-1}(N_2-U_2)^{1-\alpha_1}-w_1^R)}}.$$

Taking derivatives yields the following

$$\frac{\partial h_1(w_1)}{\partial w_1}=\frac{\delta+\lambda_L}{4\lambda_L}(\alpha_1 A(N_1-U_1)^{\alpha_1-1}(N_2-U_2)^{1-\alpha_1}-w_1^R)^{-1/2}(\alpha_1 A(N_1-U_1)^{\alpha_1-1}(N_2-U_2)^{1-\alpha_1}-w_1)^{-3/2}>0,$$

which is uniquely positive. If the density of the wage offers is increasing the density of the cross-sectional wages increases as well $\frac{\partial g_1(w_1)}{\partial w_1} > 0$.[16] Recall that the equilibrium relationship between H_1 and G_1 is given by equation (5.3). So, introducing a production function the way we do it, does not lead to a wage density with a long right tail. The mixture of the two might come a bit closer to the desired form, but two skill groups clearly do not suffice to generate the required form (see Holzner and Launov (2005)).

Constant marginal productivity over the wage distribution

One of the reasons, why we get a closed form solution for our special parameter constellation is that we have a constant marginal productivity across the wage distribution. This brings us more or less back in the BM-world for each skill group, given it is optimal for the firms to cover the same position in both wage distributions. This is astonishing, since we have decreasing marginal productivity in each skill group, as analyzed in Ridder and Van den Berg (1997).

To see why marginal productivity is constant across the wage distribution, observe that the wage uniquely determines the size of the work force of each firm. For the parameter constellation chosen, the effect of a decreasing marginal productivity when increasing the wage and therefore employment of one skill group is exactly offset by the corresponding effect of the increasing marginal productivity because the employment of the other skill group increases as well. This

[16] When the wage offer density increases, that means that there are more firms offering a higher wage. In addition, firms paying a higher wage are bigger ($l_1'(w_1) > 0$, see equation (5.5)). This implies that the wage density is steeper than the wage offer density.

increase of the other skill group arises because firms take the same position in both wage distributions. Formally, this follows because the part which contains the wage distribution cancels out.

$$\begin{aligned} \frac{\partial y}{\partial l_1} &= \alpha_1 A \left(\frac{(N_1 - U_1)\delta_1 \left(\lambda_{1,L} + \delta_1\right)}{\left(\lambda_{1,L}(1 - H_2(w_2)) + \delta_1\right)^2} \right)^{\alpha_1 - 1} \left(\frac{(N_2 - U_2)\delta_2 \left(\lambda_{2,L} + \delta_2\right)}{\left(\lambda_{2,L}(1 - H_2(w_2)) + \delta_2\right)^2} \right)^{\alpha_2} \\ &= \alpha_1 A (N_1 - U_1)^{\alpha 1 - 1} \left(\lambda_{1,L} + \delta_1\right)^{\alpha_1 - 1} (N_2 - U_2)^{1 - \alpha_1} \left(\lambda_{2,L} + \delta_2\right)^{1 - \alpha_1} \end{aligned} \tag{5.13}$$

Reservation wage, and upper bound as well as moments of the wage distribution

Having at hand the wage distribution and the marginal productivity of the individuals we can calculate the reservation wage and the upper bound of the wage distribution(s) according to the following two formulas:

$$w_1^R = z_1 + (\lambda_1 - \lambda_{1,L}) \int_{w_1^R}^{w_1^o} \frac{1 - H_1(w_1)}{r + \delta_1 + \lambda_{1,L}(1 - H_1(w_1))} dw_1 \tag{5.14}$$

and from setting $H_1(w_1^o) = 1$:

$$w_1^o = \frac{\partial y}{\partial l_1} - (\frac{\partial y}{\partial l_1} - w_1^R) \left(\frac{\delta_1}{\delta_1 + \lambda_{1,L}} \right)^2, \tag{5.15}$$

which for reasonable parameter choices is close to the but below marginal productivity.

Constraining ourselves to a case, where the lower bound of the wage distribution is not given by the reservation wage, but by an exogenous restriction, as say a minimum wage, in addition, we can calculate the moments of the wage distribution according to the following formulas (see Van den Berg and Ridder (1993)):

$$E_{G_1}(w_1) = \left(y_1' - mw_1\right) \left(1 - \frac{\delta_1}{\delta_1 + \lambda_{1,L}}\right) + mw_1,$$

where $y_1' = \frac{\partial y}{\partial l_1}$ is the marginal productivity and mw_1 is the binding minimum wage. Using the same notation as above, the variance is given by the following formula (ibid.):

$$var_{G_1}(w_1) = \frac{1}{3} \left(y_1' - mw_1\right)^2 \frac{\delta_1}{\delta_1 + \lambda_{1,L}} \left(1 - \frac{\delta_1}{\delta_1 + \lambda_{1,L}}\right)^2 = \frac{1}{3} \left(y_1' - mw_1\right)^2 \frac{\lambda_{1,L}^2 \delta_1}{\left(\delta_1 + \lambda_{1,L}\right)^3}.$$

By symmetry these formulas apply for skill group 2 as well.

A nice feature of the model is that we do not have to invoke the strong assumption that $\lambda = \lambda_L$ (the same job offer rate for employed and unemployed) which is often made in advanced search models, see e.g. Ridder and Van den Berg (1997). We allow for unobserved heterogeneity in λ.

That is also the reason why the reservation wage is (considerably) different from the alternative income of the unemployed z_1.

5.4.3 Simulation results

The general problem which we want to solve is equation (5.11). The problem with this differential equation is that there is no easy way to solve a non-autonomous, non-linear ordinary differential equation. Above, we invoke some assumptions which allow for a analytical solution. Deviating from these assumptions, we assess the solution by trying numerical methods. We argued above that it is likely that firms cover the same position in the wage distributions for both skill groups as long as there is no mass point. For all simulations, we maintain this assumption for the continuous part of the wage distribution.

We start by assessing whether the numerical solution to the variant which we can solve analytically reproduces the analytical results, which - fortunately - it does.[17] As a starting point, we consider two parameter constellations: a labor market with a high degree of frictions and a labor market with a low degree of frictions (see, table E.1 in appendix E.3 for the chosen values). Table 5.1 gives the results for the two parameter constellations.

Table 5.1: Simulation results: Constant returns to scale

Parameter	low frictions	high frictions
u_1	0.091	0.286
u_2	0.063	0.118
$y_1^{'}$	0.407	0.161
$y_2^{'}$	0.593	0.913
w_1^r	0.137	0.035
w_2^r	0.277	0.467
w_1^o	0.404	0.146
w_2^o	0.588	0.859
$E_{G_1}(w_1)$	0.371	0.116
$E_{G_2}(w_2)$	0.535	0.665
$var_{G_1}(w_1)$	0.003	0.001
$var_{G_2}(w_2)$	0.007	0.025
Π	0.064	0.231

Clearly, the market with the high degree of frictions has the higher unemployment rates. The marginal productivity for the low-skilled is higher in the market with a low degree of frictions.

[17] For all simulations, we used Mathematica's routine NDSolve. This routine chooses between different methods to find numerical solutions, most of them being a variant of the Runge-Kutta method. For a description of Runge-Kutta methods, see e.g. Bronstein, Semendjajew, Musiol, and Mühlig (2000). For a description of Mathematica's NDSolve routine, see http://documents.wolfram.com/mathematica/.

This is the case because of the higher α attached to them and because own employment is much lower (whereas the employment of the other skill group is not that much lower). The contrary is true for the marginal productivity of the other skill group, by the same arguments. The reservation wage is a premium of about 35% (17%) for skill group 1 and 175% (125%) for skill group 2 in the case of low frictions (high frictions). The lower premium in the frictional case stems from the fact that market prospects are worse. By the same token, the premium for skill group 2 is higher. The profit of the firms is higher in the frictional case, since a higher amount of frictions is associated with a higher degree of monopsony power for the firms.

Next, we analyze the impact of small deviations from the parameter restrictions as given in table 5.1 on the equilibrium. We find that altering one of the parameters $(\lambda_{1,L}, \lambda_{2,L}, \delta_1, \delta_2)$ by a small amount immediately destroys the continuous density result in the case where frictions are low. If we increase δ_1 by only 2.5%, we already get a mass point at the top of the wage distribution for skill group 2. This means that a positive fraction of the firms offer and pay the same wage for skill group 2. The reason for the mass point at the top of the distribution is that the marginal productivity is not constant across the wage distribution. For skill group 2, in the continuous part, it decreases with an increasing wage w_2 and attains the marginal productivity at a value w_2^{crit} where $H_2(w_2^{crit,-}) < 1$. Clearly, at this point, further increasing the employment of skill group 2 is no more valuable. On the contrary, for skill group 1, the marginal productivity increases in the continuous part as w_1 rises. Thus, in the continuous part, the wage density is less steep than in the baseline case.

In the case of a high degree of frictions the continuous density result is more stable. Increasing δ_1 by 25% does not change the fact that we obtain a continuous solution for both skill groups. This holds true, although the marginal productivity of skill group 2 decreases strongly over the support of w_2 (by about 20%). At the same time, the marginal productivity for skill group 1 increases considerably over the support of w_1 (by more than 20%). Thus, the point where further enhancing employment is no more valuable to the firm exists in this case as well. It appears however on the right side of the support of w: the high amount of frictions circumvents that this potential mass point is attained. Another interesting result is obtained for this case: the wage offer density for skill group 1 is hump-shaped. The reason is the following: Recall that there is a tradeoff between profit per worker and employment. High wage firms must have a higher employment to compensate for the low profits per worker. The increasing marginal productivity over the support makes up for a part of the loss through higher wages. This decreases the employment required to compensate for the higher wage cost. The wage density is less steep which is achieved through a decreasing wage offer density. Similarly, the wage offer density for skill group 1 is steeper than in the case of a constant marginal productivity.

5.5 A labor union in an equilibrium search model

5.5.1 Basic setup

So far we have said nothing about unemployment. As with most search models our model has the characteristic that minimum wages do not change employment as long as they remain under the marginal productivity of the individuals. To see this, recognize that as long as the inflow in and outflow rates out of unemployment are unchanged, equilibrium unemployment is unchanged in a stationary equilibrium. However, the inflow rate is considered exogenous and equal to δ, while the outflow rate is $\lambda(1 - H_1(mw_1))$. However, since offering wages below the minimum wage mw_1 is illegal and since we assume the minimum wage to be binding, there are no wages below the minimum wage and thus:[18]

$$u_1 = \frac{U_1}{N_1} = \frac{\delta_1}{(\delta_1 + \lambda_1)}. \tag{5.16}$$

The fact that minimum wages affect unemployment only if they are above marginal productivity is not different from a competitive model. But, in a competitive model all paid wages correspond to the marginal productivity of some individual while in the absence of a mass point in our model *all* paid wages lie strictly below the marginal productivity. The reason for this is that search frictions and the assumed wage setting mechanism imply that firms have monopsony power.[19] Therefore, a labor union (or the state) that increases a minimum wage compresses the wage distribution and redistributes rents but does not alter employment.[20]

Now, imagine that the minimum wage increases above the marginal productivity of the individuals of say skill group 1. In the BM-case, employment would be zero because individuals have a constant marginal productivity. Here, however it is still optimal to employ some members of skill group 1, since when employment is lower, marginal productivity increases. To see this, just raise the minimum wage slightly above the level of the marginal productivity of the workers. Now, half the number of individuals in skill group 1, i.e. $N_1^* = \frac{N_1}{2}$. Under these circumstances we get a new solution with two continuous wage distributions, where firms make positive profits.

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[18] Of course, the same reasoning holds for a non-binding minimum wage. Then, the (common) reservation wage is the lower bound of the wage distribution.

[19] Recognize that even in the presence of a mass point there are no employment effects of increasing a binding minimum wage as long as the minimum wages touches only the continuous part of the wage distribution. For an extensive treatment of the effects of monopsony power on labor market outcomes, see Manning (2003a).

[20] We consider labor unions here, because in the German context there is - with some exceptions - no minimum wage by the state. But labor unions contracts in connection with the “to-the-workers-advantage principle” (“Günstigkeitsprinzip”) closely resemble minimum wages.

We take up this idea in the following and introduce rationing of jobs by endogenizing λ. Assume that λ is determined by the aggregate search effort of firms.[21] Assume further that hiring is costly to firms and that firms cannot distinguish prior to the search effort whether an individual is employed or unemployed, implying that $\lambda_i = \lambda_{i,L}$ (see Mortensen (2003)).[22] Assume for simplicity in addition that only hiring in skill group 1 is costly and that hiring costs per worker contact are linear and given by c.

Consider a firm that pays a wage w_1 for skill group 1, where its stationary employment is given by $l_1(w_1)$ as given by equation (5.5).[23] The firm has to contact enough workers to exactly offset the outflows, taking into account the acceptance probability $\gamma(w_1)$ of an individual contacted. The acceptance probability is given by:

$$\gamma(w_1) = u_1 + (1 - u_1)G_1(w_1)$$

for $w_1 > w_1^R$ and $G_1(w_1)$ is given by equation (5.3). For the total amount of worker contacts necessary to maintain firm size, we obtain:

$$\frac{(\lambda_1(1 - H_1(w_1)) + \delta_1)l_1(w_1)}{\gamma(w_1)} c_1 = \lambda_1 N_1 c_1. \tag{5.17}$$

Using the number of contacts necessary for maintaining equilibrium employment in the profit equation, we get:

$$\Pi(w_1, w_2) = y(l_1(w_1), l_2(w_2)) - w_1 l_1(w_1) - w_2 l_2(w_2) - \lambda_1 N_1 c_1. \tag{5.18}$$

This implies that the first order conditions in optimally choosing the wage vector w are unchanged and thus for any parameter constellation that yields a solution with a continuous wage distribution without considering contact costs and which still yield positive (zero) profits considering contact costs, the equilibrium is unchanged.

Now, consider, that the contact rate is endogenous. Consider the decision of the firms of contacting an additional worker. As long as the (expected) profits (per worker contacted) are positive the firms will increase worker contacts (see Mortensen (2003)), i.e.:

$$\frac{\Pi(w_1, w_2)}{\lambda_1 N_1} = \frac{1}{\lambda_1 N_1} \left(y(l_1(w_1), l_2(w_2)) - w_1 l_1(w_1) - w_2 l_2(w_2)\right) - c_1 = 0. \tag{5.19}$$

[21] It is a common assumption in the search literature that it is the firms search activity that determines λ (see e.g. Postel-Vinay and Robin (2002b)). It is rarely modelled explicitly, however.

[22] See, e.g., Manning (1993), for one of the few attempts to introduce rationing of jobs in a search framework.

[23] Recognize that this requires that there is no mass point at w_1.

Maintaining the assumption that firms cover the same position in the wage distribution of the two skill groups, and using the fact that we have no mass point at (w_1, w_2) yields:

$$\frac{1}{\lambda_1 N_1} A \left(\frac{\delta_1 \lambda_1 N_1}{(\delta_1 + \lambda_1 (1 - H_1(w_1)))^2} \right)^{\alpha} \left(\frac{\delta_2 \lambda_2 N_2 \frac{\lambda_{2,L}+\delta_2}{\lambda_2+\delta_2}}{(\lambda_{2,L}(1 - H_1(w_1)) + \delta_2)^2} \right)^{1-\alpha} \tag{5.20}$$
$$-w_1 \frac{\delta_1}{(\delta_1 + \lambda_1 (1 - H_1(w_1)))^2} - w_2 \frac{\delta_2 \lambda_2 N_2 \frac{\lambda_{2,L}+\delta_2}{\lambda_2+\delta_2} \frac{1}{\lambda_1 N_1}}{(\lambda_{2,L}(1 - H_1(w_1)) + \delta_2)^2} = c_1.$$

Following Mortensen (2003), this must hold for every wage that is paid in equilibrium, and we can write (setting $H_1(w_1)$ to zero):

$$N_1^{\alpha-1} A \left(\frac{\delta_1 \lambda_1}{(\delta_1 + \lambda_1)^2} \right)^{\alpha} \left(\frac{\delta_2 \lambda_2 N_2 \frac{\lambda_{2,L}+\delta_2}{\lambda_2+\delta_2}}{(\lambda_{2,L} + \delta_2)^2} \right)^{1-\alpha} - z_1 \frac{\delta_1 \lambda_1}{(\delta_1 + \lambda_1)^2} - w_2^R \frac{\delta_2 \lambda_2 N_2 \frac{\lambda_{2,L}+\delta_2}{\lambda_2+\delta_2} \frac{1}{N_1}}{(\lambda_{2,L} + \delta_2)^2} = c_1 \lambda_1. \tag{5.21}$$

Next, we analyze how λ that solves the above equation varies with the lower bound of the wage distribution, be it the reservation wage or the binding minimum wage mw_1.

