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Labor Market Institutions and the Cost of Recessions

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Abstract

This paper studies the effect of two labor market institutions, unemployment insurance (UI) and job search assistance (JSA), on the output cost and welfare cost of recessions. The paper develops a tractable incomplete-market model with search unemployment, skill depreciation during unemployment, and idiosyncratic as well as aggregate labor market risk. The theoretical analysis shows that an increase in JSA and a reduction in UI reduce the output cost of recessions by making the labor market more fluid along the job finding margin and thus making the economy more resilient to macroeconomic shocks. In contrast, the effect of JSA and UI on the welfare cost of recessions is in general ambiguous. The paper also provides a quantitative application to the German labor market reforms of 2003-2005, the so-called Hartz reforms, which improved JSA (Hartz III reform) and reduced UI (Hartz IV reform). According to the baseline calibration, the two labor market reforms led to a substantial reduction in the output cost of recessions and a more moderate reduction in the welfare cost of recessions in Germany.

JEL-Codes: E210, E240, D520, J240.

Keywords: labor market institutions, cost of recessions, German labor market reform.

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1. Introduction

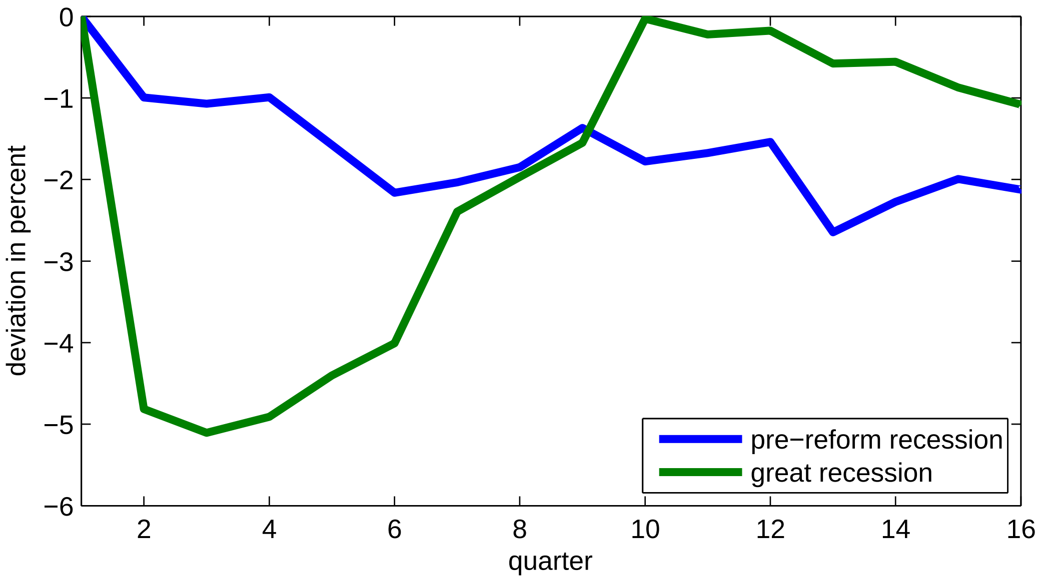
The Great Recession has generated an intense debate about the economic and social cost of recessions. Recent empirical contributions find that the output costs of recessions in the US and other advanced economies are large (Ball, 2014, Blanchard, Cerutti, and Summers, 2015, Hall, 2014, IMF, 2015). Using a model-based approach, Glover, Heathcoate, Krueger, and Rios-Rull (2014) and Krueger, Mitman, and Perri (2016) argue that the welfare costs of the Great Recession in the US have been substantial. In this paper, we take the next step and analyze the economic determinants of the output cost and welfare cost of recessions. Specifically, we analyze to what extent two labor market institutions, unemployment insurance (UI) and job search assistance (JSA), affect the output cost and welfare cost of recessions by changing the fluidity of the labor market.[1]

Our analysis is motivated by Figure 1, which depicts data that compare the output path during a typical recession in Germany before the labor market reforms of 2003-2005 (Hartz reforms) with the output path during the Great Recession in 2008/2009. Figure 1 shows that the two output paths differ significantly along two dimensions. First, the initial drop in output during the Great Recession has been much larger than the initial output loss during previous (pre-reform) recessions. Second, the economic recovery following the Great Recession has been very swift whereas the economic rebound after the typical pre-reform recession has been meager at best – the "sick man of Europe" has become the "German labor market miracle". In this paper, we argue that the German labor market reforms of 2003-2005 have contributed to the swift recovery of the German economy following the Great Recession.[2] Specifically, we argue that the Hartz III reform, which improved JSA, and the Hartz IV reform, which reduced UI, have made the German labor market more fluid and

[1]Davis and Haltiwanger (2014) define labor market fluidity as the intensity of job reallocation. In this paper, we focus on one aspect of labor market fluidity, namely the job finding rate of unemployed workers. We use the term "labor market fluidity" instead of "labor market flexibility" since the latter is often used to denote the responsiveness of wages to macroeconomic shocks.

[2]The quantitative analysis shows that the calibrated model explains part of the difference in the speed of recovery depicted in Figure 1, but does not fully account for the difference. In this sense our work is consistent with the view that economic factors beyond the German labor market reforms of 2003-2005 have contributed to the swift recovery of the German economy following the Great Recessions. See Burda and Hunt (2011) and Krause and Uhlig (2012) for a discussion of the various economic factors contributing to the good performance of the German labor market during the Great Recession.

Figure 1: Output during Pre-Reform Recessions and Great Recession



Notes: Real GDP relative to its trend during the typical pre-reform recession (blue line) and the Great Recession (green line). Real GDP in the typical pre-reform recession is the average over the three recessions starting in 1981Q2, 1992Q4, and 1995Q4. Trend output is computed as the sample mean over the sample period 1980 – 2000, respectively 2005 – 2015. Similar results obtain if trend output is computed using the method proposed by Blanchard, Cerutti, and Summers (2015).

have therefore made the German economy more resilient to adverse macroeconomic shocks. We then ask to what extent this increase in labor market fluidity has changed the cost of recessions in Germany.

Our analysis proceeds in three steps. First, we develop a tractable incomplete-market model with search unemployment and derive a convenient characterization of recursive equilibria. In the model, unemployed workers choose the intensity of job search and unemployment leaves permanent scars. Further, job destruction rates and job search efficiency vary exogenously with business cycle conditions and the government provides JSA and UI at levels that are independent of business cycle conditions. Recessions are costly since they i) generate temporary and permanent output losses and ii) have additional welfare consequences due to distributional effects and costly search effort. Second, we use a simplified version of the model to provide a theoretical analysis of the effect of UI and JSA on the cost of recessions. Third, we calibrate the model economy to German data and analyze the quantitative effects of the Hartz III reform (improvement in JSA) and Hartz IV reform (reduction in UI) on the output cost and welfare cost of recessions. Finally, we conduct a comprehensive robustness analysis in which we also consider various extensions of the baseline model.[3]

Our theoretical analysis shows that an improvement in JSA or a reduction in UI lead to a decrease in the output cost of recessions, where we define the output cost of recessions as the present value output gain from eliminating recessions. The economic intuition for this result is simple. An increase in JSA or a reduction in UI increases job finding rates at all stages of the business cycle, that is, these changes in labor market institutions make the labor market more fluid. As a consequence, the economy becomes more resilient to adverse macroeconomic shocks. Specifically, the temporary output losses of recessions are diminished since higher job finding rates reduce the hike of the unemployment rate associated with recessions. In addition, the permanent output losses associated with recessions become smaller since higher job finding rates reduce the length of unemployment spells and therefore reduce the scarring effect of recessions. Thus, an improvement in JSA or a reduction in UI reduce the output costs of recessions.

Our theoretical analysis also shows that the effect of JSA or UI on the welfare cost of recessions is in general ambiguous even though their effect on the output cost of recessions is unambiguous.[4] This lack of simple relationship between labor market institutions and the welfare cost of recessions is a direct implication of a representation result we derive in this paper, which shows that the welfare cost of recessions is the sum of three components: the output cost of recessions, the risk cost of recessions, and the effort cost of recessions. The risk cost of recessions is in general positive (recessions are times of high levels of risk), but the effort cost of recessions may be positive or negative depending on the change of search effort during recessions. More importantly, the effect of UI on the risk cost of recessions is ambiguous and both JSA and UI have ambiguous effects on the effort cost of recessions.