Define:

$$G(\lambda_1) = N_1^{\alpha-1} A \left(\frac{\delta_1 \lambda_1}{(\delta_1 + \lambda_1)^2} \right)^{\alpha} \left(\frac{\delta_2 \lambda_2 N_2 \frac{\lambda_{2,L}+\delta_2}{\lambda_2+\delta_2}}{(\lambda_{2,L} + \delta_2)^2} \right)^{1-\alpha} - z_1 \frac{\delta_1 \lambda_1}{(\delta_1 + \lambda_1)^2} - w_2^R \frac{\delta_2 \lambda_2 N_2 \frac{\lambda_{2,L}+\delta_2}{\lambda_2+\delta_2} \frac{1}{N_1}}{(\lambda_{2,L} + \delta_2)^2} - c_1 \lambda_1 = 0.$$

Implicitly differentiating yields:

$$\frac{d\lambda_1}{dz_1} = \frac{\frac{\delta_1 \lambda_1}{(\delta_1+\lambda_1)^2}}{\frac{\delta_1^2 - \delta_1 \lambda_1}{(\delta_1+\lambda_1)^3} \left(\alpha A \left(\frac{\delta_1 \lambda_1 N_1}{(\delta_1+\lambda_1)^2} \right)^{\alpha-1} \left(\frac{\delta_2 \lambda_2 N_2 \frac{\lambda_{2,L}+\delta_2}{\lambda_2+\delta_2}}{(\lambda_{2,L}+\delta_2)^2} \right)^{1-\alpha} - z_1 \right) - c_1}.$$

The denominator is negative if, a) $\lambda_1 > \delta_1$ and b) $\frac{\partial y}{\partial l_1}(\lambda_1) > mw_1$. Both conditions are likely to hold, since the first assumption is simply assuming that the unemployment rate is smaller than 50% (see equation (5.16)), while the second says that the marginal productivity must exceed the minimum wage, which is a necessary condition for production. Recognize that for these arguments to hold we have assumed that there is no mass point at the lower bound z_1. Recognize in addition, that if there is a continuous part in the wage distribution then optimality implies that if there exists a mass point it must exist at the upper bound. When the wage distribution shrinks to a single point the above arguments do not apply. In deed, the theoretical results of Ridder and Van den Berg (1997) suggest that there are many cases where there is a wage distribution with a continuous part. Our simulation results for all parameter constellations resulted in wage distributions that are continuous at the lower bound of the distribution.

5.5.2 Frictional and structural unemployment

We can now decompose the total unemployment rate in a frictional component, caused by labor market frictions, and a structural component, caused by a labor unions minimum wage. We define frictional unemployment as the unemployment rate in the absence of a minimum wage. Let z_1 be the reservation wage of the individuals and let $mw_1 > z_1$ be the binding minimum wage, then frictional unemployment is given as:

$$u_1^f = \frac{\delta_1}{(\delta_1 + \lambda_1(z_1))}, \tag{5.22}$$

while structural unemployment is the difference of total unemployment and frictional unemployment.

$$u_1^s = u_1 - u_1^f = \frac{\delta_1}{(\delta_1 + \lambda_1(mw_1))} - \frac{\delta_1}{(\delta_1 + \lambda_1(z_1))} \tag{5.23}$$

Because λ_1 decreases with the minimum wage, structural unemployment increases with the minimum wage.

5.5.3 Wage dispersion

Next, we consider the wage distribution in the case where the labor union sets a minimum wage. For the above derivations, we had only to assume that the wage distribution has a continuous part, which we argued is likely to be the case. If we impose parameters that guarantee a solution that is continuous over the complete support, we can calculate the moments of the wage distributions. This allows us to calculate comparative static results for changing the minimum wage for these moments. In order to derive comparative static results, consider now the special case, where the job offer rate is identical across states and skill groups, i.e., $\lambda_1 = \lambda_2$ and $\lambda_{i,L} = \lambda_i = \lambda$, where as above λ is determined by the hiring process for skill group 1.[24] In addition, we maintain the assumption we imposed for the analytical solution, which implies that the destruction rates are identical across groups, i.e. $\delta_1 = \delta_2 = \delta$.

For this case, we obtain a closed form solution for λ

$$\lambda = -\delta + \sqrt[2]{\frac{\delta}{c_1}\left(N_1^{\alpha-1}N_2^{1-\alpha}A - z_1 - w_2^R\frac{N_2}{N_1}\right)}.$$

[24] Admittedly, from an economic point of view, the assumption that λ is determined by the hiring process for skill group 1, but also holds for skill group 2 is hard to justify. We use this, however, just as a tractable benchmark solution.

which solves the zero profit condition. We can show easily that the effect of z_1 on λ is unambiguously negative, and we do require neither $\lambda_1 > \delta_1$ nor $\frac{\partial y}{\partial l_1}(\lambda_1) > z_1$ to hold, because

$$\frac{\partial \lambda}{\partial z_1} = -\frac{1}{2}\left(\frac{\delta}{c_1}\left(N_1^{\alpha-1}N_2^{1-\alpha}A - z_1 - w_2^R\frac{N_2}{N_1}\right)\right)^{-0.5} < 0.$$

Since the introduction of hiring costs does not change the first order conditions (s.a.), the parameter constellation chosen guarantees the existence of continuous solution as long as profits are non-negative, i.e. as long as there is production. The wage offer distribution is given by:

$$H_1(w_1) = \frac{\delta+\lambda}{\lambda}\left(1 - \sqrt[2]{\frac{(\alpha_1 A(N_1)^{\alpha_1-1}(N_2)^{1-\alpha_1} - w_1)}{(\alpha_1 A(N_1)^{\alpha_1-1}(N_2)^{1-\alpha_1} - z_1)}}\right).$$

To get a sense of the effect of an increasing minimum wage on the wage distribution, we first calculate the upper bound of the wage distribution(s).[25]

From

$$1 = \frac{\delta+\lambda}{\lambda}\left(1 - \sqrt[2]{\frac{(y_1' - w_1^o)}{(y_1' - w_1^R)}}\right) \tag{5.24}$$

obtain

$$w_1^o(z_1) = y_1' - \left(1 - \frac{\lambda}{\delta+\lambda}\right)^2 (y_1' - z_1). \tag{5.25}$$

Since there is no effect of λ on the marginal productivity, we obtain:

$$\frac{\partial w_1^o}{\partial z_1} = 2\left(\frac{\delta^2}{(\delta+\lambda)^3}\right)\frac{\partial \lambda}{\partial z_1}(y_1' - z_1) + \left(1 - \frac{\lambda}{\delta+\lambda}\right)^2. \tag{5.26}$$

The effect of increasing the minimum wage on the upper bound of the wage distribution(s) cannot be signed. The reason is that there are two counteracting effects. On the one hand, an increasing minimum wage shifts the whole distribution, including the upper bound to the right if λ is constant. This effect is captured by the second summand in the above formula. On the other hand, λ decreases as a reaction to the increasing minimum wage and therefore the market gets less competitive, thereby decreasing the upper bound. This is the first summand in the above formula, which is negative because the effect of the minimum wage on the job offer rate is negative.

Next, we analyze the effect of an increasing minimum wage on the expectation of the wage distribution. The expectation is given by (see Van den Berg and Ridder (1993)):

[25] Recognize, that the upper bound of the distribution of wage offers is also the upper bound of the distribution of paid wages.

$$E_{G_1}(w_1 - z_1) = (y_1' - z_1)\left(1 - \frac{\delta}{\delta + \lambda}\right),$$

where $y_1' = \frac{\partial y}{\partial l_1}$.

We obtain

$$\frac{\partial}{\partial z_1} E_{G_1}(w_1 - z_1) = -1\left(1 - \frac{\delta}{\delta + \lambda}\right) + (y_1' - z_1)\frac{\delta}{(\delta + \lambda)^2}\frac{\partial \lambda}{\partial z_1} < 0,$$

which is unambiguously negative. That is, the expectation of w_1 increases less than z_1. Considering however $\frac{\partial}{\partial z_1} E_{G_1}(w_1)$ causes a non-unique sign.

$$\frac{\partial}{\partial z_1} E_{G_1}(w_1) = \frac{\delta}{\delta + \lambda}\left(1 + \frac{(y_1' - z_1)}{\delta + \lambda}\frac{\partial \lambda}{\partial z_1}\right)$$

Again the non-uniqueness stems from the fact that the direct effect from increasing z_1 on the expectation is positive. However, decreasing λ counteracts the direct effect by making the market less competitive. If λ does not react, again, the effect is uniquely positive $\frac{\partial}{\partial z_1} E_{G_1}(w_1) = \frac{\delta}{\delta + \lambda}$.

For the variance, we have:

$$var_{G_1}(w) = \frac{1}{3}(y_1' - z_1)^2 \frac{\delta}{\delta + \lambda}\left(1 - \frac{\delta}{\delta + \lambda}\right)^2 = \frac{1}{3}(y_1' - z_1)^2 \frac{\lambda^2 \delta}{(\delta + \lambda)^3}.$$

The partial derivative is calculated as:

$$\frac{\partial var_{G_1}(w)}{\partial z_1} = \frac{1}{3}(y_1' - z_1)\frac{\lambda \delta}{(\delta + \lambda)^3}\left(\frac{\partial \lambda}{\partial z_1}\frac{(2\delta - \lambda)}{\delta + \lambda} - 2\lambda\right),$$

which is uniquely negative if $\lambda < 2\delta$ and thus if the unemployment rate is above 33% and depends on the parameters otherwise.

The effects on the wage dispersion discussed so far, all concern the wage distribution of skill group 1. Recognize that when the labor unions increase the minimum wage of skill group 1 it also alters the moments of the wage distribution of skill group 2. This is the case because as labor demand reacts the marginal productivity for skill group 2 decreases, and therefore the expectation and the variance change. A second reason for this is that we assume here that the λ's are identical and thus also labor demand for skill group 2 reacts. In the absence of the second factor, i.e. holding $\lambda_2, \lambda_{2,L}$ constant, the effect of an increasing minimum wage for skill group 1 on the expectation and on the variance of the wage distribution of skill group 2 is negative. This implies that the dispersion between skill groups changes as well when the dispersion within skill groups is changed. Again, the direction of the effect cannot be signed.

5.6 Labor unions objectives

So far, we have assumed that the labor unions have the possibility to impose a minimum wage that is binding. This can be justified for the German labor market by acknowledging that negotiated wages have indeed a character of minimum wages (see, e.g., Franz (2006) and Pfeiffer (2003) for empirical results). Now, we ask the question which minimum wage a labor union chooses optimally. The trade-off in the above model is as follows: increasing the minimum wage always decreases employment and can increase the expectation and decrease the variance of the wage distribution.

Let us start by assuming that the labor union maximizes the wage bill. In order to derive an analytical form for the objective function, we refer to the above special case, where $\lambda_1 = \lambda_2$, $\lambda_L = \lambda$ and $\delta_1 = \delta_2$.

$$WB = (N_1 - U_1)E_G(w_1) = N_1 \frac{\lambda}{\delta+\lambda}\left[\left(y_1' - mw_1\right)\left(1 - \frac{\delta}{\delta+\lambda}\right) + z_1\right] = N_1\left(y_1' - mw_1\right)\left(\frac{\lambda}{\delta+\lambda}\right)^2 + N_1 \frac{\lambda}{\delta+\lambda} z_1$$

The labor union will choose a minimum wage mw_1 that maximizes this sum.

$$\frac{\partial WB}{\partial mw_1} = N_1\left(\frac{\partial}{\partial mw_1}\left(y_1' - mw_1\right)\left(\frac{\lambda}{\delta+\lambda}\right)^2 + \left(y_1' - mw_1\right)\frac{\partial}{\partial mw_1}\left(\frac{\lambda}{\delta+\lambda}\right)^2\right) + \frac{\partial}{\partial mw_1} N_1 \frac{\lambda}{\delta+\lambda} mw_1$$

We obtain the optimal chosen minimum wage mw_1 of the labor union as

$$mw_1 = \frac{-\lambda\left((\delta+\lambda) + 2y_1' \frac{\partial\lambda}{\partial mw_1}\right)}{\frac{\partial\lambda}{\partial mw_1}\left((\delta+\lambda)^2 - 2\lambda\right)}. \tag{5.27}$$

Now, consider a labor union that also cares about the income of the unemployed. Its maximization problem is:

$$WU = (N_1 - U_1)E_G(w_1) + z_1 U_1 = N_1\left(y_1' - mw_1\right)\left(\frac{\lambda}{\delta+\lambda}\right)^2 + N_1 \frac{\lambda}{\delta+\lambda} mw_1 + z_1 N_1 \frac{\delta}{\delta+\lambda}.$$

We obtain

$$mw_1 = \frac{\lambda\left(\delta+\lambda\right) + y_1' 2\lambda \frac{\partial\lambda}{\partial mw_1} - z_1\left(\delta+\lambda\right)}{\frac{\partial\lambda}{\partial mw_1}\left(2\lambda - (\delta+\lambda)^2\right)}, \tag{5.28}$$

which is higher as the corresponding value of the labor union that does not care about the unemployed if we require that $\lambda > \delta$ and that both λ and δ are positive. The reason for this is that in the case where the labor union cares about the unemployed they have still a positive contribution to the objective function in the case where they are unemployed while in the case where the labor union does not care about the unemployed, they get a value of zero in the objective function. This result is astonishing in the light of the results of Insider-Outsider theory (e.g., Lindbeck and Snower (2001)). There, wages are said to be too high because unions care only about the employed (the insiders) and not about the unemployed (the outsiders). Here, we demonstrate that, given this reasonable objective functions for unions, the opposite is the case, because the unions partly internalize the costs from high unemployment. So far, the model we have introduced excludes wage renegotiations. Note, however, that the model offers scope for an Insider-Outsider story, because there are (quasi-)rents to be divided between employer and employee.

5.7 Conclusion

We have constructed an equilibrium search model where two types of labor are linked via a production function. We introduce labor demand effects in this framework and consider labor unions behavior and its influence on employment and wage dispersion via a binding minimum wage. We argue that optimal strategies are such that firms cover the same position in the wage distribution for both skill groups. We solve the model under this assumption and for particular parameter constellations and simulate solutions otherwise. Labor unions minimum wages are higher when the union cares about the unemployed; they generate structural unemployment and alter the wage distribution. In general, the effect on the wage distribution cannot be signed unambiguously as far as its moments are concerned, the reason being that the labor demand effect counteracts the increase in the minimum wage.

Deutschsprachige Zusammenfassung

Diese Dissertation beschäftigt sich mit der Verteilung von Löhnen und Beschäftigung als gleichgewichtige Ergebnisse einer Allokation durch Arbeitsmärkte und andere Institutionen. Die zentrale Bedeutung der Zuteilung von Löhnen und Beschäftigung auf Arbeitsmarktteilnehmer gründet sich in modernen Gesellschaften darauf, dass bei weitem der größte Teil der privaten Haushalte wirtschaftlich von Erwerbsarbeit abhängig ist. Arbeitsmarktergebnisse betreffen nahezu alle Mitglieder einer Gesellschaft. Die ökonomische Theorie hilft zu verstehen und zu erklären, wie eine realisierte Allokation von Beschäftigung und Einkommen aus Beschäftigung entstanden ist. In der traditionellen mikroökonomischen Analyse des Arbeitsmarktgeschehens gilt Arbeit aus individueller Sicht als etwas schlechtes, weil dafür Freizeit aufgegeben werden muss. Das verdiente Geld hingegen ist etwas gutes, weil es die Konsummöglichkeiten vergrößert. Kosten der unfreiwilligen Arbeitslosigkeit bestehen einerseits darin, dass das Ergebnis ineffizient ist und eine Verbesserung im Pareto-Sinne möglich ist. Für einen sozialen Planer, der die Summe der Nutzen der Individuen maximiert, bestehen die Kosten der Arbeitslosigkeit andererseits darin, dass die Nutzen zu ungleich verteilt sind. Für einen unfreiwillig Arbeitslosen ist, verglichen mit dem sozialen Optimum, der Grenznutzen der Freizeit zu niedrig, während der Grenznutzen des Konsums zu hoch ist. Ähnlich verhält es sich mit einer zu ungleichen Verteilung der Einkommen. Der Grenznutzen des Konsums ist bei niedrigen Einkommen zu hoch und bei hohen Einkommen zu niedrig. Eine ansonsten folgenlose Umverteilung würde die gesamtgesellschaftliche Wohlfahrt erhöhen.

Soziale, psychologische und andere ökonomische Kosten entstehen durch eine ungünstige Aufteilung von Arbeit und Einkommen auf die Individuen. Beispiele für weitere ökonomische Kosten der Arbeitslosigkeit umfassen bspw. mögliche Abschreibungen des Humankapitals in Arbeitslosigkeit. Zusätzlich entstehen bei Arbeitslosigkeit auch beträchtliche psychologische Kosten „bei den Betroffenen, die das Gefühl haben, nicht mehr gebraucht zu werden“ (Franz (2006), S.347). Weitere ökonomische Kosten einer hohen Einkommensungleichheit können auch darin bestehen, dass Individuen Präferenzen für Gleichheit haben. Soziale Kosten einer zu hohen Einkommensungleichheit bestehen beispielsweise darin, dass die Kriminalitätsraten hoch sein können und dass sich ein vergleichsweise großer Anteil der Bevölkerung im Gefängnis befindet (Morris and Western (1999)).

Diese Argumente rechtfertigen das überwältigende Interesse, das die sozialwissenschaftliche Forschung an den internationalen Entwicklungen bei Lohnungleichheit und Arbeitslosigkeit gezeigt hat. Diese Entwicklungen werden im Folgenden kurz dargestellt. Nachdem die Lohnunterschiede zwischen hochqualifizierten und geringqualifizierten Arbeitnehmern in den 1970er Jahren abgenommen haben, sind diese in den 80er und 90er Jahren in den USA und im

Vereinigten Königreich dramatisch angestiegen (Katz, Loveman, und Blanchflower (1995), Gottschalk und Smeeding (1997), und Katz und Autor (1999)). Vergleichbare Trends weisen in diesen Ländern auch die Lohnungleichheit insgesamt und die residuale Lohnungleichheit, also Lohnungleichheit zwischen Individuen mit gleichen beobachteten Charakteristika auf. In Australien, Kanada und Japan ist in den 80ern und 90ern die Lohnungleichheit ebenfalls leicht angestiegen. Dieser Anstieg blieb jedoch deutlich hinter dem Anstieg in den vorgenannten Ländern zurück.

In den kontinentaleuropäischen Ländern war ein solcher Anstieg der Lohnungleichheit im genannten Zeitraum nicht zu beobachten. Dies gilt sowohl für die Lohnungleichheit insgesamt als auch für die Lohnungleichheit zwischen Hoch- und Geringqualifizierten und innerhalb dieser Qualifikationsgruppen (Katz und Autor (1999)). Stattdessen war in der überwiegenden Zahl der kontinentaleuropäischen Länder ein teilweise drastischer Anstieg der Arbeitslosigkeit zu verzeichnen (siehe Bean (1994), Saint-Paul (2004) und Blanchard (2006)).

Der überwiegende Teil der ökonomischen Literatur zur Entwicklung der Lohnungleichheit beschäftigt sich eher mit Lohnungleichheit zwischen unterschiedlichen Gruppen als mit Lohnungleichheit innerhalb von Gruppen vergleichbarer Individuen. Das liegt vermutlich daran, dass eine *Veränderung* der Lohnungleichheit zwischen unterschiedlichen Qualifikationsgruppen einer ökonomischen Interpretation leichter zugänglich ist, als die Veränderung der residualen Lohnungleichheit. Jedoch existieren eine Reihe guter Gründe, sich eingehender mit den Determinanten residualer Lohnungleichheit zu beschäftigen. Erstens zeigen empirische Studien, dass die residuale Lohnvariation einen Großteil der gesamten Lohnvariation ausmacht.[26] Mehr als die Hälfte der Varianz der Löhne bleibt also unerklärt. Hinsichtlich der Veränderung der Lohnungleichheit beschreibt die empirische Literatur zweitens, dass ein beträchtlicher Anteil der Veränderung der Lohnungleichheit auf die Veränderung der residualen Lohnungleichheit zurückgeht (Juhn, Murphy und Pierce (1993), Katz und Autor (1999) und Cholezas und Tsakloglou (2007)). Zuletzt ist in der Literatur darauf hingewiesen worden, dass, obwohl ein Anstieg beider Arten der Lohnungleichheit zu verzeichnen war, der Anstieg für die beiden Arten nicht parallel verlaufen ist. So zeigen empirische Studien für die USA und Deutschland, dass die zeitliche Abfolge des Anstieges der residualen und der qualifikatorischen Lohnungleichheit nicht identisch waren (Juhn, Murphy und Pierce (1993), Katz und Autor (1999) und Fitzenberger (1999)).

Diese Dissertation besteht aus fünf eigenständigen Forschungspapieren, deren gemeinsamer Forschungsgegenstand die Determinanten der Lohnungleichheit zwischen Gruppen und

[26] Lohnregressionen, die Standardhumankapitalvariablen einschließen, erklären in der Regel höchstens ein Drittel der Lohnvarianz, und auch unter Einschluss von firmenseitigen Variablen erreichen sie kaum 50% (siehe Lemieux (2006) und Van den Berg (1999))).

innerhalb von Gruppen sowie der Arbeitslosigkeit ist. Zwei der Kapitel sind theoretischer Natur und nehmen eine suchtheoretische Perspektive des Arbeitsmarktes ein. Daher beschäftigen sich beide Artikel mit residualer Lohndispersion, wobei einer darüber hinausgehend auch Lohndispersion zwischen Qualifikationsgruppen betrachtet. Zwei Artikel sind empirischer Natur und beruhen ebenfalls auf einem suchtheoretischen Hintergrund. Gleich das erste Kapitel dieser Dissertation ist sowohl theoretischer als auch empirischer Natur und beruht abweichend von den anderen Kapiteln auf einem neo-klassischen Modellrahmen.[27]

Lohndispersion zwischen Qualifikationsgruppen und Arbeitslosigkeit

Das erste Kapitel (Weiss und Garloff (2005)) dieser Dissertation beschäftigt sich mit den Determinanten der unterschiedlichen Entwicklungen bei Arbeitslosigkeit und Lohnungleichheit zwischen Qualifikationsgruppen in Kontinentaleuropa und den angelsächsischen Ländern. Arbeitsmarktinstitutionen werden dabei als entscheidender Faktor zur Erklärung der unterschiedlichen Entwicklungen betrachtet. Dabei besteht der ausschlaggebende institutionelle Unterschied darin, dass unterschiedliche Konzepte staatlicher Armutsbekämpfung zur Anwendung kommen. Dieses wird theoretisch gezeigt und empirisch untermauert. Staatliche Armutsbekämpfung kann unterschiedlichen Grundgedanken folgen. Einerseits kann man Armut zeitlos und als absolutes Konzept betrachten. Arm ist demnach zum Beispiel, wer eine gewisse tägliche Kalorienzufuhr unterschreitet. Die Sozialgesetzgebung in den angelsächsischen Ländern ist an diesem Konzept orientiert. Daher wird dieses Konzept als das angelsächsische Konzept bezeichnet. Andererseits kann man Armut als relatives Konzept begreifen und damit Armut zum durchschnittlichen Lebensstandard ins Verhältnis setzen. Wiederum im Hinblick auf die Sozialgesetzgebung wird dieses Konzept als europäisches Konzept bezeichnet. Im Papier wird Sozialhilfe, also die staatliche Einrichtung, die im Falle der Bedürftigkeit als letzte Instanz einspringt, als das zentrale staatliche Instrument zur Armutsvermeidung betrachtet.

Folgende Annahmen werden im Modell getroffen. Eine neo-klassische Produktionsfunktion für zwei Qualifikationsgruppen wird mit einem unelastischen Arbeitsangebot kombiniert. Eine Gewerkschaft setzt den Lohn für die Geringqualifizierten. Zur Armutsvermeidung ist im europäischen Modell die Sozialhilfe an das Durchschnittseinkommen geknüpft, während im angelsächsischen Modell keine solche Verknüpfung existiert. Dann wird technischer Fortschritt in das Modell eingeführt, der die Nachfrage nach hochqualifizierten Arbeitnehmern erhöht. Im Allgemeinen steigt

[27] In der Literatur wurde der Begriff neo-klassisch auch zur Abgrenzung von den sogenannten neo-institutionalistischen Ansätzen verwendet (Boyer and Smith (2001)). Unter dieser Verwendung wäre diese komplette Dissertation neo-klassisch. Abweichend davon bezeichnet der Begriff neo-klassisch in dieser Dissertation Standardmodelle zu Arbeitsangebot, Arbeitsnachfrage und Humankapitalbildung unter vollständiger Information, und grenzt diese von neueren informationstheoretischen Ansätzen ab.

damit der Lohn, den diese Qualifikationsgruppe erhält. Daraus ergibt sich ein höheres Durchschnittseinkommen in der Volkswirtschaft und damit steigt die Sozialhilfe im europäischen Modell. Das Resultat des Modells ist folgendes: In Europa führt eine steigende Sozialhilfe dazu, dass die Löhne der Geringqualifizierten steigen, weil sie in Lohnverhandlungen höhere Löhne durchsetzen können. Dies wirkt dem ursprünglichen Effekt einer steigenden Lohnungleichheit entgegen. Die Lohnungleichheit steigt daher nur geringfügig an. Im Gegenzug steigt die Arbeitslosigkeit, weil der Lohn der Geringqualifizierten im Verhältnis zu deren Produktivität zu hoch ist. Im angelsächsischen Modell passiert etwas anderes: Während die Löhne der Hochqualifizierten und das Durchschnittseinkommen kräftig ansteigen, bleibt die Sozialhilfe davon unberührt. Daher kommt es zu keiner Korrektur der gestiegenen Lohnungleichheit. Die Arbeitslosigkeit der Geringqualifizierten bleibt ebenfalls unberührt, da ihre Löhne von den Veränderungen im Hochlohnbereich unberührt sind.

In der empirischen Analyse wird der Zusammenhang zwischen Durchschnittseinkommen und Sozialhilfe in 14 OECD Ländern betrachtet. In den meisten Ländern existieren klare gesetzliche Regelungen für die Anpassung der Sozialhilfe an das Durchschnittseinkommen. In einigen Ländern ist dies indessen nicht der Fall. Für diese Länder werden Regressionsergebnisse zu Rate gezogen, um den vermuteten Zusammenhang nachzuweisen. Es zeigt sich, dass die Frage, ob die Sozialhilfe an das Durchschnittseinkommen angekoppelt ist oder nicht, tatsächlich ein zentraler Unterschied zwischen den kontinentaleuropäischen und den angelsächsischen Ländern ist. Die Verknüpfung zwischen Durchschnittseinkommen und Sozialhilfe existiert in Europa tatsächlich, während dieser Zusammenhang in den angelsächsischen Ländern nicht existiert.

Der Ansatz weist indes zwei Schwachstellen auf. Erstens ignoriert er weitgehend die Bedeutung von Gewerkschaften für Beschäftigung, obwohl diese von der Literatur als bedeutend eingestuft wird (z.B. Card (2001)). Zweitens abstrahiert das Modell von residualer Lohnungleichheit. Weiter oben ist aber schon auf die große Bedeutung der residualen Lohnungleichheit an sich und im Zusammenhang mit der Veränderung der Lohnungleichheit hingewiesen worden.

Residuale Lohndispersion und Arbeitslosigkeit

Das zweite Kapitel (Garloff (2007)) dieser Arbeit greift die beiden genannten Kritikpunkte auf und widmet sich residualer Lohnungleichheit und untersucht den Einfluss von Gewerkschaften auf die Beschäftigung. Zugleich wird ein Literaturüberblick zu suchtheoretischen Ansätzen erstellt. Gleichgewichtige Suchmodelle generieren im Gleichgewicht unterschiedliche Löhne für Individuen identischer Grenzproduktivität. Persistente Lohndifferenziale werden in diesen Modellen durch die Existenz unvollständiger Information, auch als Suchfriktionen bezeichnet, erklärt. Im Grundmodell, eingeführt von Burdett und Mortensen (1998), gibt es ein eindeutiges Gleichgewicht derart, dass sich Firmen entlang einer stetigen Lohnverteilung für identische Individuen sortieren.

Individuen sortieren sich nicht unmittelbar in Firmen mit hohen Löhnen, weil die Suche nach Information über Löhne zeitaufwändig ist. Firmen, die sich zunächst nicht unterscheiden, bieten und bezahlen identischen Arbeitnehmern unterschiedliche Löhne. Im Hinblick auf den Gewinn liefern diese unterschiedlichen Strategien nämlich optimale Ergebnisse. Hochlohnfirmen können viele Arbeitnehmer attrahieren, machen aber geringe Gewinne pro Arbeitnehmer, während Niedriglohnfirmen nur wenige Arbeitnehmer halten können. Pro Arbeitnehmer erzielen sie aber vergleichsweise hohe Gewinne. Zwei offene Fragen existieren jedoch in diesem Modellrahmen. Heterogenitäten von Arbeitnehmern und Firmen sind wichtige Merkmale im Hinblick auf das Arbeitsmarktergebnis. Wie lässt sich, erstens, dieser Tatsache in dem (homogenen) Modellrahmen Rechnung tragen? Das homogene Modell generiert zudem eine Lohndichte, die über die Lohnverteilung steigt. Dies ist mit empirischen Lohnverteilungen nicht in Übereinstimmung zu bringen und wirft, zweitens, die Frage auf, ob Modifikationen des Grundmodells Abhilfe schaffen können. Das Kapitel gibt einen Überblick über Fortentwicklungen der gleichgewichtigen Suchtheorie, die Heterogenitäten auf beiden Marktseiten in den Modellrahmen integrieren. Im speziellen werden Modellerweiterungen vorgestellt und diskutiert, die unterschiedliche Grenzproduktivitäten der Firmen und Individuen zulassen. Eine Modellerweiterung diskutiert unterschiedliche Reservationslöhne. In allen Fällen wird die Form der Lohndichte untersucht, die das Modell impliziert.

Zusätzlich werden Gewerkschaften in diesen Rahmen integriert. Vereinfachend wird angenommen, dass sich der Einfluss der Gewerkschaften auf die Lohnsetzung dadurch abbilden lässt, dass sie einen Mindestlohn setzen. Folgende Resultate sind festzuhalten: Zunächst sind solche Modelle, die unterschiedliche Grenzproduktivitäten zulassen, in der Lage, rechtsschiefe Einkommensverteilungen zu generieren, welche dann beobachteten Verteilungen ähnlich sind. Des Weiteren ist nicht eindeutig, welcher Einfluss eines Mindestlohn auf die Höhe der Beschäftigung sich aus den betrachteten Modellen ergibt. In einigen Modellvarianten hat der Mindestlohn keinen Einfluss auf die Beschäftigungshöhe. Solche Modellvarianten umfassen das homogene Modell, ein Modell mit stetiger Produktivitätsverteilung der Firmen sowie die Modelle mit nicht-konstanter Grenzproduktivität. Der Grund für dieses Ergebnis ist darin zu sehen, dass die gleichgewichtige Lohnverteilung komplett unterhalb der Grenzproduktivität der Individuen angesiedelt ist. Damit bewirkt ein Mindestlohn eine Umverteilung von Gewinnen von den Firmen zu den Individuen, ohne indes die Beschäftigung zu beeinträchtigen. Negative Beschäftigungseffekte eines bindenden Mindestlohnes ergeben sich in einem Modell, das stetige Heterogenität auf beiden Seiten des Arbeitsmarktes modelliert. Der Grund ist in diesem Fall, dass ein Teil der Firmen-Arbeitnehmer-Kombinationen nicht mehr profitabel ist, weil der Mindestlohn den Output der Kombination übersteigt. Zu guter Letzt zeigen sich in einer Modellvariante mit homogenen Produktivitäten aber unterschiedlichen Reservationslöhnen positive Beschäftigungseffekte von Mindestlöhnen. Das liegt daran, dass in diesem Falle die Wahrscheinlichkeit, dass ein zufällig gezogener Lohn aus der Lohnverteilung oberhalb des Reservationslohnes eines zufällig gezogenen Individuums liegt, höher ist. Zusätzlich bleibt festzuhalten, dass unabhängig von der gewählten Modellvariante jeweils die komplette Lohnverteilung auf die Änderung eines bindenden Mindestlohnes reagiert und dass im Allgemeinen ein Anstieg des Durchschnittslohnes und ein Rückgang der Streuung zu verzeichnen sind.

Nachdem im zweiten Kapitel ein Modellrahmen zur Analyse residualer Lohndispersion etabliert wurde, werden im dritten Kapitel (Fitzenberger und Garloff (2007b)) empirische Vorhersagen der gleichgewichtigen Suchtheorie untersucht. In der empirischen Umsetzung werden Suchfriktionen durch Arbeitsmarktübergänge gemessen. Wichtige Übergangsraten umfassen die Übergänge von Beschäftigung in Arbeitslosigkeit, Übergänge von Arbeitslosigkeit in Beschäftigung sowie Wechsel zwischen unterschiedlichen Beschäftigungsverhältnissen. Gemeinsam charakterisieren die genannten Übergangsraten aus Sicht der Suchtheorie, wie stark der Markt Friktionen unterworfen ist und wie hoch die daraus resultierende Nachfragemacht der Firmen ist. Mit Hilfe deutscher, administrativer Daten werden Arbeitsmarktübergänge für unterschiedliche Teilmärkte analysiert. Die Ergebnisse weisen darauf hin, dass sich Suchfriktionen zwischen den Teilmärkten teilweise erheblich unterscheiden und dass Unterschiede, wie bspw. zwischen Altersgruppen und zwischen unterschiedlichen Positionen in der Lohnverteilung, den Erwartungen aus der Suchtheorie entsprechen.