[3]Specifically, in this paper we focus on the household side and analyze how recessions affect job search and human capital of risk-averse workers (labor supply). In our robustness analysis, we consider, among others, an extension of the baseline model with vacancy posting by firms along the lines of the standard Diamond-Mortensen-Pissarides model (labor demand).

[4]We define the welfare cost of recessions as the welfare gain from eliminating recessions. This welfare cost of recessions is related to the welfare cost of business cycles as introduced by Lucas (1987, 2003), but not the same. See Section 4 and the Appendix for a detailed comparison of these two concepts.

Thus, these changes in labor market institutions have in general an ambiguous effect on the welfare cost of recessions even though their effect on the output cost of recessions is unambiguous.

In a third and final step, we use a calibrated version of the model to provide a quantitative analysis of the effect of JSA and UI on the output cost of recessions and the welfare cost of recessions. Specifically, we study the German labor market reforms of 2003-2005, the so-called Hartz reforms, which turned "the sick man of Europe" into a "labor market miracle". Two essential ingredients of these reforms were i) a complete overhaul of the Public Employment Agency dramatically improving the quality of JSA (Hartz III reform) and ii) a substantial reduction in UI for the long-term unemployed (Hartz IV reform). As argued above, economic theory suggests that both an improvement in JSA and a reduction in UI will lead to a reduction in the output cost of recessions by increasing job finding rates. There is strong empirical evidence that, in line with the theoretical prediction, the Hartz III reform and the Hartz IV reform led to a substantial increase in the non-cyclical component of the job finding rate of unemployed workers. This empirical evidence in conjunction with the scale of the German labor market reforms of 2003-2005 make them an ideal candidate for a quantitative assessment of the theory we outline here.[5]

Two main results emerge from our quantitative analysis. First, both the Hartz III reform (improvement in JSA) and the Hartz IV reform (reduction in UI) have led to a substantial improvement in labor market fluidity and a corresponding reduction in the output cost of recessions in Germany. Specifically, in line with the empirical evidence, the two reforms taken together have increased job finding rates by more than one-third at all stages of the business cycle, and this improvement in labor market fluidity has reduced the output cost of recessions by 25.0 percent from 2.014 percent of lifetime consumption to 1.510 percent of lifetime consumption. Further, a substantial part of the reform-induced reduction in the output cost of recessions is driven by a reduction in the permanent output losses associated with

[5]In the US, labor market policy has often been adjusted in response to business cycle conditions, the recent extension of unemployment benefit eligibility from 26 weeks to up to 99 weeks being a case in point. However, after WWII the US has not witnessed any permanent changes in labor market policy comparable to the Hartz reforms. Of course, most European countries introduced some type of labor market reform in the last 20 years, but they were either much more limited in scope than the Hartz reforms or the implementation was much more gradual.

recessions. In other words, skill losses during unemployment and the associated hysteresis effect are an important driver of the output cost of recessions, and the two reforms reduced this cost by shortening the length of unemployment spells.

As a second result, we find that both the Hartz III reform and the Hartz IV reform have reduced the welfare cost of recessions in Germany, but we also find that this cost reduction is significantly weaker than the corresponding reduction in the output cost of recessions. Specifically, the two reforms taken together have reduced the output cost of recessions by roughly 25.0 percent, but their effect on the welfare cost of recessions only amounts to a reduction by 9.9 percent. This difference arises because one channel through which the two reforms reduce the output cost of recessions is by increasing search effort during recessions, which adversely affects welfare and therefore increases the welfare cost of recessions. Thus, our assessment of the impact of the two reforms on the cost of recessions heavily depends on the cost concept we employ. If we take an output-based approach, the reform-induced increase in job finding rates implies large reductions in the cost of recessions. In contrast, once we take into account the utility consequences of reform-induced changes in search effort, we find a significantly smaller reform effect on the cost of recessions.[6]

We conduct an extensive robustness analysis in which we consider both changes in our calibration targets and changes in model specification. Our robustness analysis shows that our main quantitative results are robust to a wide range of parameter values and model specifications. However, we also find that the strength of the reform effect is sensitive to changes along three model dimensions. First, the effect of the two reforms on the cost of recessions becomes weaker if the elasticity of job search with respect to UI lies at the lower end of the spectrum of empirical estimates. Second, an extension with vacancy posting by firms along the lines of the Diamond-Mortensen-Pissarides model implies larger effects of UI (Hartz IV reform) on the cost of recessions than the baseline model and smaller effects of JSA (Hartz III reform). Finally, if a reduction in UI causes substantial productivity losses due to a worsening of match quality, an economic channel that has been discussed in previous work, the effect of the Hartz IV reform on the cost of recessions becomes weaker. Overall, we

[6]The two reforms also have a non-negligible impact on the risk cost of recessions. However, this risk-channel is dominated by the change in the effort cost of recessions – see the discussion in Section 6 for details.

conclude that the available evidence suggests that the German labor market reforms led to a substantial reduction in the output cost of recessions and a significantly weaker reduction in the welfare cost of recessions. However, more empirical research on the relevant elasticities and matching technologies is needed to derive firm conclusions regarding the exact size of the cost reductions.

In summary, this paper provides a theoretical and quantitative analysis of the effect of JSA and UI on the output cost and welfare cost of recessions. In addition to these substantive contributions, this paper also makes a methodological contribution in the sense that it develops a tractable incomplete-market model with search unemployment and provides a convenient characterization of recursive equilibria. Specifically, we show that if the cost of financial intermediation (the interest rate spread) is large enough, then there are recursive equilibria with no asset trade (no borrowing and lending) and an aggregate state variable that consists of the vector of unemployment rates and human capital shares over employment states – a four-dimensional object in our model with short-term unemployment and long-term unemployment. Thus, neither the infinite-dimensional distribution of financial asset holdings nor the infinite-dimensional distribution of human capital are relevant state variables, and in this sense the model is highly tractable. The tractability of the model is indispensable for providing analytical results and is also useful for our quantitative analysis since we do not have to rely on approximation methods.

Literature. This paper is related to several strands of the literature. In terms of economic motivation, our paper is closely related to the recent empirical literature that has computed output losses associated with recessions and investigated the effect of recessions on potential output. For example, Atkinson, Luttrell, and Rosenblum (2013) and Hall (2014) analyze the output losses associated with the Great Recessions in the US, Ball (2014) and IMF (2015) study to what extent the Great Recession has caused long-run damage in advanced economies, and Blanchard, Cerutti, and Summers (2015) compute losses in potential output for a large number of recessions occuring at different times in different countries. Cerra and Saxena (2008) and Reinhart and Rogoff (2014) study the output dynamics following recessions that are accompanied by financial crises. In line with our work, this literature has found evidence that many recessions have long-lasting output effects (hysteresis). Our approach differs in two important ways from the approach taken in this literature. First, we use a model-based approach, that is, we provide a structural interpretation of the empirical results and also conduct a welfare analysis. Second, we go beyond this literature and discuss some fundamental determinants (i.e. policy choices) of the cost of recessions. Specifically, we show that labor market reform can reduce the cost of recessions and that the existence of hysteresis effects can therefore increase the need for labor market reform.[7]

In terms of method, our paper is closely related to the large literature on the welfare cost of business cycles following the seminal contribution of Lucas (1987, 2003). This literature has extensively studied to what extent the introduction of uninsurable idiosyncratic risk increases the welfare cost of business cycles. For example, Atkeson and Phelan (1994), Imrohoroglu (1989), and Krusell and Smith (1999) analyze cyclical fluctuations in unemployment rates and unemployment duration and Gomes, Greenwood, Rebelo (2001) introduce endogenous search effort. Krebs (2003) and Storesletten, Telmer, and Yaron (2001) study cyclical variations in labor income risk more generally and Beaudry and Pages (2001) and Krebs (2007) focus on the long-term earnings losses associated with job displacement. The literature has also analyzed models in which aggregate fluctuations affect the level of output or the growth rate of output (Barlevy, 2004, den Haan and Sedlacek, 2014) and the effect of more general preference assumptions (Alvarez and Jermann, 2004, and Tallarini, 2000). Our paper differs from this literature by focusing on the cost of recessions as opposed to the cost of business cycles, a shift in focus that is motivated by the recent policy debate and empirical work on the cost of the Great Recession. We share this shift in focus with the recent contributions that assess the welfare cost of the Great Recession in the US (Glover, Heathcoate, Krueger, and Rios-Rull, 2014, and Krueger, Mitman, and Perri, 2016). However, we go beyond this work and study how labor market institutions affect the cost of recessions, and provide an application to one of the most significant labor market reforms of the last few decades, namely the German labor market reforms of 2003-2005.