Eine entscheidende Voraussetzung für die Existenz gleichgewichtiger Lohnverteilungen unter Individuen identischer Grenzproduktivität sind Jobwechsel. Aus Sicht der Suchtheorie dienen Jobwechsel dazu, Lohnzuwächse zu erzielen. Aus Sicht der Humankapitaltheorie erklärt sich Lohnwachstum hingegen durch zunehmende Berufserfahrung, steht also mit der Mobilitätsentscheidung nicht im Zusammenhang. Im dritten Kapitel dieser Arbeit werden Arbeitsplatzwechsel detailliert analysiert und deren Determinanten und Folgen unter die Lupe genommen. Es zeigt sich, dass Lohnzuwächse ein wichtiges Motiv von Arbeitsplatzwechseln sind: die meisten Jobwechsler (mehr als zwei Drittel) haben Lohnzuwächse und diese sind im Durchschnitt beträchtlich (etwa 20%). Allerdings gibt es einen durchaus bemerkenswerten Anteil von Jobwechslern (ca. 22%), die im Durchschnitt nicht unerhebliche Einbußen (ca. 16%) hinnehmen müssen. Dies wird dahingehend interpretiert, dass der Lohn zwar ein wichtiges aber nicht das einzige Motiv für Jobwechsel ist. Dieser Befund stellt eine Herausforderung für den einfachen suchtheoretischen Ansatz dar. Über die Lohnverteilung hinweg zeigt sich, dass mit steigendem Lohn sowohl der Anteil der Gewinner wie auch deren relativer Gewinn abnimmt. Für diejenigen Jobwechsler, die den Arbeitsplatz auf dem Umweg über die Arbeitslosigkeit wechseln, ergibt sich folgendes Bild. Ausgenommen für Langzeitarbeitslose (>1 Jahr) sinkt der Anteil der Gewinner über die Arbeitslosendauer. Dahingegen ist beim relativen Gewinn der Gewinner keine eindeutige Tendenz zu erkennen. Schließlich werden in dem Papier Determinanten einer Veränderung in der *relativen* Position in der Lohnverteilung untersucht.

Wie erwartet zeigt sich, dass den Jobwechseln dabei eine wichtige Rolle zukommt. Sie sind dabei umso wichtiger, je jünger Individuen sind. Zusammenfassend kann man festhalten, dass Löhne, Lohnveränderungen und Arbeitsmarktübergänge eng zusammenhängen und dass Arbeitsplatzwechsel eine wichtige Determinante des Lohnwachstums sind.

Im vierten Kapitel (Fitzenberger und Garloff (2005a)) dieser Arbeit werden widersprüchliche Hypothesen für den Zusammenhang zwischen Lohndispersion einerseits und Arbeitsmarktdynamik bzw. Arbeitslosigkeit andererseits aufgestellt und getestet. Als theoretische Grundlage dienen hierbei auf der einen Seite die Suchtheorie und auf der anderen Seite der neo-klassische Arbeitsmarktansatz. Aus der neo-klassischen Arbeitsmarktsicht ergibt sich der Zusammenhang zwischen Arbeitslosigkeit und Lohndispersion aus der folgenden Überlegung. Arbeitsmarktinstitutionen, wie bspw. gewerkschaftliche Lohnbeeinflussung, stören das sich aus dem Marktprozess ergebende Gleichgewicht und führen zu einer zu geringen Spreizung der Löhne. Insbesondere Löhne der Geringqualifizierten sind oberhalb des markträumenden Niveaus. Dies führt zu einer hohen Arbeitslosigkeit.[28] Diese Argumentation impliziert einen negativen Zusammenhang zwischen Lohnungleichheit und Arbeitslosigkeit. Im Gegensatz dazu sagen Suchmodelle für homogene Individuen keinen solchen Zusammenhang voraus und implizieren, dass bspw. Mindestlöhne keine negativen Beschäftigungseffekte nach sich ziehen. Suchfriktionen sind dafür verantwortlich, wenn sowohl Lohndispersion als auch Arbeitslosigkeit hoch sind. Hieraus ergibt sich ein positiver Zusammenhang zwischen Arbeitslosigkeit und Lohndispersion.

Des Weiteren werden im Papier Zusammenhänge zwischen Arbeitsmarktübergängen und Lohndispersion untersucht, die sich aus dem suchtheoretischen Modellrahmen ergeben. Analog werden ähnliche Zusammenhänge unter der Annahme von Hysteresis-Effekten auch aus Sicht des neo-klassischen Modellrahmens abgeleitet.

Deutsche, administrative Daten werden dazu verwendet, die abgeleiteten Hypothesen zu testen. Als Beobachtungseinheit werden dabei Zellen von Individuen mit identischen beobachtbaren Merkmalen konstruiert. Zur Stratifikation dienen dabei die Merkmale Alter und Bildung. Um Probleme mit unbeobachtbarer Heterogenität zu verringern, wird ein verallgemeinerter kleinster Quadrate Ansatz mit fixen Effekten (FEGLS) gewählt. Aufgrund der wechselseitigen umgekehrten Kausalität, die sich aus der Theorie ergibt, wird die zeitliche Struktur der Daten zur Identifikation verwendet. Leider sind die Resultate in keine Richtung überzeugend. Während ein Teil der Resultate die suchbasierte Sicht des Arbeitsmarktes stützt, entspricht ein anderer Teil der Resultate den Vorhersagen aus der neo-klassischen Sichtweise. Ein robustes Resultat ist jedoch, dass es *keinen* negativen Zusammenhang zwischen Lohndispersion und Arbeitslosigkeit

[28] Dies ist einer der vorherrschenden Erklärungsansätze für die hohe Arbeitslosigkeit in Kontinentaleuropa und ist in der Literatur unter den Begriffen „Krugman-Hypothese“ (Krugman (1994))) und „unified theory“ (Blank (1997)) diskutiert worden.

gibt. Innerhalb von Zellen ähnlicher Individuen, ist also nicht die „unbearable stability“ (Prasad (2004)) der Lohnstruktur für die hohe deutsche Arbeitslosigkeit verantwortlich.

Neo-Klassik und Suchtheorie: Eine Synthese?

Im fünften und letzten inhaltlichen Kapitel (Fitzenberger und Garloff (2007a)) dieser Dissertation werden die Determinanten von residualer und qualifikatorischer Lohndispersion in einem gemeinsamen Modellrahmen betrachtet. Zusätzlich werden auch friktionelle und strukturelle Arbeitslosigkeit in demselben Modellrahmen untersucht. Friktionelle Arbeitslosigkeit entsteht danach durch unvollständige Information, wohingegen strukturelle Arbeitslosigkeit durch zu hohe (Mindest-)Löhne verursacht wird. Im Modell wird ein Suchansatz à la Burdett und Mortensen (1998) mit einer neo-klassischen Produktionsfunktion für zwei Arbeitsinputs verknüpft. Diese Modellstruktur impliziert ein System zweier partieller Differentialgleichungen. Ist die optimale Strategie für Firmen dergestalt, dass sie dieselbe Position in der Lohnverteilung beider Arbeitsinputs einnehmen, so vereinfacht sich das Problem zu einer gewöhnlichen Differentialgleichung. Unter bestimmten Einschränkungen des Modells kann eine analytische, stetige Lohnverteilung ermittelt werden, die keine Massepunkte aufweist. Das optimale Verhalten der Firmen lässt sich dann durch ihre Position in den Lohnverteilungen der beiden Arbeitsinputs beschreiben. Allerdings steigen die Lohndichten für beide Arbeitsinputs mit dem Lohn an. Dies muss gelten, damit die Beschäftigung über die Lohnverteilung ausreichend schnell ansteigt. Dies wiederum ist notwendig, um den grundlegenden Mechanismus des Modells sicherzustellen: identische Gewinne für Hochlohn- und Niedriglohnfirmen werden erreicht, indem Hochlohnfirmen eine „ausreichend“ größere Beschäftigung aufweisen als Niedriglohnfirmen.

In einem nächsten Schritt werden dann die dem Modell auferlegten Beschränkungen gelockert. Lohnverteilungen werden für Fälle simuliert, in denen eine analytische Lösung nicht verfügbar ist. Im Allgemeinen zeigen die Simulationen Dichtefunktionen, die am oberen Ende explodieren: die Lohnverteilung weist Massepunkte auf. Diese Massepunkte befinden sich immer an der Obergrenze der Lohnverteilungen und der zugehörige Lohn entspricht der Grenzproduktivität bei dieser Beschäftigung. Es ist einleuchtend, dass an dieser Stelle der Mechanismus von Suchmodellen nicht mehr funktionieren kann. Zusätzliche Arbeitnehmer tragen nicht mehr zum Gewinn bei und damit entfällt der Anreiz, den Lohn weiter zu erhöhen. Es bleibt allerdings festzuhalten, dass ein Mindestlohn im stetigen Teil der Lohnverteilung auch in diesem Modell beschäftigungsneutral ist.

In einem weiteren Schritt wird die Häufigkeit, mit der Firmen und Arbeitnehmer in Kontakt kommen, im Hinblick auf das Verhalten der Firmen endogenisiert. Die Häufigkeit, mit der Arbeitnehmer Jobangebote erhalten, hängt von den Suchanstrengungen der Firmen ab und diese sind kostenträchtig. Unter vergleichsweise schwachen Einschränkungen des allgemeinen Modellrahmens wird gezeigt, dass steigende Mindestlöhne zu sinkender Arbeitsnachfrage führen, wodurch die Beschäftigung sinkt. Das liegt daran, dass die Suchanstrengungen aus dem Gewinn der Firmen finanziert werden müssen und steigende Mindestlöhne zu geringeren Gewinnen führen. Dadurch sinken auch die Suchanstrengungen. Demnach koexistieren strukturelle und friktionelle Arbeitslosigkeit in diesem Modell. Beschränkt man das Modell weiter, so können die Momente der Lohnverteilung analytisch bestimmt werden. Jedoch sind die Effekte von steigenden Mindestlöhnen auf die Momente der Lohnverteilung uneindeutig, weil die *komplette* Lohnverteilung auf die Veränderung des Mindestlohnes reagiert. Zuletzt wird die Zielfunktion einer Gewerkschaft modelliert, die einen Mindestlohn setzen kann. Es zeigt sich, dass Gewerkschaften, die auch das Einkommen Arbeitsloser betrachten, einen höheren Mindestlohn setzen, als Gewerkschaften, die nur das Einkommen von Beschäftigten betrachten. Dies ergibt sich aus der Tatsache, dass im ersten Fall Arbeitslose noch einen positiven Beitrag zur Zielfunktion erbringen, wohingegen im zweiten Fall deren Beitrag Null ist.

Ausblick und Politikempfehlungen

Als Ergebnisse dieser Arbeit bleiben insbesondere zwei Erkenntnisse festzuhalten. Zunächst zeigt Kapitel eins, dass Arbeitsmarktinstitutionen wichtig für das Verständnis von Arbeitsmarktergebnissen sind. Sozialhilfe ist ein wichtiger Faktor zum Verständnis internationaler Unterschiede bei der Entwicklung von Lohnungleichheit und Arbeitslosigkeit. Des Weiteren betont diese Arbeit, dass Suchfriktionen wichtiger Bestandteil der Erklärung des Arbeitsmarktgeschehens sind. Die Bedeutung von residualer Lohnungleichheit für die Entwicklung der Lohnungleichheit insgesamt wird hervorgehoben. Insbesondere Kapitel drei und vier dieser Arbeit erbringen Belege für die Bedeutung von Suchfriktionen. Solche Belege umfassen die Tatsache, dass Arbeitsplatzwechsel eine so zentrale Rolle für das Lohnwachstum der Individuen einnehmen. Außderdem kann die Tatsache, dass geringe Lohndispersion in Zellen ähnlicher Individuen eher mit geringer als mit hoher Arbeitslosigkeit einhergeht, als Beleg für die Bedeutung von Suchfriktionen gewertet werden.

Die zwei theoretischen Kapitel zwei und fünf belegen allerdings, dass die Formalisierung eines Modellrahmens, der nicht nur Suchfriktionen sondern auch unterschiedliche Arbeitnehmer- und Arbeitgebertypen und schließlich je nach Einsatz unterschiedliche Grenzproduktivitäten von Arbeitnehmern zulässt, sehr aufwändig ist. Teilweise müssen Simulatiosmethoden zur Lösung der Modelle zur Anwendung kommen. Dies wiederum begrenzt den Wert dieser Modelle. Außerdem war die Literatur bisher nicht in der Lage, technischen Wandel oder Globalisierung, in diesen Modellrahmen zu integrieren. Beide Faktoren gelten indes als unverzichtbar zur Erklärung der jüngeren Veränderungen der Lohnstruktur bzw. der Arbeitslosigkeit. Obwohl die theoretische Möglichkeit besteht, würden vermutlich nur wenige Ökonomen den Standpunkt vertreten, dass in Zeiten beschleunigten Informationsaustausches steigende Suchfriktionen für den Anstieg der Lohnungleichheit verantwortlich sind und daher Faktoren wie technischer Wandel ignoriert werden können. Jedoch weist Kapitel 5 dieser Arbeit eine Forschungsrichtung auf, die Entwicklungspotentiale bietet. In der Tat ist es vorstellbar, dass sich Faktoren wie technischer Wandel in ein solches Modell integrieren lassen. Es würde sicherlich eine deutliche Bereicherung der Literatur darstellen, wenn in einer solchen Modellerweiterung die Auswirkungen von technischem Wandel auf unterschiedliche Arten von Arbeitslosigkeit und Lohndispersion sowie deren Interaktionen untersucht werden könnten. Dazu leistet diese Arbeit einen Beitrag.

Welche praktischen Schlussfolgerungen - für die Politik - können aber nun aus dieser Arbeit gezogen werden? Diese Arbeit kann bspw. etwas zu der aktuellen Diskussion um die Einführung staatlich garantierter Mindestlöhne beitragen. Der deutsche Arbeitsminister Müntefering hat sich für eine flächendeckende Einführung von Mindestlöhnen ausgesprochen (Interview mit BamS, 26.3.2007). Dahingegen warnt der wissenschaftliche Beirat beim Wirtschaftsministerium vergleichsweise deutlich vor einer Einführung von Mindestlöhnen (Offener Brief des Wissenschaftlichen Beirats an Bundesminister Glos zur Mindest- und Kombilohnproblematik, 18.3.2006). Der Arbeitsminister scheint vor allem aus moralischen Erwägungen gegen zu niedrige Löhne zu sein, denn nach seiner Ansicht „verstoßen (sie) gegen die Menschenwürde“. Des Weiteren führt er soziale Kosten ins Feld, da zu niedrige Löhne die „soziale Stabilität“ gefährden. Der wissenschaftliche Beirat führt dagegen „fatale Auswirkungen“ auf die Beschäftigung und eine „höhere Arbeitslosigkeit“ ins Feld. Außerdem verweist der Beirat auf Gefährdungen durch den politischen Prozess. Der in der Dissertation vorgeschlagene Modellrahmen hilft mit, Teile dieser Argumente zu bewerten. Einiges spricht dafür, dass ein Mindestlohn eine Umverteilung in dem Sinne darstellt, dass Löhne der Arbeitnehmer erhöht werden und dies zu Lasten der Gewinne der Firmen geht. Dies könnte Menschen vor Armut schützen und damit die Menschenwürde garantieren. Andererseits könnte eine sinkende Beschäftigung diesem Effekt zuwider laufen. Eine sinkende Beschäftigung ist aber weder aus theoretischer Perspektive notwendig zu erwarten, noch empirisch eindeutig belegt (siehe Neumark und Wascher (2007)). Die anderen angeführten Argumente lassen sich vor dem gewählten Modellhintergrund indes kaum bewerten. Eine abschließende Bewertung ist daher schwierig. Es bleibt aber festzuhalten, dass Mindestlöhne vor dem gewählten Rahmen nicht von vorne herein ausscheiden, als probates Mittel um Gewinne von Firmen zu Arbeitnehmern umzuverteilen und damit Löhne zu gewährleisten, die nicht gegen die Menschenwürde verstoßen.

A Appendix for Chapter 1

A.1 Empirical evidence

A.1.1 The link between benefits and per-capita income

To confirm our main hypothesis, in Section 1.3 we look at the legislation of 14 countries (see Figure A.1). In addition, here we use an empirical assessment to complement the results of the legal analysis. For 10 countries the legal situation is clear and confirms our crude classification in "European" and "Anglo-Saxon" countries. In three "European" countries Belgium, France, and Spain, benefits are not linked automatically to the average income or wages. Partly the law itself envisions that there are additional discrete adjustments. This is the case for example in Belgium. There, the law explicitly allows the king to adjust the benefit payments to the development of the living standards. As the legal situation allows these countries to be "European" and "Anglo-Saxon", we choose the empirical results to uncover the connection between average wages and benefit levels. For various reasons direct data on benefit levels are not available: In general, benefit payments depend on individual characteristics (wealth, income, household size, etc.) and differ across regions. Furthermore, in-kind transfers often make up an important part of total benefits. Therefore, we use data on (real) social expenditures on unemployment per unemployed from the OECD to approximate the benefit payments. We take the social expenditures on unemployment as a proxy for expenditures on benefits and take the number of unemployed individuals (from the OECD) as a proxy for the number of benefit recipients.[1] The last row of Figure A.1 reports results from regressions of changes in real social expenditures on unemployment per unemployed on real GDP per capita changes.[2] The influence is significantly positive and roughly of the same magnitude for the three countries, where the legal situation is ambiguous. To assess the quality of our proxy social expenditures for unemployment per unemployed, we run the same regression for the other countries where we know the administrative rules. Most results are as we expect. In particular, the relation between GDP p.c. and social expenditures per unemployed is insignificant in the U.S. and the UK while it is significant in most European countries.[3] The

[1] We use social expenditures on unemployment, since a category for benefits alone does not exist so that this category comes closest to our needs. Using in addition social expenditures on housing and incapacity-related benefits does not change the principal conclusions. Results are available upon request.

[2] It is likely that both real GDP per capita and real social expenditures per unemployed are trended. We use first differences in order not to run into the problem of a spurious regression.