Our paper is also related to the vast literature on labor market institutions and unemployment. This literature has studied extensively the effect of various labor market institutions

[7]Blanchard, Cerutti, and Summers (2015) and Wolf (2015) have argued that the presence of hysteresis effects implies that macroeconomic stabilization policy should be more aggressive. See also the related policy discussion on "secular stagnation" (VoxEU, 2014). Clearly, our results do not contradict this conclusion, but they show that there are alternative policy instruments that can effectively combat the cost of recessions due to hysteresis effects.

on non-cyclical unemployment, but much less work has been done on the interaction between labor market institutions and macro shocks. Blanchard and Wolfers (2000) provide a comprehensive empirical study of the issue and Ljungqvist and Sargent (1998) use a search model to argue that the rise in European unemployment observed in the 1980s and 1990s can be explained by the interaction of a generous social insurance system with a rise in labor market turbulence. More recently, Mitman and Rabinovich (2014) use a search and matching model to study how counter-cyclical unemployment benefit extensions can explain jobless recoveries in the US, and Davis and Haltiwanger (2014) argue that past policy choices have diminished the fluidity of the US labor market and contributed to the slow recovery following the Great Recession. Further, there is recent work analyzing optimal UI over the business cycle (Jung and Kuester, 2014, Mitman and Rabinovich, 2014, and Landais, Michaillat, and Saez, 2015) as well as recent work on New-Keynesian models with incomplete markets and frictional labor markets.[8] These contributions have provided important insights into a number of issues. However, the previous literature has not studied the effect of labor market institutions on the output cost and welfare cost of recessions, which is the focus of the current paper.

Finally, our paper is related to the economic literature on the German labor market reforms of 2003-2005 (the Hartz Reforms). There is a large empirical literature on this issue, which is surveyed in Sections 2 and the Appendix. Structural studies of the Hartz reforms based on macroeconomic search (and matching) models are surprisingly rare. Three notable exceptions are Launov and Waelde (2013), Krause and Uhlig (2012), and Krebs and Scheffel (2013). Most closely related to the current paper is the study by Krebs and Scheffel (2013), who provide a welfare analysis of the Hartz reforms. However, Krebs and Scheffel (2013) do not consider cyclical variations in labor market variables and therefore cannot analyze the cost of recessions.

2. German Labor Market Reforms 2003-2005

In Section 2.1 we provide a brief overview of the German labor market reforms of 2003-2005, the so-called Hartz reforms. In Sections 2.2 we discuss the Hartz III reform (improvement in JSA) and survey the empirical micro literature, which finds that this reform has increased

[8] See, for example, Christiano, Trabandt, and Walentin (2012), Gornemann, Kuester, and Nakajima (2016), and denHaan, Rendahl, and Riegler (2015).

job finding rates through an improvement in matching efficiency. In Section 2.3 we discuss the Hartz IV reform (reduction in UI) and survey the empirical micro literature that has estimated the effect of UI on job finding rates (search effort). In Section 2.4 we present the aggregate time series evidence on job finding rates, unemployment rates, and the Beveridge curve, and argue that these data provide further evidence in support of the view that the Hartz III reform and the Hartz IV reform have increased the fluidity of the German labor market by increasing matching efficiency and search effort.

2.1 Historical Background

At the beginning of the 2000s, the dismal performance of the German labor market and a tightening of the social security budget convinced the German government that a drastic policy reversal had to take place. As a consequence, the German government enacted in 2003-2005 a number of far-reaching labor market reforms, the so-called Hartz reforms. These reforms consisted of four laws that were implemented in three steps in January 2003 (Hartz I+II), January 2004 (Hartz III), and January 2005 (Hartz IV). The main objective of the Hartz reforms was simple yet ambitious: improve the process of moving workers from unemployment to employment.[9] To achieve their objective, the reforms used a multi-layered strategy that had three core elements: i) increase the matching efficiency by providing job search assistance, ii) increase labor supply by activating the unemployed, and iii) increase labor demand by deregulating the market for temporary work and providing employment subsidies. At the risk of over-simplification, we can say that the Hartz III was mainly about the first point, the Hartz IV reform was concerned with the second point, and the Hartz I and Hartz II reforms were mainly dealing with the last point. In this paper, we confine attention to the Hartz III and Hartz IV reforms, to which we turn next.

2.2 Hartz III Reform (Improvement in Job Search Assistance)

On January 1, 2004, Hartz III was enacted with the goal to improve the efficiency of the

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[9]The core elements of the reform were based on recommendation made by an expert commission that was headed by Peter Hartz, the Chief Human Resources Officer of Volkswagen at that time. In the preamble of the commission's report (Hartz et al 2002) this objective in combination with the idea of "challenge and promote" ("Fordern und Foerdern") are singled out as the most important principles guiding the reform effort. Jacobi and Kluve (2006) provide a detailed account of the Hartz reforms and Wunsch (2005) provides a comprehensive survey of German labor market policy before the reform. See also Krebs and Scheffel (2013).

job placement services for the unemployed. To this end, the Public Employment Agency was restructured and transformed from a strongly centralized and bureaucratic institution with little quality control into a decentralized, customer-oriented organization with a high degree of responsibility and accountability of local employment offices (called job centers after the reform). Further, in the wake of the reform many services were streamlined and heavy emphasis was placed on job search assistance to improve the process of matching unemployed workers with vacant jobs. In addition, the reform broke the de facto monopoly of the Public Employment Agency, which introduced competition in the market for job placement services. In particular, a voucher system was introduced providing individual job seekers with the opportunity to choose private placement agencies.[10]

In the Appendix we review the evidence regarding the effect of Hartz III on the efficiency of job search. The available evidence suggests that the restructuring of the Public Employment Agency (Hartz III) increased the quality of JSA leading to an increase in the efficiency parameter of the aggregate matching function by at least 5 percent and perhaps up to 10 percent (Fahr and Sunde, 2009, and Klinger and Rothe, 2012). Note that by estimating a matching function this literature controls for variations in vacancy rates and therefore controls for variations in this labor demand channel. The evidence also suggests that the introduction of vouchers for placement services improved the job finding rate of affected workers by about $10-30$ percent (Winterhager, Heinze, and Spermann, 2006). On average, 20 percent of unemployed workers receive a voucher (Pfeiffer and Winterhager, 2006), which translates into an increase in the unconditional job finding rate by $2-6$ percent for all unemployed workers. Thus, the available evidence suggests that Hartz III in conjunction with the introduction of the voucher system improved the quality of JSA substantially and led to an increase in search efficiency by at least $7-16$ percent. Based on this evidence, in our quantitative analysis we simulate the effect of the Hartz III reform as an increase in search efficiency by 8 percent – see Section 6 for details.