[3] Austria, Italy, the Netherlands, and Portugal are the exceptions to the rule. For Austria, the Netherlands and Portugal the results are insignificant. For Italy, the situation is somewhat special. With the so called "Scala Mobile", introduced in the 70s, the state intervened directly in the wage formation. This led to a compression of wages. Then, its stepwise abolition in the 80s has contributed to the reversion of the trend. (see Brunello, Comi, Lucifora, and Scarpa (2005) and Manacorda (2004))

Country	Austria	Belgium	Denmark	France	Finland	Germany	Greece
name of the programme	Sozialhilfe	Revenu d'intégration leefloon	Starthjaelp	Revenu minimum d'insertion	Toimeentulotuki	Sozialhilfe	none
adjustment frequency	automatic, yearly	automatic, yearly plus irregular	automatic, yearly	automatic, yearly	automatic, yearly	automatic, yearly	–
linkage to	public pensions	CPI plus discretionary increases	wages	CPI	public pensions	public pensions, wages	–
regression coefficient (standard error)	−1.518 (1.308)	0.955* (0.435)	2.965* (1.059)	1.265* (0.419)	1.045* (0.364)	1.132* (0.359)	– (–)

Country	Italy	Netherlands	Portugal	Spain	Sweden	UK	USA
name of the programme	Minimo Vitale, Reddito minimo	Algemene Bijstand	Rentimento social de inserçao	Ingreso minimo de inserciòn, Renta minima	Ekonomiskt bistånd	Income Support	various programmes, eg, Food Stamp Program, General Assistance
adjustment frequency	automatic, yearly	twice a year, automatic	automatic, yearly	semi-automatic, yearly	yearly	yearly	automatic, irregular
linkage to	wages GDP p.c.	wages	social pension	discretionary, CPI	standard ofliving	CPI	discretionary, CPI
regression coefficient (standard error)	−2.464* (0.489)	2.409 (1.951)	0.573 (0.545)	1.219* (0.592)	2.433* (1.062)	−0.366 (0.211)	−0.090 (0.419)

Figure A.1: Social security in "Anglo-Saxon" and in "European" countries

Source: Cantillon, van Mechelen, Marx, and van den Bosch (2004) and MISSOC (Mutual Information System on Social Protection in the EU Member States and the EEA): http://europa.eu.int/comm/employment_social/social_protection/index_en.html and own calculation.
* means significant on a 5% confidence level.

purpose of these regressions is modest, however: We use the best information we could assemble. That is, we use the legal situation for the countries where the situation is unambiguous and use the regression results for the other countries, where the results are at least in accordance with our classification.

A minimum wage that depends on average wages has a similar effect as benefits that depend on average wages.[4] This is the case in France and Spain, where the minimum wage is tied to average income by law. So, for these two countries there is an additional link between the wage of the low-skilled and the wage of the high-skilled, even when, as in France, the benefits are not tied to the average income by law. A minimum wage that is tied to average income also induces adverse employment effects of skill-biased technological change. Again, for the U.S. and the UK this link does not exist. In the U.S., the minimum wage has not even been adjusted to consumer prices. In 2000 the minimum wage was 25% lower in real terms than in 1978 (see Card and DiNardo (2002), Figure 22). In the UK, a national minimum wage has only been introduced in 1999 and can therefore not account for changes in inequality and employment in the 1980s and 90s.

A.1.2 Descriptive evidence to proposition 1.4

Proposition 1.4 states that skill-biased technological change leads to rising wage inequality *and* rising unemployment in European countries because the relative wage cannot fully adjust to changes in relative labor demand. Put differently: If the wage dispersion in Europe rises, it does not rise enough and unemployment rises as well. The unemployment rate should thus be positively correlated with the skill-premium in Europe. For example, in Germany 1975 - 2004, the correlation between the unemployment rate of the low-skilled and the skill premium has been 0.703.[5] This substantiates the theoretical result in Proposition 1.4.[6]

For the “Anglo-Saxon” model, we expect a zero correlation between wage dispersion and unemployment of the low-skilled, since wages of the low-skilled do not react to changes in the wages of the skilled. If the wage dispersion increases, it increases enough to adjust to changes in rel-

[4] See Weiss and Garloff (2005).

[5] Unemployment rates by qualification are from Reinberg and Hummel (2002) and Reinberg and Hummel (2005). The skill premium has been calculated from administrative data where the wage for low-skilled workers is proxied by the lowest performance group of blue-collar workers (“Leistungsgruppe 3, Arbeiter”) and the wage for skilled workers is proxied by the highest performance group of white-collar workers (“Leistungsgruppe 2, Angestellte”), Source: German Federal Statistical Office. Note however, that some recent studies point to an increase of the wage inequality by 2001 as well (see Kohn (2006) and Gernandt and Pfeiffer (2006)). One study argues that the wage inequality in the upper part of the wage distribution in Germany was changing similar as in the US and that only the development in the lower part of the wage distribution was different (see Dustmann, Ludsteck, and Schönberg (2007)).

[6] The finding that higher wage dispersion and unemployment are positively correlated (across age-by-education cells) in Germany is also found and discussed by Fitzenberger and Garloff (2005b).

ative labor demand. Unemployment remains unchanged while wage dispersion increases. For the U.S. 1975 - 2003, the correlation between the unemployment rate of the low-skilled and the skill premium has been 0.004.[7] As we expected, the correlation between the wage premium and unemployment is zero.[8]

[7] Unemployment rates by educational attainment stem from U.S. Census Bureau (1975 - 2004) and Francesconi, Orszag, Phelps, and Zoega (1998). Wages stem from the CPS (U.S. Census Bureau, internet release, www.census.gov/hhes/www/income/histinc/incpertoc.html).

[8] Unemployment of the low-skilled and wage dispersion are unlikely to contain a trend. While this is obvious for the unemployment rate at least in an asymptotic sense, it is plausible for wage dispersion, too. Nevertheless, we performed the same regression in first differences. Albeit less strongly, the results of a regression of the unemployment rate of the low-skilled on the wage premium in levels is significant for Germany (and insignificant for the United States).

B Appendix for Chapter 2

B.1 Derivation of the reservation wage as a function of the parameters

Consider the derivative $\frac{\partial W_L(\bar{w})}{\partial \bar{w}}$ from (2.5). Rewriting (2.5) as $W_L(\bar{w}) = \frac{\bar{w}+\delta W_U+\lambda_L \int_{\bar{w}}^{\infty} W_L(w)dH(w)}{[r+\delta+\lambda_L \int_{\bar{w}}^{\infty} dH(w)]}$, the resulting derivative is given by $W_L'(\bar{w}) = \frac{\partial W_L(\bar{w})}{\partial \bar{w}} = \frac{1}{r+\delta+\lambda_L(1-H(\bar{w}))}$.[1] Denote with w^o the upper limit of $H(w)$, then integration by parts yields $\int_{w_R}^{w^o}(W_L(w) - W_U)dH(w) = [(W_L(w) - W_U)H(w)]_{w_R}^{w^o} - \int_{w_R}^{w^o} H(w)W_L'(w)dw$. This leads to:

$$
\begin{aligned}
w_R &= z + (\lambda - \lambda_L)\left[W_L(w^o) - W_U - \int_{w_R}^{w^o} H(w)W_L'(w)dw\right] \\
&= z + (\lambda - \lambda_L)\left[\int_{w_R}^{w^o} (1 - H(w))W_L'(w)dw\right] = z + (\lambda - \lambda_L)\int_{w_R}^{w^o} \frac{1 - H(w)}{r + \delta + \lambda_L(1 - H(w))}dw.
\end{aligned}
$$

The second row follows by using $W_L(w^o) - W_U = \int_{w_R}^{w^o} W_L'(w)dw$ and the above expression for $W_L'(w)$.

B.2 Derivation of the equilibrium employment at wage w

Starting point for the derivation of (2.10), is the following equation which describes inflows and outflows to firms paying wages above w, $(\lambda U + \lambda_L L(w))(1 - H(w)) = \delta(N - U - L(w))$.

Differentiating both sides of the equation with respect to the wage, substituting $h(w)$ for $H'(w)$, using that $L'(w) = l(w)h(w)$, and dividing by $h(w)$ yields:

$$[\delta + \lambda_L(1 - H(w))]l(w) = \lambda U + \lambda_L L(w). \tag{B.1}$$

Firms maximize expected profits $\Pi(w) = (y - w)l(w)$. The first-order condition for a profit maximum yields the following differential equation:

$$\frac{l'(w)}{l(w)} = \frac{1}{y - w}. \tag{B.2}$$

This equation holds for all firms that pay wages above w_R. With the help of (B.2) $l(w)$ can be determined explicitly. Integrating both sides $\int \frac{l'(w)}{l(w)}dw = \int \frac{1}{y-w}dw$ or $\log l(w) + d_1 = -\log(y -$

[1] The result is obtained by using the quotient rule and the fact that $\frac{\bar{w}+\delta W_U+\lambda_L \int_{\bar{w}}^{\infty} W_L(w)dH(w)}{[r+\delta+\lambda_L \int_{\bar{w}}^{\infty} dH(w)]} = W_L(\bar{w}) = \frac{A(\bar{w})}{B(\bar{w})}$. This yields $W_L'(\bar{w}) = \frac{A'B-AB'}{B^2} = \frac{1}{B}(A' - W_L(\bar{w})B') = \frac{1}{B}(1 - \lambda_L W_L(\bar{w})h(\bar{w}) + \lambda_L W_L(\bar{w})h(\bar{w})) = \frac{1}{B}$.

$w) + d_2$ is obtained, where d_1 and d_2 are integration constants. Letting $d = d_2 - d_1$ and exponentiating both sides yields:

$$l(w) = \frac{\exp(d)}{y-w} = \frac{D}{y-w}. \tag{B.3}$$

The integration constant D can be derived through the constraint that (B.1) imposes on the above equation. Evaluating (B.1) and (B.3) at w_R and imposing equality, I obtain $l(w_R) = \frac{\lambda U}{\delta+\lambda_L} = \frac{D}{y-w_R}$ or $D = \frac{\lambda U}{\delta+\lambda_L}(y - w_R)$. Using D and U in (B.3) provides the solution to the differential equation: $l(w) = \frac{\lambda\delta N}{(\delta+\lambda_L)(\delta+\lambda)} \cdot \frac{y-w_R}{y-w}$.

The equilibrium profits of a firm that pays a wage from the support of the wage distribution is given by $\Pi(w) = (y-w)l(w) = \frac{\lambda\delta N(y-w_R)}{(\delta+\lambda_L)(\delta+\lambda)}$.

The upper limit of the support of wage distribution w^o can be calculated by inserting w^o in (B.1) and in $l(w) = \frac{\lambda\delta N}{(\delta+\lambda_L)(\delta+\lambda)} \cdot \frac{y-w_R}{y-w}$, and solving for $l(w^o)$, respectively. Noting that $L(w^o) = N-U$, I obtain

$$w^o = y - (y - w_R)\left(\frac{\delta}{\delta+\lambda_L}\right)^2. \tag{B.4}$$

as upper limit of the support of the wage distribution and the distribution of paid wages. Note, that the highest paid wage is below the marginal productivity of the employees.

B.3 Profits with continuous productivity dispersion

The solution of (2.18) $\Pi'(y) = \breve{l}(K(y))$ is obtained when integrating $\Pi(y) = \int_{\underline{y}}^{y} \Pi'(\varrho)d\varrho = A + \int_{\underline{y}}^{y} \breve{l}(K(\varrho))d\varrho$. A is the integration constant and follows from (2.16), when evaluated at $(\underline{y},\underline{w})$, where $\underline{w} = \max\{w_R, w_{\min}\}$. Therewith, $A = \frac{\delta}{\delta+\lambda_L}\frac{N-U}{M}(\underline{y} - \underline{w})$. Furthermore, the share of firms that pays wages below $K(y)$ is equal to the share of firms whose productivity is below y: $H(K(y)) = \Gamma(y)$. Using (2.15), it is $\breve{l}(K(y)) = \delta\frac{(N-U)}{M}\frac{\delta+\lambda_L}{[\delta+\lambda_L(1-\Gamma(y))]^2}$ and thus the profit function becomes:

$$\begin{aligned}
\Pi(y) &= \frac{\delta}{\delta+\lambda_L}\frac{N-U}{M}(\underline{y}-\underline{w}) + \int_{\underline{y}}^{y} \delta\frac{(N-U)}{M}\frac{\delta+\lambda_L}{[\delta+\lambda_L(1-\Gamma(\varrho)]^2}d\varrho \\
\Pi(y) &= \int_{\underline{w}}^{y} \delta\frac{(N-U)(\delta+\lambda_L)}{M}\frac{1}{[\delta+\lambda_L(1-\Gamma(\varrho))]^2}d\varrho.
\end{aligned} \tag{B.5}$$

The second row follows from the fact that $\Gamma(y) = 0$ for $y \in [\underline{w}, \underline{y}]$ and thus the integral on the interval $[\underline{w}, \underline{y}]$ in the second row, equals the first summand in the first row. This equation yields the profit of a type y firm depending on the model parameters and on the distribution of firm productivities. Solving $\Pi(y) = (y - K(y))\breve{l}(K(y))$ with respect to $K(y) = w$ yields an expression for the wage as a function of the productivity y: $w = K(y) = y - \frac{\Pi(y)}{\tilde{l}(K(y))}$. Using the corresponding expressions yields: $K(y) = y - [\delta + \lambda_L(1 - \Gamma(y))]^2 \int_{\underline{w}}^{y} \frac{1}{[\delta+\lambda_L(1-\Gamma(\varrho))]^2} d\varrho$.

B.4 Variance analysis

Start by assuming a utility function with constant relative risk aversion (CRRA) and consider a worker who is employed in a firm of type y, then: $\ln w_w(\varepsilon, y, y') = \ln\varepsilon + \ln w_w(1, y, y')$. The conditional (on y) expectation of the log-wage is given by Postel-Vinay and Robin (2002b), p.2310): $E_{(\varepsilon,y'|y)}(\ln w|y) = E_\varepsilon(\ln\varepsilon) + E_{(y'|y)}(\ln w_w(1, y, y')|y)$.[2] Using independence of ε and (y, y'), the conditional (on y) variance is given by $var_{(\varepsilon,y'|y)}(\ln w|y) = var_\varepsilon(\ln\varepsilon) + var_{(y'|y)}(\ln w_w(1, y, y')|y)$. Applying this variance decomposition, the variance of wages can be decomposed in the variance of the conditional expectation of wages and in the expectation of the conditional variance $var_w(\ln w) = var_y[E_{(\varepsilon,y'|y)}(\ln w|y)] + E_y[var_{(\varepsilon,y'|y)}(\ln w|y)] = var_y[E_\varepsilon(\ln\varepsilon) + E_{(y'|y)}(\ln w_w(1, y, y')|y)] + E_y[var_\varepsilon(\ln\varepsilon) + var_{(y'|y)}(\ln w_w(1, y, y')|y)]$. Thus, the following decomposition of the wage variance is obtained:

$$var_w(\ln w) = var_\varepsilon(\ln\varepsilon) + var_y[E_{(y'|y)}(\ln w_w(1, y, y')|y)] + E_y[var_{(y'|y)}(\ln w_w(1, y, y')|y)].$$

The first summand of this formula results from productivity differences among employees. The second summand reflects the effect of different firm productivities on the variance of paid wages. The expected wage changes along with y, the productivity of the firm. The variance of the conditional expectation reflects the variance of wages between firms of different productivities. Note, that the conditional expectation of the log-wage and thus the variance of the second summand depends on the joint distribution of y, y'. The third summand reflects wage fluctuations for firms and workers whose productivity is identical. Thus, the wage fluctuations among identical individuals in identical firms are contained in this part.[3] From the point of view of an individual it is explained by the luck of receiving a valuable job offer that implies pay raises. The extent of this variance is explained by frictions because frequent job offers lead to a faster adjustment of wages to the marginal productivity and thus lowers the variance.

[2] The indices indicate with respect to which variable the expectation is to be constructed.

[3] This is the part of the wage dispersion that is explained by the model of Burdett and Mortensen (1998).

C Appendix for Chapter 3

C.1 Abbreviations

1. Labor market states:
   (E) employed,
   (BR) recipient of transfer payments (i.e. unemployment benefits, unemployment assistance and income maintenance during participation in training programs),
   (OOS) out of sample.