2.3 Hartz IV (Reduction in Unemployment Benefits)

The Hartz IV legislation was enacted in January 1, 2005, and constituted a radical overhaul of

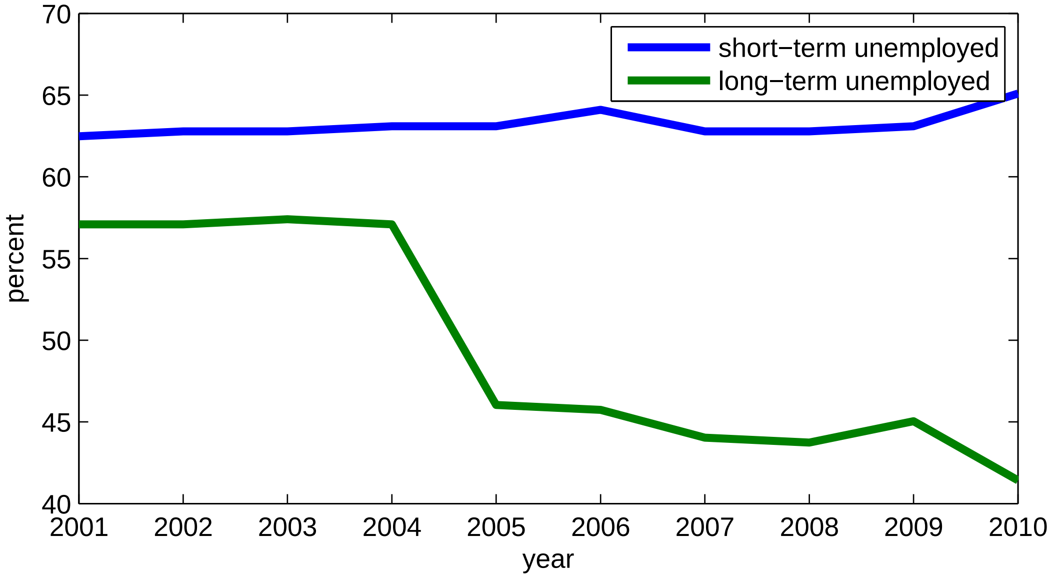
[10]The voucher system was already introduced in 2002 as part of the Job-AQTIV amendment, but the Hartz III reform allowed for a more wide-spread application of vouchers.

the German unemployment insurance system. The main objective of Hartz IV was to activate unemployed job seekers. Before the reform, the unemployment system was characterized by a very long period of Unemployment Benefit entitlement followed by a relatively generous and essentially unlimited, means-tested Social Welfare Program (consisting of a combination of Unemployment Assistance and/or Social Assistance). The Hartz IV reform resulted in a simple two-tier unemployment insurance system in which most unemployed workers with unemployment spells less than one year (short-term unemployed) receive unemployment benefits that are proportional to earnings at the last job (called Unemployment Benefit I) and most unemployed workers with an unemployment spell of more than one year (long-term unemployed) receive means-tested payments that heavily depend on household composition (called Unemployment Benefit II).[11]

The Hartz IV reform reduced unemployment payments for many households, but the extent of the reduction varies substantially across household groups and length of unemployment spell. One way to aggregate this heterogeneity is to use the OECD data on net replacement rates for different household groups and to compute an average net replacement rate as described in more detail in Krebs and Scheffel (2013). In Figure 2 we plot the resulting net replacement rate over the period 2000-2012. Clearly, Hartz IV had almost no effect on the net replacement rate of the short-term unemployed (unemployment spell less than one year), but a very large effect on the net replacement rate of the long-term unemployed (unemployment spell more than one year). Specifically, Hartz IV reduced the net replacement rate from 0.57 in the period 2000-2004 to 0.46 after the reform in 2005 – a reduction by 11 percentage points. Based on this evidence, in our quantitative analysis conducted in Section 6 we simulate the effects of Hartz IV assuming that it reduced the net replacement rate for the long-term unemployed by 11 percentage points and that it left the net replacement rate for the short-term unemployed unchanged.

[11]The Hartz IV reform also introduced new measures to activate the long-term unemployed/welfare recipients through monitoring, but given the theoretical structure of our model we cannot evaluate this part of the Hartz IV reform. Note also that the eligibility period for short-term unemployment benefits (Unemployment Benefit I) was reduced in February 2006, but this change was not officially a part of the Hartz-laws and had only a small effect on the average net replacement rate (see Krebs and Scheffel, 2013).

Figure 2: Average Net Replacement Rate 2001 – 2010



Notes: Own calculation based on OECD data. Net replacement rates conditional on family types are taken from the OECD Tax-Benefit Models and averages are computed using population weights taken from the OECD Family Database.

We note that a net replacement rate of 57 percent, the value for the long-term unemployed in Germany before the reform, is exceptionally high. In comparison, using comparable OECD data and methodology, we find a value of 27 percent in Spain and 38 percent in France for the long-term unemployed. Indeed, even after the reform, the net replacement rate for the long-term unemployed in Germany, which lies at 46 percent, is still higher than in Spain and France. In contrast, net replacement rates for short-term unemployed are very similar for all three countries: 68 percent for France, 66 percent for Spain, and 63 percent for Germany. Finally, using comparable OECD data and methodology, for the US we find a net replacement rate of 55 percent for the short-term unemployed and 14 percent of the long-term unemployed. Thus, compared to the US, the unemployment insurance and welfare system in post-reform Germany is still relatively generous.

In Section 5 we survey the empirical literature on the effect of unemployment benefits on job finding rates of unemployed workers. This literature has shown that the generosity of unemployment benefits is an important determinant of unemployment duration, and the results of this literature will be used to calibrate the model economy – see Section 5 for details. There is very little micro-econometric work evaluating the effect of the benefit reductions associated with the Hartz IV reform on job-finding rates of the unemployed. One reason for this lack of evidence is that the Hartz IV reform entailed a significant change in the official measurement of unemployment, which substantially changed the composition of the pool of unemployed. However, a recent paper by Engbom, Detragiache, and Raei (2015) provides a difference-in-difference analysis of the labor market effect of the Hartz reforms that takes into account these composition effects. They find that those unemployed workers who experienced the largest reform-induced reduction in unemployment benefits were also the workers whose job finding rates increased the most. Clearly, this empirical finding is in line with the view that the Hartz IV reform increased search incentives.[12]

2.4 Time Series Evidence

This paper emphasizes two channels through which the Hartz III reform and the Hartz IV reform improved the fluidity of the German labor market: improvements in matching efficiency and increases in search effort. The previous two sections argued that the empirical literature provides strong evidence in support of the view that these two reforms increased job finding rates by increasing matching efficiency and search effort. In this section, we argue that the aggregate time series evidence is also in line with this view.

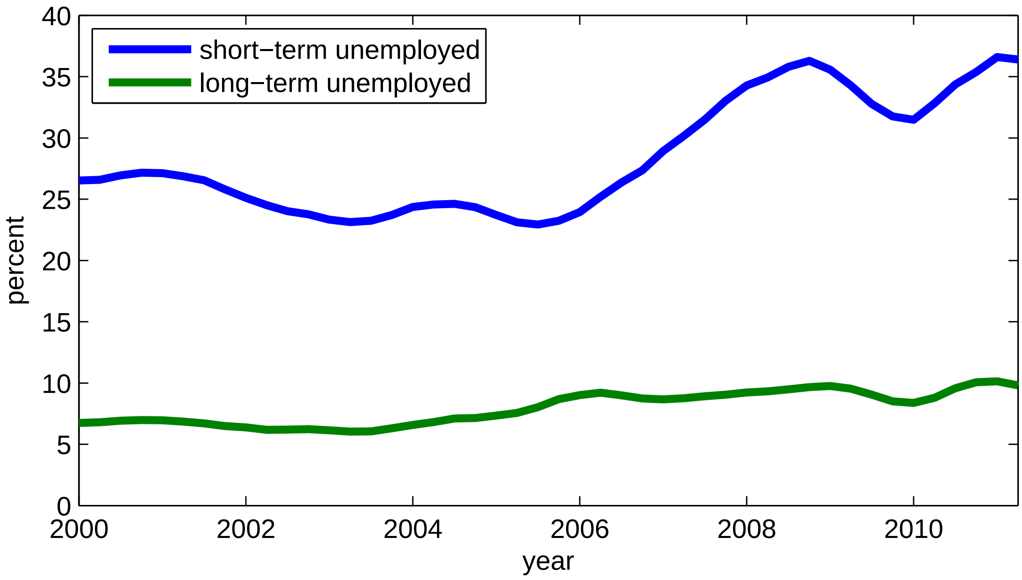
Figure 3 depicts the job finding rates for both short-term unemployed and long-term unemployed workers in the period 2000-2012. The figure shows that these job finding rates have been relatively stable before the implementation of the two reform packages and then began to rise steadily until the years 2007, at which stage they remained relatively stable at a significantly higher level.[13] For the long-term unemployed, the average job finding rate in the period 2000-2003 is 6.3 percent and the average job finding rate in the period 2007-2012 is 9.3 percent – an increase by almost 48 percent. For the short-term unemployed, the

[12]Engbom, Detragiache, and Raei (2015) also find that the Hartz reforms taken together (Hartz I-IV) led to a substantial reduction of re-employment wages of unemployed workers, but their empirical approach does not differentiate among the various reform components (Hartz I, II, III, and IV). See also Krebs and Scheffel (2013) for a discussion of the effect of the Hartz reforms on wages.