2. E–OE is the share of individuals who change jobs between two consecutive years.

3. E–E is the share of individuals who are employed in the first year and still (or again) employed in the second year.

4. BR–E is the share of individuals who are benefit recipients in the first year and employed in the second year.

C.2 Average stocks and transitions rates across demographic groups

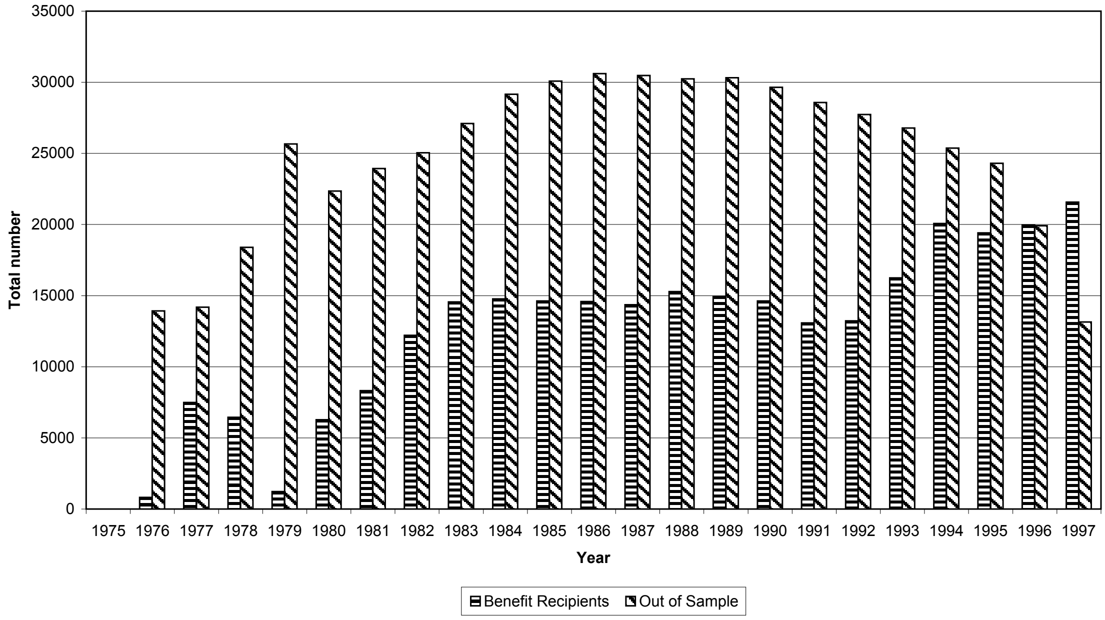

Figure C.1: Total number of benefit recipients and individuals that are temporarily not in the data set

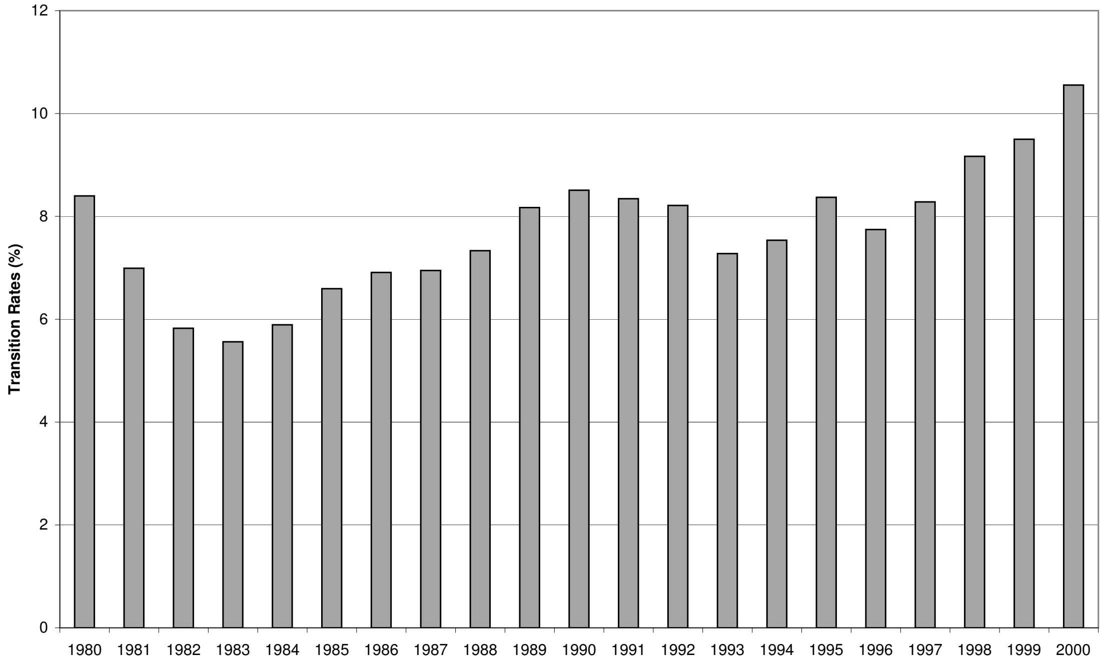

Figure C.2: Job-to-job transitions as percentage of employment

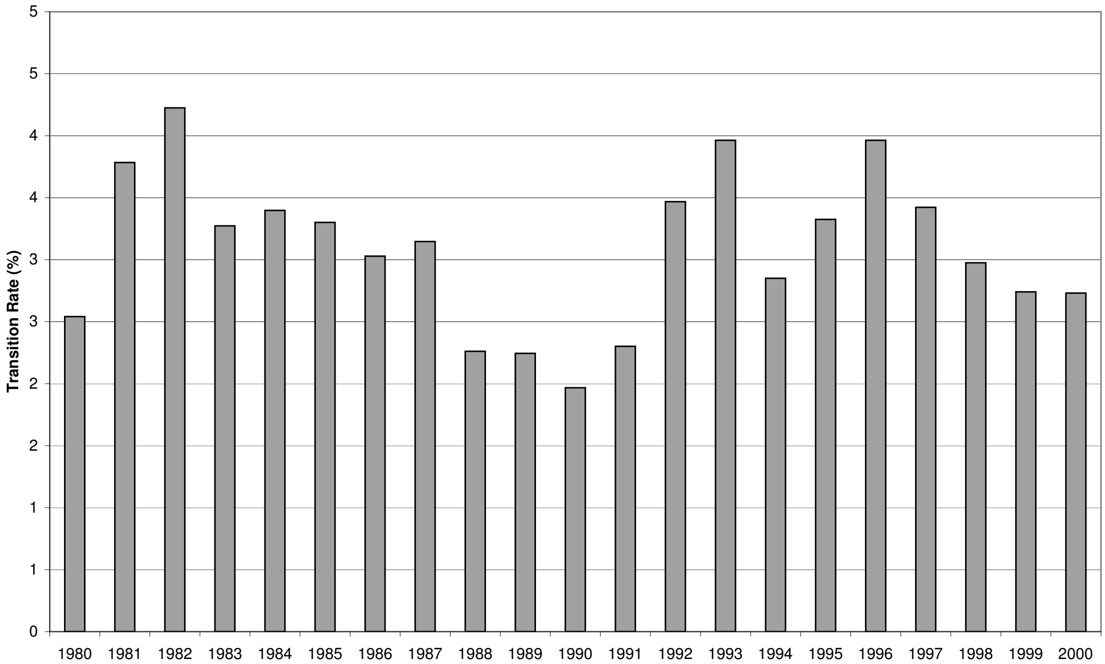

Figure C.3: Transition rate from employment to benefit recipiency

Table C.1: Stocks across different characteristics

Characteristic	Employed	Benefit recipient	Out of sample	Benefit recipient rate	Out of sample rate	Total
All	298449	25692	44317	0.070	0.120	368458
Sectors						
Farming, energy, mining	8082	–	–	–	–	–
Manufacturing	23325	–	–	–	–	–
Producer durable good prod.	60056	–	–	–	–	–
Consumer goods production	21575	–	–	–	–	–
Food/stimulants industry	9396	–	–	–	–	–
Construction	21162	–	–	–	–	–
Commerce	41430	–	–	–	–	–
Traffic/telecommunication	13034	–	–	–	–	–
Services (business)	30312	–	–	–	–	–
Services (household)	11994	–	–	–	–	–
Services (society)	37497	–	–	–	–	–
Social security/local auth.	19700	–	–	–	–	–
Missing	887	–	–	–	–	–
Professional status						
Apprentices	19982	888	2704	0.038	0.115	23574
Clerks	121197	6602	14934	0.046	0.105	142733
Skilled workers/craftsmen[o]	62408	5823	5823	0.079	0.079	74054
Unskilled workers[o]	57857	9870	10159	0.127	0.130	77886
Masters/foremen	5665	300	335	0.048	0.053	6300
Home workers	386	46	85	0.089	0.164	517
Part-time workers[(a)]	4903	116	2696	0.015	0.349	7715
Part-time workers[(b)]	25966	2034	7542	0.057	0.212	35542
Missing	83	14	38	0.104	0.281	135
Education						
Category 1[(c)]	71880	8489	9512	0.094	0.106	89881
Category 2[(d)]	178697	12566	19968	0.059	0.095	211231
Category 3[(e)]	3440	189	1364	0.039	0.273	4993
Category 4[(f)]	6882	369	1603	0.042	0.181	8854
Polytechnic	8435	380	1696	0.036	0.161	10511
University	11237	550	3417	0.036	0.225	15204
Unknown	17809	3134	6731	0.113	0.243	27674
Missing	68	12	27	0.112	0.252	107
Nationality						
Foreigner	23836	3047	4227	0.098	0.136	31110
German	271257	21852	39541	0.066	0.119	332650
Missing	3355	793	550	0.169	0.117	4698
Sex						
Female	116579	9293	21642	0.061	0.133	147764
Male	181869	16399	22675	0.071	0.095	218877
Age						
< 16 years [(j)]	10094	717	1789	0.057	0.142	12600

Characteristic	Employed	Benefit recipient	Out of sample	Benefit recipient rate	Out of sample rate	Total
16-20 years	16455	770	1162	0.042	0.063	18387
21-25 years	31227	3078	6349	0.076	0.156	40654
26-30 years	35794	3250	9330	0.067	0.193	48374
31-35 years	36722	2924	8020	0.061	0.168	47666
36-40 years	35706	2451	6140	0.055	0.139	44297
41-45 years	35580	2287	4366	0.054	0.103	42233
46-50 years	32625	2287	2803	0.061	0.074	37715
51-55 years	28268	2758	1832	0.084	0.056	32858
56-60 years	18778	4230	1356	0.174	0.056	24364
61-62 years	1110	310	134	0.199	0.086	1554
$>$ 62 years $^{(k)}$	16089	630	1036	0.035	0.058	17755

$^{(o)}$ *Unskilled* and *Skilled* reflect the position an individual holds in his current (if employed) or previous (if benefit recipient) job, while *low-skilled*, *medium-skilled*, and *high-skilled* refer to educational attainment.
$^{(a)}$Working less than half of normal time
$^{(b)}$Working more than half of normal time
$^{(c)}$No vocational training degree, no High School Diploma
$^{(d)}$Vocational training degree, no High School Diploma
$^{(e)}$No vocational training degree, High School Diploma
$^{(f)}$Vocational training degree, High School Diploma
$^{(h)}$In Euro per day
$^{(i)}$Top coding category for part of the employees
$^{(j)}$...when entering the labor market
$^{(k)}$...when leaving the labor market

Table C.2: Transition rates for all employees

E-OE	E-SE	E-BR	E-OOS	E-LS
7.72	82.97	3.09	3.04	3.18

BR-E	BR-BR	BR-OOS	BR-LS
23.92	47.64	12.76	15.68

OOS-E	OOS-BR	OOS-OOS	OOS-LS
24.49	7.96	64.06	3.49

E: employed, OE: other employer than in the previous year,
SE: same employer as in previous year, BR: benefit recipient,
OOS: out of sample, LS: last spell (vanishes from the data set)
All transition rates in percent

Table C.3: Transition rates across demographic groups

(in %)	E-OE	E-SE	E-BR	E-OOS	E-LS	BR-E	BR-BR	BR-OOS	BR-LS	OOS-E	OOS-BR	OOS-OOS	OOS-LS
Sex													
Men	7.63	83.58	3.00	2.76	3.03	23.80	51.01	10.85	14.34	25.17	9.91	61.02	3.91
Women	7.87	82.02	3.25	3.47	3.40	24.12	41.90	16.03	17.94	23.84	5.92	67.19	3.05
Nationality													
Germans	7.65	83.47	2.91	3.00	2.97	24.07	47.29	12.86	15.77	24.62	7.56	65.00	2.82
Foreigners	7.02	78.34	4.50	4.52	5.60	20.14	50.08	12.94	16.84	24.59	8.74	59.54	7.12
Education													
Low-skilled	5.07	83.96	3.88	2.99	4.09	14.67	55.60	11.37	18.35	22.08	10.77	61.93	5.21
Medium-skilled	7.42	84.34	2.85	2.62	2.76	26.00	45.61	12.85	15.55	25.53	9.00	62.30	3.16
High-skilled	9.22	82.43	2.00	2.53	3.79	30.97	41.01	12.08	15.93	27.81	6.41	62.39	3.38
Wages													
Low wage	7.61	72.92	4.67	11.12	3.67	17.65	48.89	19.39	14.06	21.68	4.34	71.90	2.08
Mid wage	5.18	79.34	2.63	10.70	2.14	15.69	51.41	17.44	15.45	31.56	3.48	64.01	0.94
High wage	5.25	84.93	1.39	6.19	2.23	8.75	52.26	15.40	23.58	32.39	3.16	63.27	1.18
Age													
A16-20	10.97	78.00	4.64	3.86	2.52	23.24	49.59	10.96	15.21	42.68	11.26	38.78	7.27
A21-25	14.45	71.36	5.36	5.79	3.03	34.27	43.92	13.20	8.60	38.73	14.57	41.09	5.61
A26-30	10.57	78.92	4.29	3.01	3.20	30.21	48.34	9.89	11.56	37.34	16.72	39.43	6.51
A31-35	8.72	82.94	3.34	2.25	2.74	27.64	51.67	9.48	11.20	37.51	18.68	37.23	6.58
A36-40	7.18	86.36	2.78	1.53	2.14	26.06	54.10	8.96	10.87	36.40	20.88	35.14	7.57
A41-45	6.16	88.34	2.55	1.19	1.76	22.46	57.81	7.91	11.82	35.00	24.21	32.14	8.64
A46-50	5.16	89.20	2.62	1.04	1.98	17.43	60.67	6.76	15.13	30.58	30.43	28.58	10.51
A51-55	4.29	88.23	3.39	1.06	3.02	10.95	62.83	4.59	21.63	25.65	37.84	22.97	13.54
A56-60	2.62	68.70	6.42	1.71	20.55	2.30	47.80	1.76	48.13	12.12	51.45	11.42	25.01
A61-62	0.96	29.07	13.85	1.63	54.48	0.13	23.23	0.11	76.52	0	53.94	0	46.06

(in %)	E-OE	E-SE	E-BR	E-OOS	E-LS	BR-E	BR-BR	BR-OOS	BR-LS	OOS-E	OOS-BR	OOS-OOS	OOS-LS
Professional status													
Apprentices	6.19	81.67	3.13	6.87	2.13	12.43	49.50	26.13	11.93	26.34	5.45	66.78	1.43
Clerks	7.31	84.65	2.16	2.93	2.94	20.80	44.48	15.18	19.53	23.24	5.45	69.48	1.82
Skilled workers/craftsmen	5.48	84.81	3.28	3.70	2.73	18.07	51.58	14.43	15.92	24.19	8.50	65.16	2.17
Unskilled workers	4.73	82.53	4.78	4.10	3.86	14.95	56.00	14.05	15.00	19.29	9.19	68.03	3.49
Masters/foremen	3.47	88.03	2.21	2.11	4.17	9.26	47.74	7.25	35.75	27.09	8.27	61.88	2.76
Home workers	2.28	82.05	6.50	3.37	5.80	13.15	48.78	8.96	29.10	31.32	10.15	51.81	6.71
Part-time workers[a]	2.39	82.67	0.67	5.17	9.10	7.22	53.60	18.76	20.41	24.25	1.72	70.68	3.35
Part-time workers[b]	3.70	84.62	3.17	4.36	4.14	11.45	44.05	18.76	25.74	20.63	4.11	73.22	2.04

[a]Working less than half of normal time

[b]Working more than half of normal time

Table C.4: Correlation of real GDP growth with transition rates

Correlation between transition rate from ...	... and real GDP growth (correlation coefficient)	Standard deviation
job to other job	0.326	0.217
job to other job (t+1)	0.328	0.222
job to same job	0.413	0.209
job to BR	-0.856	0.119
job to BR (t+1)	-0.379	0.218
job to other states	-0.819	0.132
BR to employment	0.357	0.214
BR to employment (t+1)	0.303	0.224
BR to other states	0.009	0.230

BR: Benefit recipiency state as defined in the data section.