[13]The fact that the cyclical component of the German job finding rate is relatively small has also been documented in Jung and Kuhn (2014) and will be further discussed in Section 5.

corresponding numbers are 24 and 37 percent – an increase by 54 percent. Thus, the time series evidence supports the main economic channel emphasized in this paper, namely that the Hartz III reform and the Hartz IV reform increased job finding rates thereby making the German labor market more fluid.

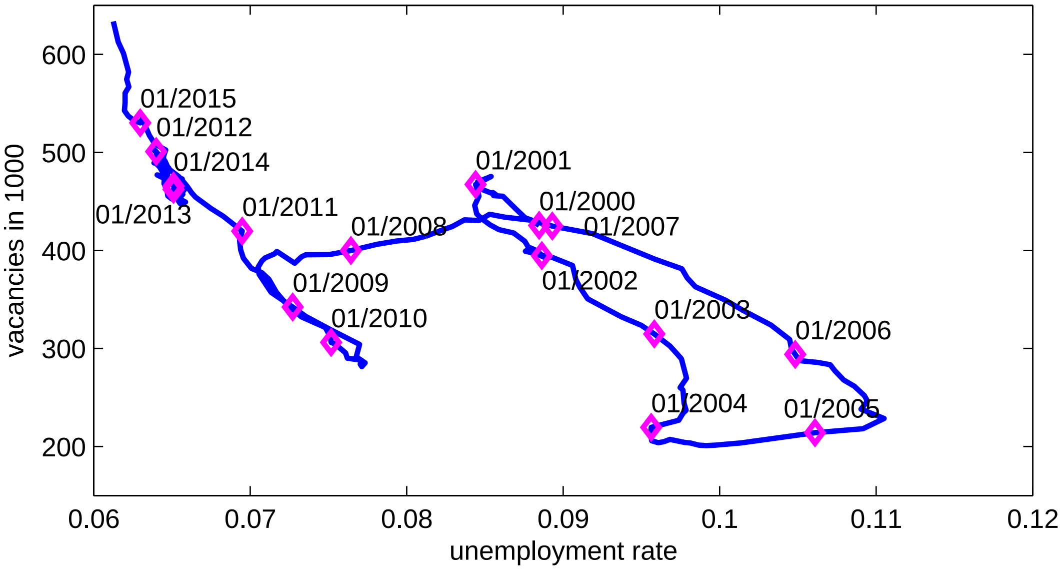
Figure 3: Quarterly Job Finding Rates by Duration of Unemployment Spell 2000 – 2011



Notes: Monthly job finding rates by duration of unemployment spell provided by the German Employment Agency. Data are seasonally adjusted and aggregated to quarterly frequency.

In principle, the increase in job finding rates depicted in Figure 3 can be caused by an increase in matching efficiency, an increase in search effort (labor supply) or an increase in vacancy posting (labor demand). To disentangle the first two channels from the vacancy channel, in Figure 4 we show the vacancy-unemployment relationship (Beveridge curve) for Germany in the period 2000 – 2015. Figure 4 shows that the German Beveridge curve experienced a substantial inward shift shortly after the implementation of the Hartz III and Hartz IV reforms, which is in line with our view that the two reforms led to an increase job finding rates by increasing matching efficiency and search effort. According to the quantitative analysis conducted in Section 6, the two reforms taken together account for most of the non-cyclical rise in job finding rates depicted in Figure 3 and two-thirds of the shift in the Beveridge curve depicted in Figure 4 – see Section 6 for details.

Figure 4: Beveridge Curve 2000 – 2015



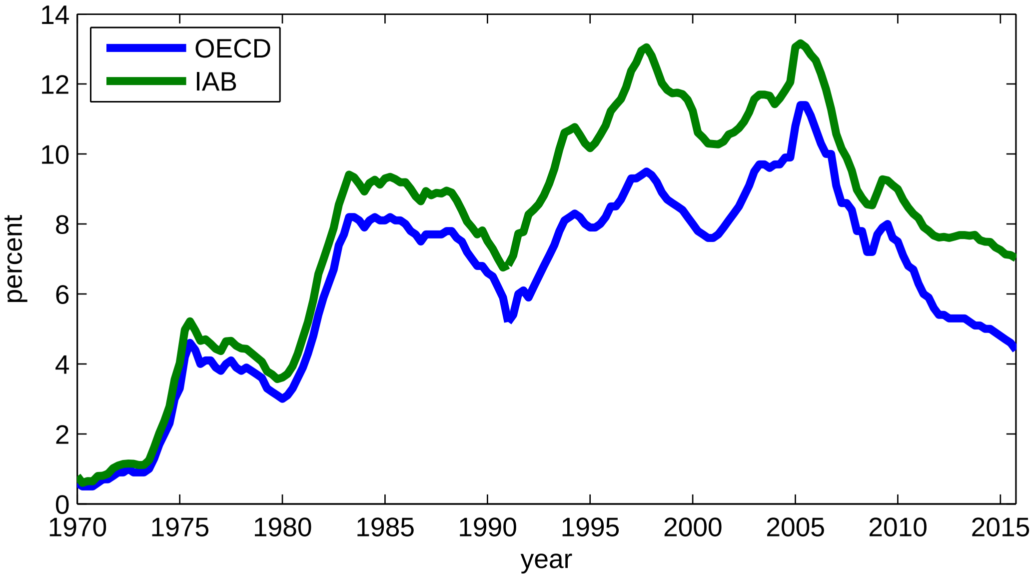
Notes: Vacancies and unemployment rates provided by the German Employment Agency. Data are seasonally adjusted.

Figure 5 shows the unemployment rate in Germany in the period 1970-2015 and lends additional support to the view that the German labor market reforms of 2003-2005 caused a break in the long-run trend. Specifically, the graph suggests that the unemployment rate has a strong cyclical component, but also a trend component that has been rising since the 1970s until the mid 2000s. This trend was then reversed in the mid 2000s, and the unemployment rate fell from its peak of almost 11 percent in 2005 to 7.5 percent in 2008, barely increased during the Great Recession, and then continued its downward trend reaching 4.4 percent at the end of 2015.[14] Figure 5 suggests that since 2005 the non-cyclical component of the German unemployment rate has declined by at least 3 percentage points and perhaps even 5 percentage points. Our quantitative analysis implies that the Hartz III reform and the

[14]The spike in the unemployment rate in 2005 is a purely statistical artifact. More precisely, the Hartz IV reform entailed a significant change in the official measurement of unemployment, which added more than half a million workers to the pool of unemployed between January 2005 and March 2005 (see Bundesagentur fuer Arbeit, 2005). Note that more than 80 percent of these added unemployed workers lacked the equivalent of a high school degree, which means that the quality of the pool of unemployed workers worsened. Thus, the quality-adjusted increase in job finding rates after the reforms is even larger than the increase depicted in Figure 3.

Hartz IV reform made a substantial contribution to this decline in structural unemployment – see Section 6 for details.

Figure 5: Unemployment Rate 1970 – 2015



Notes: The blue line shows the unemployment rate reported by the OECD and the green line shows the unemployment rate reported by the German Employment Agency (IAB).

3. Model

In this section, we develop the model and provide a convenient characterization of equilibrium. The model combines the tractable incomplete-market model of Constantinides and Duffie (1996) and Krebs (2007) with a model of search unemployment along the lines of Hansen and Imrohoroglu (1992) and Ljungqvist and Sargent (1998). The tractability of the model allows us to discuss the main economic issues as clearly as possible and avoids the use of approximation methods in our quantitative analysis. The baseline model rules out the possibility that aggregate labor market conditions (labor market tightness) affect individual job finding rates, that is, there are no search externalities in the baseline model and the micro elasticity of job search coincides with the macro elasticity of job search.[15]

[15]This follows the bulk of the literature on search unemployment (Acemoglu and Shimer, 2000, Alvarez

In Section 7 we discuss and analyze an extension of the model with a matching technology that allow for search externalities and endogenous vacancies along the lines of the standard Diamond-Mortenson-Pissarides framework.