C.3 Wage distributions for different groups and years

Log-wage distribution for:

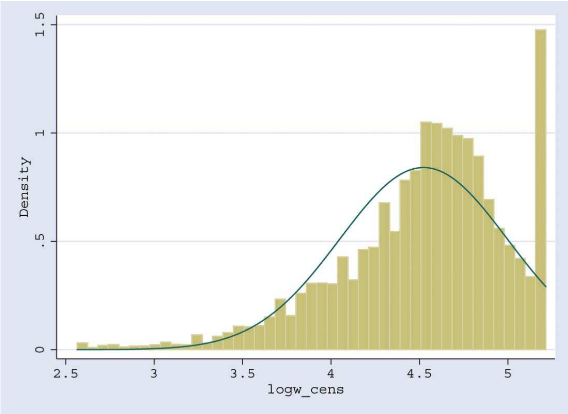

Figure C.4: full-time employed individuals (including apprentices) in 1986

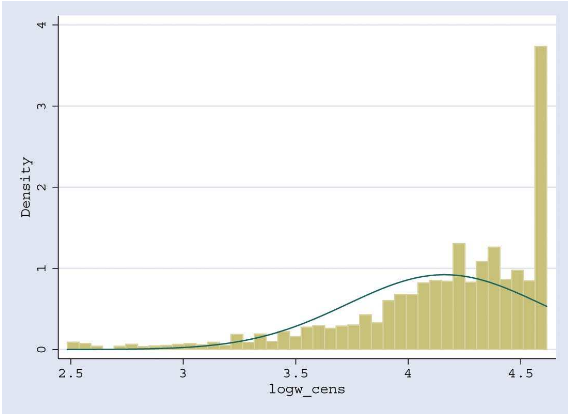

Figure C.5: clerks in 1976

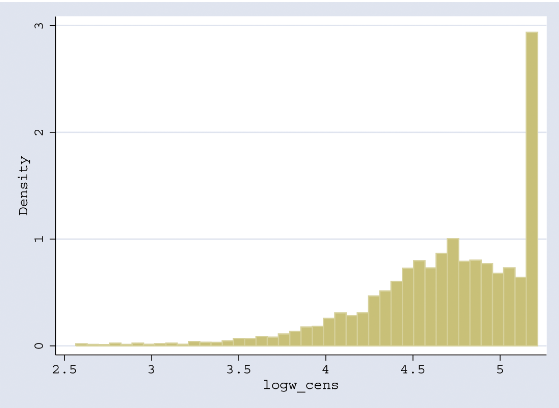

Figure C.6: clerks in 1986

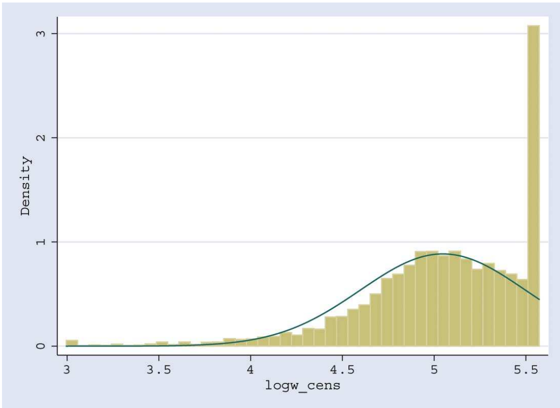

Figure C.7: clerks in 1996

C.4 Results from direct job–to–job changes for different wage definitions

In the dataset about 5% of the wage observations are censored, and the censoring probabilities differ strongly over the characteristics in the dataset. The way how we treat this censored values might strongly affect our results. Therefore we use different procedures to cope with the censored values. For the first wage definition (A) we performed separate Tobit-regressions for the censoring above and below. For full-time employees (excluding apprentices, home workers and the missing category) we used Tobit-regressions to predict the conditional expectation for (deflated) wages that were censored from above within the group of full-time employed for each year. Other censored values were omitted from our analysis. We performed Tobit-regressions for part-time employees and apprentices to predict values that were censored from below and replaced the censored values with their conditional expectations. For the second definition (B) we did the same, but we used data from the official statistics for the mean of the wage distribution to predict conditional expectations. For the third definition (C) we replaced all censored values by the censoring thresholds. Finally, for the fourth definition (D) we excluded all censored values from the analysis.

Table C.5: Wage changes after job–to–job transitions for different wage definitions

	Observations	Share winners	Share losers	No change
Wage A	324009	70.7	22.2	7.1
Wage B	324009	70.7	22.2	7.1
Wage C	324258	71.2	24.5	4.3
Wage D	288414	72.7	23.5	3.8

	Relative gain of the winners (in %)	Relative loss of the losers (in %)	Average wage change (in %)
Wage A	20.5	-13.1	11.6
Wage B	20.5	-13.1	11.6
Wage C	19.4	-10.7	11.2
Wage D	20.0	-11.6	11.9

There are some more observations in the C variable since, for wage C, we do not omit full-time employed individuals, whose wage is censored from below. No change means that the wage is exactly the same before and after the job–to–job transition. Wage A: Tobit estimates for upper and lower bound. Wage B: Tobit estimates, based on the annual income data of the official statistics. Wage C: Censored values are replaced by their censoring threshold. Wage D: Censored values are excluded from our analysis.

As one can see in table C.5, results do not differ by much. The maximum difference in the share of winners and the share of losers is less than 2 percentage point. The average gain differs by a maximum of about 1 percentage point, while average losses differ by less than 2 percentage points.

Table C.6: Transitions within working-time categories

	Obs.	Share winners	Share losers	No change
Full-time 2 to full-time 2	324009	70.7	22.10	7.1
Part-time 1 to part-time 1	20073	68.2	24.6	7.3
Part-time 2 to part-time 2	2995	53.3	27.9	18.8

	Relative gain of the winners (%)	Relative loss of the losers (%)	Average wage change (%)
Full-time 2 to full-time 2	20.4	-13.0	11.6
Part-time 1 to part-time 1	15.9	-11.4	8.0
Part-time 2 to part-time 2	24.9	-19.4	7.9

Full-time 2: Within the group of full-time employed, excluding apprentices.
Part-time 1: Working hours are more than 50% of regular working hours.
Part-time 2: Working hours are less than or equal to 50% of regular working hours.

Table C.7: Transitions within wage categories

	Observations	Share winners	Share losers	No change
Tercile 1	54270	77.8	18.9	3.3
Tercile 2	41990	68.8	27.0	4.2
Tercile 3	48642	60.6	24.3	15.1

	Relative gain of the winners (in %)	Relative loss of the losers (in %)	Average wage change (in %)
Tercile 1	26.0	-10.6	18.2
Tercile 2	13.5	-11.1	6.2
Tercile 3	11.7	-16.2	3.1

Table C.8: Transitions within unemployment categories

	Obs.	Share winners	Share losers	No change
Unemployed > 3 months	28634	52.6	44.6	2.9
Unemployed $> 3 \leq 6$ months	20735	51.7	45.6	2.6
Unemployed $> 6 \leq 9$ months	12181	49.9	47.7	23.0
Unemployed $> 9 \leq 12$ months	6713	47.1	50.8	2.1
Unemployed > 12 months	25706	54.0	44.8	1.2

	Relative gain of the winners (%)	Relative loss of the losers (%)	Average wage change (%)
Unemployed > 3 months	35.7	-28.5	6.1
Unemployed $> 3 \leq 6$ months	32.5	-27.0	4.5
Unemployed $> 6 \leq 9$ months	34.3	-27.6	3.9
Unemployed $> 9 \leq 12$ months	35.4	-28.8	2.0
Unemployed > 12 months	51.7	-31.2	13.9

Table C.9: Share of winners and losers after job–to–job transitions by category

Variable	Winners	Losers
Medium-skilled	-0.010	-0.013
	(0.015)	(0.011)
High-skilled	-0.073***	-0.101***
	(0.016)	(0.011)
28-30 years	-0.003	-0.021
	(0.028)	(0.020)
31-33 years	-0.037	-0.015
	(0.028)	(0.020)
34-36 years	-0.049*	-0.029
	(0.028)	(0.020)
37-39 years	-0.056**	-0.042**
	(0.028)	(0.020)
40-42 years	-0.031	-0.032
	(0.028)	(0.020)
43-45 years	-0.084***	-0.036*
	(0.028)	(0.020)
46-48 years	-0.078***	-0.032
	(0.029)	(0.021)
49-51 years	-0.030	-0.051**
	(0.029)	(0.021)
52-54 years	-0.019	-0.037*
	(0.029)	(0.021)
Time	0.001	0.000
	(0.000)	(0.000)
Relative gain/loss	-0.016	-0.028
	(0.018)	(0.063)
Intercept	-1.689	-0.899
	(1.861)	(1.391)
N	615	586
R^2	0.070	0.146
$\chi^2_{(13)}$	46.3	100.2

Significance levels: $*$: 10% $**$: 5% $***$: 1%

OLS regressions on age-education-year cells as observation unit.

Table C.10: Relative gain or loss after job–to–job transitions by category

Variable	Winners	Losers
Medium-skilled	0.005	-0.015***
	(0.005)	(0.004)
High-skilled	0.035***	-0.045***
	(0.007)	(0.005)
28-30 years	-0.030**	-0.005
	(0.010)	(0.007)
31-33 years	-0.046***	-0.005
	(0.010)	(0.007)
34-36 years	-0.076***	0.002
	(0.010)	(0.007)
37-39 years	-0.078***	-0.003
	(0.010)	(0.007)
40-42 years	-0.085***	-0.004
	(0.010)	(0.008)
43-45 years	-0.091***	-0.001
	(0.011)	(0.008)
46-48 years	-0.109***	0.015*
	(0.011)	(0.008)
49-51 years	-0.110***	0.005
	(0.011)	(0.008)
52-54 years	-0.125***	0.014*
	(0.011)	(0.008)
Share of winners/losers	0.022**	0.033***
	(0.012)	(0.011)
Intercept	0.224***	-0.120***
	(0.011)	(0.006)
N	553	497
R^2	0.377	0.206
$\chi^2_{(12)}$	334.6	128.9

Significance levels: $*$: 10% $**$: 5% $***$: 1%

OLS regressions on age-education-year cells as observation unit.

Table C.11: Share of winners and losers after job–to–job transitions by category, controlling for the position in the wage distribution

Variable	Winners	Losers
Tercile 2	-0.071***	0.077***
	(0.008)	(0.007)
Tercile 3	-0.170***	0.087***
	(0.008)	(0.007)
Medium-skilled	-0.007	-0.035***
	(0.007)	(0.006
High-skilled	0.040***	-0.074***
	(0.008)	(0.008)
28-30 years	0.006	-0.028**
	(0.013)	(0.011)
31-33 years	-0.005	-0.037***
	(0.013)	(0.011)
34-36 years	-0.006	0.042***
	(0.013)	(0.012)
37-39 years	-0.008	-0.042***
	(0.013)	(0.012)
40-42 years	0.011	-0.014
	(0.014)	(0.012)
43-45 years	-0.000	-0.013
	(0.014)	(0.012)
46-48 years	0.015	-0.004
	(0.014)	(0.013)
49-51 years	0.032**	-0.031**
	(0.014)	(0.013)
52-54 years	0.037	0.017
	(0.015)	(0.013)
Relative gain/loss	0.026	0.008
	(0.016)	(0.039)
Intercept	0.765***	0.251***
	(0.012)	(0.011)
N	2177	2043
R^2	0.209	0.141
$\chi^2_{(14)}$	575.2	335.4

Significance levels: $*$: 10% $**$: 5% $***$: 1%

OLS regressions on age-education-wage tercile-year cells as observation unit.

Table C.12: Relative gain or loss after job–to–job transitions by category, controlling for the position in the wage distribution

Variable	Winners	Losers
Tercile 2	-0.138***	-0.005
	(0.011)	(0.004)
Tercile 3	-0.164***	-0.052***
	(0.012)	(0.004)
Medium-skilled	0.007	-0.012***
	(0.010)	(0.004)
High-skilled	0.076**	-0.039***
	(0.011)	(0.004)
28-30 years	-0.026	0.000
	(0.018)	(0.006)
31-33 years	-0.037**	0.001
	(0.018)	(0.006)
34-36 years	-0.061***	-0.001
	(0.018)	(0.007)
37-39 years	-0.064***	-0.001
	(0.018)	(0.007)
40-42 years	-0.066***	-0.003
	(0.018)	(0.007)
43-45 years	-0.035*	-0.006
	(0.019)	(0.007)
46-48 years	-0.074***	0.011
	(0.019)	(0.007)
49-51 years	-0.082***	0.006
	(0.019)	(0.007)
52-54 years	-0.095***	0.015**
	(0.020)	(0.007)
Share of winners/losers	0.048	0.002
	(0.029)	(0.012)
Intercept	0.274***	-0.098***
	(0.027)	(0.006)
N	2177	2043
R^2	0.162	0.145
$\chi^2_{(14)}$	420.9	346.5

Significance levels: $*$: 10% $**$: 5% $***$: 1%

OLS regressions on age-education-wage tercile-year cells as observation unit.

Table C.13: Wage growth for job changers and stayers

	1977		1978		1979		1980	
	Stayers	Changers	Stayers	Changers	Stayers	Changers	Stayers	Changers
Year	0.052	0.124	0.051	0.100	0.043	0.088	0.021	0.057
Year+1	0.048	0.043	0.039	0.027	0.043	0.005	0.017	0.000
Year+2	0.028	0.022	0.007	0.002	0.004	-0.003	0.016	0.008
Year+3	-0.002	-0.002	-0.006	-0.005	0.005	0.006	0.041	0.036
Year+4	-0.008	-0.007	0.002	0.004	0.038	0.034	0.028	0.025

	1981		1982		1983		1984	
	Stayers	Changers	Stayers	Changers	Stayers	Changers	Stayers	Changers
Year	0.020	0.031	0.031	0.032	0.068	0.058	0.060	0.052
Year+1	0.029	0.010	0.064	0.039	0.056	0.030	0.080	0.051
Year+2	0.052	0.038	0.043	0.029	0.064	0.049	0.056	0.040
Year+3	0.032	0.027	0.052	0.048	0.042	0.040	0.027	0.022
Year+4	0.049	0.047	0.039	0.039	0.024	0.021	0.019	0.014

	1985		1986		1987		1988	
	Stayers	Changers	Stayers	Changers	Stayers	Changers	Stayers	Changers
Year	0.083	0.077	0.075	0.072	0.060	0.052	0.055	0.045
Year+1	0.072	0.042	0.056	0.026	0.052	0.020	0.074	0.041
Year+2	0.041	0.023	0.038	0.018	0.059	0.038	0.058	0.038
Year+3	0.023	0.016	0.042	0.037	0.041	0.036	0.027	0.021
Year+4	0.038	0.035	0.037	0.034	0.022	0.020	0.006	0.004

	1989		1990		1991		1992	
	Stayers	Changers	Stayers	Changers	Stayers	Changers	Stayers	Changers
Year	0.078	0.070	0.077	0.069	0.041	0.054	0.042	0.035
Year+1	0.073	0.040	0.040	0.025	0.039	0.009	0.031	0.004
Year+2	0.035	0.023	0.031	0.007	0.025	0.002	0.058	0.029
Year+3	0.014	0.006	0.009	-0.000	0.040	0.027	0.025	0.010
Year+4	0.001	-0.001	0.031	0.025	0.014	0.009	0.006	0.003

	1993		1994		1995		1996	
	Stayers	Changers	Stayers	Changers	Stayers	Changers	Stayers	Changers
Year	0.033	0.023	0.066	0.048	0.041	0.028	0.036	0.020
Year+1	0.064	0.031	0.042	0.013	0.036	0.006	0.0557	0.022
Year+2	0.038	0.012	0.031	0.005	0.051	0.020	0.062	0.030
Year+3	0.015	0.004	0.033	0.019	0.042	0.028	0.025	0.006
Year+4	0.024	0.018	0.032	0.027	0.012	0.005	0.014	0.011

C.5 Decile transitions

Table C.14: Decile transitions, all employees

Variable	Coefficient	(Std. err.)
28-30 years	-0.044*	(0.025)
31-33 years	-0.128***	(0.026)
34-36 years	-0.202***	(0.035)
37-39 years	-0.269***	(0.038)
40-42 years	-0.325***	(0.040)
43-45 years	-0.367***	(0.040)
46-48 years	-0.393***	(0.041)
49-51 years	-0.432***	(0.053)
52-54 years	-0.458***	(0.047)
1976	-0.134***	(0.051)
1977	-0.172***	(0.044)
1978	-0.176***	(0.058)
1979	-0.143***	(0.049)
1980	-0.212***	(0.061)
1981	-0.131***	(0.051)
1982	-0.163***	(0.052)
1983	-0.263***	(0.072)
1984	-0.170***	(0.050)
1985	-0.154***	(0.045)
1986	-0.172**	(0.073)
1988	-0.225***	(0.077)
1989	-0.125***	(0.047)
1990	-0.158***	(0.054)
1994	-0.122***	(0.046)
1996	-0.107***	(0.036)
1998	-0.102**	(0.052)
2000	-0.214***	(0.061)
Medium-skilled	0.238***	(0.065)
High-skilled	0.223***	(0.044)
Job change dummy	0.285***	(0.008)
Interquantile range/1000	0.275	(0.714)
E-E/10000	-0.356*	(0.197)

Variable	Coefficient	(Std. err.)
E-OE/10000	-0.292	(2.309)
_cut1	-1.286***	(0.069)
_cut2	0.371***	(0.068)
N	1749847	
Log-likelihood	-1660653	

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Standard Errors are robust with respect to correlations within age-education cells. Abbreviations, see above section C.1. Some insignificant year dummies are omitted.

Table C.15: Decile transitions with interactions, all employees

Variable	Coefficient	(Std. err.)
28-30 years	-0.048*	(0.026)
31-33 years	-0.137***	(0.025)
34-36 years	-0.204***	(0.027)
37-39 years	-0.270***	(0.029)
40-42 years	-0.327***	(0.029)
43-45 years	-0.373***	(0.034)
46-48 years	-0.394***	(0.041)
49-51 years	-0.431***	(0.049)
52-54 years	-0.449***	(0.050)
Time	0.002	(0.001)
Medium-skilled	0.190***	(0.057)
High-skilled	0.207***	(0.037)
Job change dummy	0.336***	(0.019)
Job change x 28-30 years	-0.011	(0.025)
Job change x 31-33 years	-0.029	(0.020)
Job change x 34-36 years	-0.109***	(0.022)
Job change x 37-39 years	-0.162***	(0.024)
Job change x 40-42 years	-0.167***	(0.029)
Job change x 43-45 years	-0.160***	(0.033)
Job change x 46-48 years	-0.212***	(0.033)
Job change x 49-51 years	-0.197***	(0.026)
Job change x 52-54 years	-0.198***	(0.020)
Interquantile range/1000	0.738	(0.698)
E-E/10000	-0.299**	(0.132)
_cut1	2.513	(2.306)
_cut2	4.166*	(2.338)
N	1749847	
Log-likelihood	-1663725	

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Standard Errors are robust with respect to correlations within age-education cells. Abbreviations, see above section C.1.