As in Constantinides and Duffie (1996) and Krebs (2007), in equilibrium workers do not self-insure and the consumption response to income shocks is one-to-one (proposition 1). This model implication is supported by the data in the case of highly persistent or permanent income shocks, but is at odds with the data in the case of transitory income shocks (Blundell, Pistaferri, and Preston, 2008). Clearly, the income losses associated with unemployment spells have both a transitory and a permanent component, and in this sense the model is not consistent with one dimension of the data. However, for the particular issue addressed here, this feature of the model is unlikely to be a major drawback. Specifically, the extent to which workers self-insure against the transitory component of an unemployment (job displacement) shock can be measured by the initial consumption drop upon becoming unemployed. In our quantitative analysis, we calibrate the model economy so that this initial consumption drop matches the available empirical evidence and we further show in our robustness analysis that our main quantitative results do not depend on the size of this consumption drop.

There is a second dimension of the data that is not fully matched by the model: In the data, many households have positive net financial wealth, whereas in the model households hold zero assets in equilibrium. However, this gap between model and data is unlikely to be a major concern for the issue analyzed here. Specifically, about 40 percent of US households age $25-60$ have close to no or negative net wealth (Krueger, Mitman, and Perri, 2016). Taking into account the illiquidity of some assets, Kaplan and Violante (2014) estimate that up to 35 percent of all US households are hand-to-mouth consumers. In Germany, 28 percent of all adults have no or negative net wealth and 39 percent of all one-person households of age less than 60 have no or negative net wealth (Grabke and Westermeier, 2014). Further, in Germany 65 percent of all unemployed individuals and close to 100 percent of all long-term unemployed have no or negative net wealth (Grabke and Westermeier, 2014). Thus, for the group of households that is the focus of this study, namely the unemployed and those

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and Veracierto, 2001, Lentz, 2009, Ljungqvist and Sargent, 1998, Shimer and Werning, 2008).

employed workers who are most likely to become unemployed, the model implication with respect to financial asset holdings is broadly in line with the data.

3.1 Workers

Time is discrete and open ended. There is a unit mass of infinitely-lived workers. The employment status of a worker in period t is denoted by s_t and can take on three values, $s_t \in \{e, su, lu\}$, where e stands for employed, su for short-term unemployed, and lu for long-term unemployed. Employed individuals work a fixed and common number of hours in each period. In other words, there is no labor-leisure choice. Employed workers receive a before-tax wage wh, where h is the level of human capital of the individual worker and w is the common wage rate per unit of human capital. The assumption that all employed workers receive the same wage per unit of human capital rules out on-the-job search. Unemployed workers search for jobs and choose a search intensity l. In each period, an unemployed worker either receives a job offer (success), which promises per period wage payment wh for a worker with human capital h, or the worker does not receive an offer (no success) and remains unemployed. We confine attention to the case in which unemployed workers always accept job offers – below we provide conditions on fundamentals that ensure that this is indeed an equilibrium outcome.

The exogenous source of business cycle fluctuations is defined by a Markov process with state S and stationary transition probabilities, which we denote by $\pi(S'|S)$. For simplicity, we assume that there are only two aggregate states $S = R, N$, where $S = R$ denotes recession and $S = N$ normal times. Business cycle conditions S affect the labor market in two ways. First, employed workers can become unemployed with exogenous probability $\pi_{su|e}(S)$. We call the transition probability $\pi_{su|e}(S)$ the job destruction/loss rate. Note that the job destruction rate is independent of effort, that is, there is no moral hazard problem during employment.

The second way S affects the labor market is through its effect on the efficiency of job search. Specifically, the probability that the job search of an unemployed worker is successful (the job finding rate) depends on individual search effort l, a cycle-independent but type-dependent efficiency parameter x_s, with $s = su, lu$, as well as business cycle condition S. The efficiency variables x_{su} and x_{lu} are determined by the level and quality of public job search assistance (JSA) for the two types of unemployed workers. To achieve search efficiency x_s, the government has to spend resources $\lambda_s(x_s)$ with $s = su, lu$, where $\lambda_s(.)$ is an increasing and convex function. We denote the job finding rate of an unemployed worker of type $s = su, lu$ who exerts search effort l and receives JSA x_s by $\pi_{e|s}(l, x_s, S)$ with $s = su$ (short-term unemployed) and $s = lu$ (long-term unemployed). We assume that for given S, the job finding rate $\pi_{e|s}(l, x_s, S)$ is an increasing and concave function in (l, x_s). An unemployed worker begins the unemployment spell as short-term unemployed and becomes long-term unemployed with exogenous probability $\pi_{lu|su}$.

Workers have different skills and abilities that determine their productivity. The human capital of an individual worker, h_t, is an aggregate of all those worker characteristics that affect a worker's labor productivity. Employed workers receive after-tax labor income $(1 - \tau)wh_t$, where τ is a linear tax on labor income (social security tax). Human capital of a worker evolves exogenously, that is, it is not a choice variable. The law of motion for individual human capital is

$$h_{t+1} = \begin{cases} (1+\epsilon_{t+1})h_t & if\ s_{t+1} = e \\ (1-\delta_{su})h_t & if\ s_{t+1} = su \\ (1-\delta_{lu})h_t & if\ s_{t+1} = lu \end{cases} . \tag{1}$$

In (1), the variable ϵ_{t+1} is a random variable that captures wage risk of employed workers. We assume that $\{\epsilon_t\}$ is i.i.d. over time and across workers and allow for the possibility that $E[\epsilon] > 0$, which captures the productivity effect of learning-by-doing or on-the-job training. Note that the wage per unit of human capital, w, in conjunction with the process of individual human capital (1) define the individual wage/earnings process, and that the mean of ϵ_{t+1} defines the average growth rate of wages/earnings. The parameters δ_{su} and δ_{lu} capture skill depreciation during unemployment for workers who are short-term unemployed, respectively long-term unemployed. Equation (1) implies that unemployment has permanent effects on wages if $E[\epsilon] > \delta_{su}, \delta_{lu}$. Note that such a scarring effect of unemployment can also occur if $\delta_{su} = \delta_{lu} = 0$ as long as there is wage growth for employed workers, $E[\epsilon > 0]$. Finally, note that our formulation implies that the scarring effect of unemployment increases during a typical recession due to the increase in unemployment duration, but that we rule out the possibility that δ_{su}, δ_{lu}, or $E[\epsilon]$ depend on aggregate labor market conditions S.

At the beginning of life, workers have no financial wealth but they can save at the risk free rate r_t and borrow at the rate $r_t+\alpha$, where α is a parameter that describes an exogenous cost of financial intermediation. Clearly, α is also the equilibrium spread between lending rate, r_t, and borrowing rate, $r_t+\alpha$. In addition, we assume that for long-term unemployed workers a fraction ψ of financial assets are confiscated, which represents the fact that in many countries, and in particular in Germany, unemployment benefits are only paid to long-term unemployed workers who have depleted their assets (means-tested program).[16] Finally, we assume that unemployed workers receive unemployment benefits $b(s_t)h_t$ with $s_t = su, lu$.[17] Thus, the worker's budget constraint reads

$$\begin{aligned} a_{t+1} &= \begin{cases} (1+r_t)a_t + (1-\tau)wh_t - c_t & if\ a_{t+1} \geq 0\ and\ s_t = e \\ (1+r_t)a_t + b(su)h_t - c_t & if\ a_{t+1} \geq 0\ and\ s_t = su \\ \psi(1+r_t)a_t + b(lu)h_t - c_t & if\ a_{t+1} \geq 0\ and\ s_t = lu \\ (1+r_t+\alpha)a_t + (1-\tau)wh_t - c_t & if\ a_{t+1} < 0\ and\ s_t = e \\ (1+r_t+\alpha)a_t + b(s_t)h_t - c_t & if\ a_{t+1} < 0\ and\ s_t = su, lu \end{cases} \\ a_{t+1} &\geq -\bar{D}h_t \qquad (2) \\ & (a_0, h_0)\ \ given\ with\ a_0 = 0\ , \end{aligned}$$

where c_t denotes consumption, a_t denotes financial asset holdings at the beginning of period t, and $\bar{D} > 0$ is an explicit debt constraint. Note that our equilibrium characterization result (proposition 1) remains valid even if we replace the debt constraint in (2) by the debt constraint $a_{t+1} \geq -\bar{D}$ or by a no-Ponzi scheme condition. In (2) each c_t is a function mapping histories of individual shocks, s^t, and aggregate shocks, S^t, into consumption choices $c_t(s^t, S^t)$. A similar comment applies to a_{t+1} and h_{t+1}.

In this paper, we consider two types of labor market institutions. The first labor market

[16]In our quantitative analysis, we define long-term unemployment as an unemployment spell more than one year. In the US, most workers who are non-employed for more than one year are in general not eligible for unemployment benefits, but might be eligible for disability insurance or welfare payments, which are both means-tested programs.

[17]For tractability reasons, we assume that unemployment benefit payments are proportional to the current level of human capital so that for given unemployment type $s_t = su, lu$ the search effort chosen by unemployed workers is independent of unemployment duration – see the equilibrium characterization below. In many countries, unemployment benefit levels for the short-term unemployed are proportional to the human capital level (labor income) at the last job and unemployment benefit levels for the long-term unemployed (or welfare payments for welfare recipient) are often independent of current or past human capital. This feature of actual unemployment insurance systems implies that search incentives decline with unemployment duration when there is skill depreciation during unemployment, an effect that is not captured by the current formulation.

institution is the Public Employment Agency that provides job search assistance (JSA) and job placement services, which improves the job finding rates through its effect on the efficiency parameters $x = (x_{su}, x_{lu})$. The resource cost of providing JSA, $\lambda_s(x_s)$, is paid by the government and enters into the government budget constraint, which we define below. The second labor market institution is the unemployment insurance system (UI) defined by the benefit levels $b = (b_{su}, b_{lu})$, which enter into the worker's budget constraint and the government's budget constraint. The benefit levels b affect search incentives of unemployed workers and therefore their job finding rates. Unemployment benefits, b, and job search assistance, $\lambda(x_s)$, are financed through the labor income (social security) tax, τ, which also affects search incentives of unemployed workers by affecting the take-home pay of employed workers. Note that labor market institutions (b, x, τ), only affect job finding rates, but have no effect on job destruction rates in our formulation. Note further that b, x, and τ do not depend on business cycle conditions S. We make this assumption in order to focus on labor market institutions, i.e. labor market policies that do not respond to business cycle conditions.

Workers are risk-averse and have identical preferences that allow for a time-additive expected utility representation. The one-period utility function depends on consumption, search effort, and the employment status. We confine attention to utility functions that are additive over consumption and search effort, and logarithmic over consumption, $u_s(c, l) = \ln c - d_s(l)$, where d_s is an increasing and strictly convex function in l. This formulation entails the case in which a type-independent disutility function is defined over time spent searching l hours and working n hours: $\tilde{d} = \tilde{d}(l, n)$. To see this, note that for unemployed workers, $s = su, lu$, we have $l > 0$ and $n = 0$. Thus, the term $d_s(l) = \tilde{d}(l, 0)$ represents the disutility of searching l hours and not spending any time working, $n = 0$. For the employed workers, we have $l = 0$ (there is no on-the-job search) and $n > 0$, and $d_e(0) = \tilde{d}(0, \bar{n})$ represents the disutility from working a fixed number of hours, $n = \bar{n}$, and not searching.

Expected life-time utility (welfare) associated with a consumption-effort plan $\{c_t, l_t\}$ for a worker of initial type s_0 is given by

$$W\left(\{c_t, l_t\}|s_0\right) \doteq E\left[\sum_{t=0}^{\infty} \beta^t \left(\ln c_t - d(l_t, s_t)\right)|s_0\right] , \tag{3}$$

where β is the pure discount factor of workers. Note that the expectations $E[.]$ in (3) is taken with respect to a joint distribution over idiosyncratic and aggregate shocks that depends on the effort plan $\{l_t\}$ through its effect on transition probabilities, π.

The initial type of a worker is defined by a pair (s_0, h_0) – recall that $a_0 = 0$ for all workers. The initial aggregate state of the economy is defined by $S_0 = N, R$ and M_0, where M_0 is a joint distribution over initial employment states, s_0, and initial human capital levels, h_0. Note that we do not include the initial distribution over asset holdings into M_0 since we have $a_0 = 0$ for all workers. Note also that the marginal distribution of M_0 over employment states is simply the vector of initial unemployment rates, $U_0 = (U_{0,su}, U_{0,lu})$. For given initial state (s_0, h_0, S_0, M_0), workers choose a plan $\{c_t, l_t, a_t\}$ so as to maximize (3) subject to (2), where a plan is a sequences of (arbitrary) functions of the history of individual employment states and aggregate productivity shocks: $c_t = c_t(s^t, S^t)$, $l_t = l_t(s^t, S^t)$, and $a_{t+1} = a_t(s^t, S^t)$. Aggregate variables are denoted by upper case letters and are obtained from individual plans by taking the expectations over individual histories and initial types conditional on the history of aggregate shocks: $C_t \doteq E_t[c_t] = \int_{h_0,s_0} \sum_{s^t} c_t(h_0, s_0, M_0, S_0; s^t, S^t)\pi_t(s^t, S^t|s_0, S_0)dM_0(h_0, s_0)$. This notation linking individual plans to aggregate variables is used throughout the paper.[18] Note that we have $C_t = C_t(M_0, S_0, S^t)$, that is, aggregate variables depend on the initial state, (S_0, M_0), and the (partial) history of aggregate shocks, S^t.

3.2 Firms

There is a continuum of firms producing a single consumption good using labor as the only input factor. A firm is defined by its productivity parameter that takes on two values, $Z > 0$ or 0. One firm is matched with one worker and a worker-firm match produces $Z \times h$ or 0. We assume that a firm with productivity 0 will have productivity 0 forever, and therefore shuts down. Thus, the job destruction rate $\pi_{u|e}(S')$ introduced in the previous section is equal to the probability that firm-level productivity changes from Z in period t to 0 in period $t + 1$. Note that these transitions rates, $\pi_{u|e}(S')$, are exogenous. We assume that the matching of workers with firms is random so that aggregate output produced in period t is equal to $\tilde{Y}_t = ZH_{t,e}$, where $H_{t,e} = E[h_t|s_t = e]$ is the aggregate human capital stock of employed

[18] This approach is common in the literature. The usual caveat applies if we want to interpret the result of this "aggregation process" as the average value of (integration over) a continuum of random variables (Uhlig, 1996).

workers. The labor market is competitive in the sense that the real wage per unit of human capital, w, is equal to the marginal product of labor: $w = Z$. This means that workers receive the entire match surplus and firms make zero profit.

The assumption that all producing firms have a common productivity, Z, rules out the possibility that UI has a positive effect on productivity and wages by encouraging unemployed workers to search for high productivity jobs (Acemoglu and Shimer, 1999, 2000). The empirical literature has found mixed results regarding the effect of UI on post-displacement wages (Card, Chetty, and Weber, 2007, and Schmieder, Wachter, and Bender, 2016). We return to this issue in our robustness analysis in Section 7, where we consider an extension of the baseline model in which UI affects the quality/productivity of newly formed worker-firm matches.

We assume that $lnZ - d_e(0) > lnb_s - d_s(0)$ with $s = su, lu$, which ensures that in equilibrium it is always optimal for unemployed workers to accept job offers. Note that even though employed workers are paid a common wage per unit of human capital, $w = Z$, the model implies a non-degenerate, endogenous cross-sectional distribution of wages/earnings since the cross-sectional distribution of human capital is non-degenerate and endogenous. This cross-sectional distribution fans out over time given that workers are infinitely lived and wages/earnings follow a logarithmic random walk with drift – see equation (1). Thus, there is no stationary cross-sectional distribution of wages/earnings. However, it is straightforward to extend the model to the case in which workers face a constant probability of death and a stationary cross-sectional distribution of wages/earnings exists (Constantinides and Duffie, 1996).

3.3 Equilibrium

We assume that the risk-free asset that can be traded by workers is in zero net supply. Thus, market clearing in the (domestic) asset market reads

$$A_t = 0 . \tag{4}$$

Denote by A_t^- the total debt of workers and A_t^+ the total asset holdings of workers. Note that $A_t^- = A_t^+$ because of (4). We define output net of the cost of financial intermediation as $Y_t = \tilde{Y}_t - A_t^-$.