Table C.16: Decile transitions for changers

Variable	Education category 1	Education category 2	Education category 3
28-30 years	-0.103***	-0.059***	-0.013
	(0.010))	(0.011)	(0.099)
31-33 years	-0.205***	-0.140***	-0.165
	(0.017)	(0.019)	(0.173)
34-36 years	-0.228***	-0.258***	-0.364*
	(0.020)	(0.023)	(0.200)
37-39 years	-0.316***	-0.355***	-0.473**
	(0.026)	(0.028)	(0.211)
40-42 years	-0.311***	-0.410***	-0.573***
	(0.032)	(0.030)	(0.202)
43-45 years	-0.405***	-0.468***	-0.592***
	(0.033)	(0.030)	(0.196)
46-48 years	-0.472***	-0.545***	-0.679***
	(0.036)	(0.030)	(0.180)
49-51 years	-0.466***	-0.583***	0.651***
	(0.040)	(0.032)	(0.174)
52-54 years	-0.481***	-0.612***	-0.659***
	(0.044)	(0.030)	(0.153)
Interquantile range/1000	12.753**	2.656***	-1.977*
	(5.751)	(0.212)	(1.159)
E-OE/10000	-1.684	0.259*	3.456*
	(1.414)	(0.157)	(2.074)
E-E/10000	-0.134**	-0.044**	-0.497
	(0.064)	(0.017)	(0.388)
_cut1	-0.705**	-1.047***	-2.019***
	(0.274)	(0.085)	(0.213)
_cut2	0.264	0.028	-0.339
	(0.277)	(0.057)	(0.301)
N	9322	86839	20061
Log-likelihood	-9824	-89799	-17750

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Standard Errors are robust with respect to correlations within age-education cells. Abbreviations, see above section C.1.

Table C.17: Decile transitions for stayers

Variable	Education category 1	Education category 2	Education category 3
28-30 years	-0.075***	-0.043***	-0.095
	(0.008)	(0.009)	(0.162)
31-33 years	-0.114***	-0.137***	-0.314
	(0.014)	(0.014)	(0.267)
34-36 years	-0.125***	-0.219***	-0.527*
	(0.016)	(0.018)	(0.269)
37-39 years	-0.154***	-0.299***	-0.655***
	(0.020)	(0.023)	(0.248)
40-42 years	-0.168***	-0.378***	-0.766***
	(0.025)	(0.025)	(0.231)
43-45 years	-0.198***	-0.495***	-0.789***
	(0.027)	(0.027)	(0.211)
46-48 years	-0.209***	-0.552***	-0.843***
	(0.032)	(0.030)	(0.191)
49-51 years	-0.218***	-0.615***	-0.825***
	(0.034)	(0.036)	(0.193)
52-54 years	-0.279***	-0.645***	-0.834***
	(0.036)	(0.039)	(0.174)
Interquantile range/1000	7.796	3.697***	-4.324**
	(4.759)	(0.394)	(1.892)
E-OE/10000	-1.165	0.071	1.073
	(1.044)	(0.186)	(2.589)
E-E/10000	-0.137***	-0.072***	-0.063
	(0.053)	(0.017)	(0.438)
_cut1	-0.855***	-1.579***	-2.615***
	(0.154)	(0.098)	(0.289)
_cut2	0.547***	0.122*	-0.332
	(0.163)	(0.073)	(0.354)
N	217376	1230733	185516
Log-likelihood	-222682	-1154455	-138390

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Standard Errors are robust with respect to correlations within age-education cells. Abbreviations, see above section C.1.

Table C.18: Decile transitions for unemployed

Variable	Education category 1	Education category 2	Education category 3
28-30 years	-0.038**	-0.081***	0.292***
	(0.015)	(0.019)	(0.024)
31-33 years	-0.003	-0.162***	0.351***
	(0.023)	(0.036)	(0.040)
34-36 years	-0.182***	-0.230***	0.080
	(0.037)	(0.051)	(0.077)
37-39 years	-0.115***	-0.230***	-0.113***
	(0.040)	(0.055)	(0.041)
40-42 years	-0.145***	-0.287***	-0.092***
	(0.049)	(0.064)	(0.025)
43-45 years	-0.120***	-0.375***	-0.137***
	(0.044)	(0.074)	(0.050)
46-48 years	-0.133***	-0.369***	-0.236***
	(0.045)	(0.080)	(0.038)
49-51 years	-0.147***	-0.429***	-0.129***
	(0.052)	(0.084)	(0.037)
52-54 years	-0.207***	-0.328***	-0.207***
	(0.060)	(0.088)	(0.038)
Interquantile range/1000	-12.647	-0.889*	-1.730
	(13.120)	(0.481)	(1.433)
BR-E/1000	12.969	1.558	9.339
	(6.691)	(1.132)	(10.853)
_cut1	-0.843***	-0.774***	-0.608***
	(0.301)	(0.099)	(0.083)
_cut2	0.106	0.212***	0.545***
	(0.289)	(0.051)	(0.067)
N	1933	11964	1434
Log-likelihood	-2032	-12171	-1496

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Standard Errors are robust with respect to correlations within age-education cells. Abbreviations, see above section C.1.

D Appendix for Chapter 4

Definition of Variables used in Empirical Analysis

1. jdr refers to the job destruction rate and has three different versions:

> $jdr1$ (E–BR) is the rate of persons that are employed (E) in one year and who receive benefits (BR) in the next year.
>
> $jdr2$ (E–BR|OOS) is the rate of individuals who are employed in the first year and receive benefits or are out of sample (OOS, conditional on returning) in the following year.
>
> $jdr3$ (E–NoE) includes in the second year also individuals that do not return to the labor market.

2. jfr refers to the job finding rate and has two different versions:

> $jfr1$ (BR–E) is the rate of individuals that receive benefits in one year and who are employed in the next year.
>
> $jfr2$ (BR|OOS–E) comprises both benefit recipients and individuals that are temporarily not in the dataset (i.e. conditional on returning) in the first year.

3. jcr (E–OE) is the share of individuals that has changed jobs between two consecutive years.

4. When rates are used as left hand side variable in regressions, they are transformed as follows

$$tr = log(rate/(1 - rate))$$

to insure that the variable is unbounded.

5. The wage dispersion measure iqr is the difference between the log of the eighth decile and the second decile. For the purpose of the regression, on the left hand side, we take the log of the difference, i.e.

$$liqr = log(iqr),$$

to ensure that the variable is unbounded.

6. The unemployment rate u in the narrow definition is defined as

$$u = \frac{BR}{E + BR + OOS} ,$$

and, in the broad definition, $\tilde{u}$ is given by

$$\tilde{u} = \frac{BR + OOS}{E + BR + OOS} \ .$$

As a left hand side variable, we use the transformation $u = log(u/(1-u))$.

7. The narrow frictions indicator is calculated as

$$\eta = \frac{jdr1}{jdr1 + jcr} \ ,$$

while the broad definition is given by

$$\tilde{\eta} = \frac{jdr3}{jdr3 + jcr} \ .$$

Tables

Table D.1: Changes in the relative position of the wage distribution

Variable	Coefficient	(Std. Err.)
28-30 years	-0.1492**	(0.036)
31-33 years	-0.2148**	(0.039)
34-36 years	-0.2663**	(0.039)
37-39 years	-0.3084**	(0.039)
40-42 years	-0.3877**	(0.041)
43-45 years	-0.4211**	(0.044)
46-48 years	-0.4530**	(0.049)
49-51 years	-0.4786**	(0.057)
52-54 years	-0.5242**	(0.054)
time	0.0040	(0.003)
Medium-skilled	0.2756**	(0.048)
High-skilled	0.2540**	(0.038)
Job change dummy	0.3388**	(0.010)
Job change x 28-30 years	0.0002	(0.027)
Job change x 31-33 years	-0.0335**	(0.016)
Job change x 34-36 years	-0.0507**	(0.011)
Job change x 37-39 years	-0.0819**	(0.014)
Job change x 40-42 years	-0.1344**	(0.012)
Job change x 43-45 years	-0.1014**	(0.019)
Job change x 46-48 years	-0.1252**	(0.015)
Job change x 49-51 years	-0.1140**	(0.015)
Job change x 52-54 years	-0.1277**	(0.02)
iqr/1000	-0.4190	(1.127)
E-E/10000	-0.7428**	(0.154)
_cut1	6.8558	(5.552)
_cut2	8.4212	(5.554)

N	991041
Log-likelihood	-966348.106
$\chi^2_{(24)}$	25642.882

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Standard errors are robust with respect to correlations within groups (panel adjusted). Abbreviations, see appendix D.

E Appendix for Chapter 5

E.1 Proof of proposition 1

Sampling one firm at random is a random draw (w_1, w_2) from the wage offer distribution H, and $H(w_1, w_2)$ is the probability that the wages w_1 and w_2 are below these specific values (More precisely that the random variables $W_1 <= w_1$ and $W_2 <= w_2$). Sampling one worker from each skill group at random, instead implies two random draws from the two marginal distributions of paid wages $G_1(w_1)$ and $G_2(w_2)$. If an individual samples a firm and decides whether to accept the wage offer (w_1, w_2) he or she only cares about one of these wages, implying that the decision is based upon the marginal.

The marginal distributions $H_1(w_1), L_1(w_1)$ are given by integrating out the other wage variable:

$$H_1(w_1) = \int_0^{w_1} h_1(w_1)dw_1 = \int_0^{w_1} \left[\int_0^{\infty} h(w_1, w_2)dw_2\right] dw_1 = \int_0^{\infty} h_2(w_2)H_{w_1|w_2}(w_1|w_2)dw_2$$

$$\frac{L_1(w_1)}{(N_1 - U_1)} = G_1(w_1) = \int_0^{w_1} \int_0^{\infty} g(w_1, w_2)dw_2 dw_1$$

The interpretation of the joint wage density $g(w_1, w_2)$ is simply the probability of drawing one worker of each skill group at random, i.e. the product of the two marginals $g(w_1, w_2) = g_1(w_1)g_2(w_2)$. The marginal distributions of paid wages $G_1(w_1), G_2(w_2)$ themselves follow from $H_1(w_1), H_2(w_2)$ and from the dynamics of employment following from the individual efforts to look for a higher paying jobs (from the marginal wage offer distribution) and from job destruction (see equation 5.3).

Concerning the strategies of the firms, there are three possibilities:

- Deterministic strategy: Fixing a wage for skill group i determines the optimal wage for skill group $j \neq i$. Then, sampling a firm at random yields a random draw (w_1, w_2) and $H(w_1, w_2) = H_1(w_1) = H_2(w_2)$. (analogous to Holzner and Launov (2005))

- Independent strategy: Fixing a wage for skill group i does not influence the optimal wage for skill group $j \neq i$. Then, sampling a firm at random yields a random draw (w_1, w_2) and $H(w_1, w_2) = H_1(w_1)H_2(w_2)$.

- Mixed strategy: Conditional on paying a wage w_1 for skill group 1 there exists a wage distribution for skill group 2. This distribution however is different from the marginals. Then, sampling a firm at random yields a random draw (w_1, w_2) and $H(w_1, w_2) \neq H_1(w_1)H_2(w_2)$.

In the paper, we argue that it is likely that we obtain a deterministic strategy.

E.2 Solution strategies

One solution possibility is to assume that the wage for one skill group is fixed exogenously. In this case, individuals of this skill group evenly distribute across firms. For the other skill group, we can then apply the results of Ridder and Van den Berg (1997). That is, for some parameter constellations we obtain BM-type solutions, for some we obtain a wage distribution with mass point and for some we obtain only a mass point.

Another solution possibility is to assume that the labor market for one of the skill groups (for example of the high-skilled, (i.e. $i = 2$) is competitively organized, meaning marginal productivity pay. Assume that $\alpha_1, \alpha_2 < 1$. Now, assume that we start from a BM-type solution for the non-competitive skill group ($i = 1$). This can only be an equilibrium, when labor of skill group 2 distributes over firms in a way that exactly offsets the differences in marginal productivity resulting from the different sizes in skill group 1. More formally it must hold that

$$\frac{\partial y}{\partial l_2} = \alpha_2 A l_1^{\alpha_1} l_2^{\alpha_2 - 1} = \alpha_2 A \left(\frac{(N_1 - U_1)\delta_1(\lambda_{1,L} + \delta_1)}{(\delta_1 + \lambda_{1,L}(1 - H_1(w_1)))^2} \right)^{\alpha_1} l_2^{\alpha_2 - 1} = w_2 \tag{E.1}$$

is identical for every paid wage w_1 and the according employment of skill group 2. The fact that firms make identical profits implies an equilibrium.[1]

E.3 Solving the differential equation

Taking the homogeneous part of the differential equation (equation 5.11), we write the equation as:

$$\frac{h_1(w_1)}{H_1(w_1)} = -\frac{1}{2\left(\alpha_1 A(\lambda_{1,L} + \delta_1)^{\alpha_1 - 1}(N_1 - U_1)^{\alpha_1 - 1}(\lambda_{2,L} + \delta_2)^{1-\alpha_1}(N_2 - U_2)^{1-\alpha_1} - w_1\right)} \tag{E.2}$$

[1] It is not clear how this equilibrium would arise, because all firms pay identical wages and therefore the distribution of employment over firms is arbitrary. But there is no reason to deviate once this equilibrium is achieved. The above equation follows from the FOC of the profit function with respect to l_2.

Then integrating both sides and exponentiating yields

$$H_1(w_1) = A_2 \sqrt[2]{(\alpha_1 A(\lambda_{1,L} + \delta_1)^{\alpha_1 - 1}(N_1 - U_1)^{\alpha_1 - 1}(\lambda_{2,L} + \delta_2)^{1-\alpha_1}(N_2 - U_2)^{1-\alpha_1} - w_1)} \tag{E.3}$$

where A_2 is an integration constant to be determined by an initial condition.

A particular solution is given, when setting $h_1(w_1) = 0$ in (5.11), $H_1(w_1) = \frac{\delta_1 + \lambda_{1,L}}{\lambda_{1,L}}$ yielding the following:

$$H_1(w_1) = A_2 \sqrt[2]{(\alpha_1 A(\lambda_{1,L} + \delta_1)^{\alpha_1 - 1}(N_1 - U_1)^{\alpha_1 - 1}(\lambda_{2,L} + \delta_2)^{1-\alpha_1}(N_2 - U_2)^{1-\alpha_1} - w_1)} + \frac{\delta_1 + \lambda_{1,L}}{\lambda_{1,L}}$$

Using that $H_1(w_1^R) = 0$ finally helps determining the integration constant:

$$A_2 = -\frac{\delta_1 + \lambda_{1,L}}{\lambda_{1,L}} \frac{1}{\sqrt[2]{(\alpha_1 A(\lambda_{1,L} + \delta_1)^{\alpha_1 - 1}(N_1 - U_1)^{\alpha_1 - 1}(\lambda_{2,L} + \delta_2)^{1-\alpha_1}(N_2 - U_2)^{1-\alpha_1} - w_1^R)}} \tag{E.4}$$

Thus, the solution for the wage distribution of skill group 1 becomes:

$$H_1(w_1) = \frac{\delta_1 + \lambda_{1,L}}{\lambda_{1,L}} \left(1 - \sqrt[2]{\frac{(\alpha_1 A(\lambda_{1,L} + \delta_1)^{\alpha_1 - 1}(N_1 - U_1)^{\alpha_1 - 1}(\lambda_{2,L} + \delta_2)^{1-\alpha_1}(N_2 - U_2)^{1-\alpha_1} - w_1)}{(\alpha_1 A(\lambda_{1,L} + \delta_1)^{\alpha_1 - 1}(N_1 - U_1)^{\alpha_1 - 1}(\lambda_{2,L} + \delta_2)^{1-\alpha_1}(N_2 - U_2)^{1-\alpha_1} - w_1^R)}}\right)$$

E.4 Simulation parameters

In magnitude the friction parameter (δ, λ) we choose are comparable with the estimation results of equilibrium search models for the Dutch and for the German labor market (see Van den Berg and Ridder (1998), Launov and Wolf (2005)).

Table E.1: Simulation parameters

Parameter	Low frictions	High frictions
δ_1	0.004	0.008
λ_1	0.04	0.02
$\lambda_{1,L}$	0.03	0.015
N_1	1	3
α_1	0.6	0.3
δ_2	0.008	0.016
λ_2	0.12	0.08
$\lambda_{2,L}$	0.06	0.03
N_2	1	1
α_2	0.4	0.7
A	1	1
r	0.02	0.04
z_1	0.1	0.03
z_2	0.1	0.2

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