We next define feasible labor market institutions (b, x, τ). To this end, note first that any government choice of a labor market institution (b, x, τ) induces a stochastic process of government spending, $\{G_t\}$, and government revenues, $\{T_t\}$, where G_t and T_t are defined as

$$\begin{aligned} G_t &\doteq [b_{su} + \lambda_{su}(x_{su})]\, H_{t,su} + [b_{lu} + \lambda_{lu}(x_{lu})]\, H_{t,lu} \\ T_t &\doteq \tau w H_{t,e} \end{aligned} \quad (5)$$

The first term in the definition of G is government spending on short-term unemployed workers (unemployment benefits plus jobs search assistance) and the second term is spending on long-term unemployed workers (recall that the functions λ_s measure the resource cost of providing job search assistance). Government revenue, T_t, is equal to the revenue from the flat-rate labor income tax (social security tax).

A labor market institution, (b, x, τ), is feasible if the induced fiscal policy, $\{G_t, T_t\}$, satisfies a present value budget constraint. More precisely, for any fiscal policy $\{G_t, T_t\}$ define the associated expected present value of government deficits/surpluses as

$$PV_g(M_0, S_0) \doteq E\left[\sum_{t=0}^{\infty} \nu_t \frac{G_t - T_t}{Y_t} | M_0, S_0\right]$$

where ν_t is the t-period discount factor used by the government and the expectation indicates that we average over histories of aggregate states S^t conditional on the initial aggregate state: $E[G_t|M_0, S_0] = \sum_{S^t} G_t(M_0, S_0; S^t)\pi_t(S^t|S_0)$ and $E[T_t|M_0, S_0] = \sum_{S^t} T_t(M_0, S_0; S^t)\pi_t(S^t|S_0)$. We use the deficit-to-output ratio, instead of the deficit, in order to avoid technical issues that arise when taking the limit for sequences of random variables that grow in expectations, which occurs naturally in the equilibria considered in this paper. A labor market institution (b, x, τ) is feasible if it induces a fiscal process $\{G_t, T_t\}$ that satisfies the present value budget constraint

$$PV_g(M_0, S_0) = 0 \,. \quad (6)$$

The idea underlying the present value budget constraint (6) is that the government can borrow and lend in international capital markets, and that it uses this ability to finance the budget deficits and surpluses induced by cycle-independent labor market institutions (b, x, τ). Specifically, consider the sequential government budget constraint

$$D_{t+1} = (1 + r_w)(1 + D_t) + T_t - G_t \,, \quad (7)$$

where D_t is government debt and r_w is the interest rate at which the government can borrow or lend (the world interest rate). It is straightforward to show that for $D_0 = 0$ the sequential budget constraint (7) in conjunction with the no-Ponzi scheme condition $\lim_{t\to\infty} E[(1+r_w)^{-t} D_t | M_0, S_0] = 0$ implies the present value budget constraint (6) if we choose $\nu_t = (1+r_w)^{-t} \prod_{n=1}^{t}(1+g_n)$ in (6), where g_n is the growth rate of output. Note that our equilibrium characterization result (see proposition 1) also holds if $r_w = r$, that is, if the world interest rate is equal to the domestic lending/saving rate. Note further that we impose the no-Ponzi-scheme condition only at the initial state (M_0, S_0). If the no-Ponzi scheme condition is imposed for all histories S^t, then the equivalence between sequential budget constraint and present-value budget constraint only holds in the case in which the government has access to a sequentially complete set of financial contracts.

For the fiscal policies considered in this paper, the debt process may have an unbounded debt-to-output ratio and such government policies are sometimes considered problematic – see, for example, Bohn (1995) for a general discussion. To address this issue, we show in the Appendix that for any economy with labor market institution (b, x, τ) and corresponding fiscal policy $\{G_t, T_t\}$ with unbounded debt-to-output ratio there is an economy with the same labor market institution (b, x, τ) and a fiscal policy $\{G'_t, T'_t\}$ with bounded government debt-to-output process so that equilibrium effort choices are the same and the welfare cost of recessions are arbitrarily close in the two economies. The $\{G'_t, T'_t\}$ in the new economy is defined by the labor market institution (b, x, τ) plus a consumption tax/subsidy that is only non-zero when government debt is very high – see the Appendix for details. In this sense the labor market institutions considered in this paper also satisfy a bounded debt-to-output condition.

Given the concepts introduced so far, our definition of sequential equilibrium is standard:

Definition. For given labor market institution $(b, x, \tau,)$ and initial state (M_0, S_0), a sequential equilibrium is a wage rate w, a sequence of interest rates, $\{r_t\}$, and a family of worker plans, $\{c_t, a_t, l_t\}$, so that

i) For all worker types (h_0, s_0), the individual plan $\{c_t, a_t, l_t\}$ maximizes expected lifetime utility (3) subject to (2).

ii) Market clearing condition (4) holds in each period t.

The labor market institution (b, x, τ) is feasible if the government budget constraint (6) is satisfied.

The household budget constraint (2) in conjunction with the asset market clearing condition (4) and the government budget constraint (6) imply the aggregate resource constraint (goods market clearing condition)

$$E\left[\sum_{t=0}^{\infty} \nu_t \frac{C_t}{Y_t} | M_0, S_0\right] + E\left[\nu_t \frac{\Lambda_t}{Y_t} | M_0, S_0\right] \;=\; 1 \;, \tag{8}$$

where C_t is aggregate consumption and Λ_t is aggregate spending on job search assistance for unemployed. Note that the aggregate resource constraint (8) is an expected present value constraint, where the expectation is taken over all histories S^t. This has to be the case since the government budget constraint (6) is an expected present value constraint.

3.4 Equilibrium Characterization

The previous section defined sequential equilibria. Recursive equilibria are defined accordingly. We now turn to the characterization of recursive equilibria confining attention to recursive equilibria with minimal state space. We show below that it suffices to use the exogenous state S as the relevant aggregate state variable. In other words, neither the cross-sectional distribution of assets nor the cross-sectional distribution of human capital are relevant state variables. Anticipating this result, we can write the worker's maximization problem as

$$\begin{aligned} V_s(a,h,S) \quad &= \quad \max_{c,l,a'} \left\{ \ln c - d_s(l) + \beta \sum_{s',\epsilon',S'} V_{s'}(a',h',S')\, \pi_{\epsilon'}\, \pi_{s'|s}(l,S')\, \pi(S'|S) \right\} \\ s.t. \quad & (a',c) \in \Gamma_s(a,h,S) \\ & h' = (1+\eta_{s',\epsilon'})h \;, \end{aligned} \tag{9}$$

where the human capital "shocks" η are defined as $\eta_{s',\epsilon'} = \epsilon'$ if $s' = e$ and $\eta_{s',\epsilon'} = -\delta_{s'}$ for $s' = su, lu$. The correspondence Γ is defined by the individual budget set (2). Note that effort choice l is only relevant for the transition probability $\pi_{s'|s}(l, S')$ if $s = su, lu$.

We show below that in equilibrium workers do not trade the risk-free asset (do not self-insure) and consume their current income: $a_t = 0$ and $c_t = \phi(s_t)h_t$ for all histories, where we define $\phi(e) = (1-\tau)w$ and $\phi(s) = b(s)$ for $s = su, lu$. In this case, the value function of workers is given by

$$V_s(0,h,S) \;=\; v_s(S) + \frac{1}{1-\beta} ln\, h \;, \tag{10}$$

where v together with the optimal effort choice are the solution to the intensive-form Bellman equation

$$\begin{aligned} v_s(S) \;&=\; \max_l \Bigg\{ \ln\phi_s - d_s(l) + \frac{\beta}{1-\beta} \sum_{s',\epsilon',S'} \ln(1+\eta_{s',\epsilon'})\,\pi_{\epsilon'}\,\pi_{s'|s}(l,S')\,\pi(S'|S) \\ &\quad + \beta \sum_{s',S'} v_{s'}(S')\,\pi_{s'|s}(l,S')\,\pi(S'|S) \Bigg\} \;. \end{aligned} \tag{11}$$

The solution to equation (11) determines the equilibrium effort choice of workers, $l = l(S)$. We have $a_t = 0$ and $c_t = \phi(s_t)h_t$ with $h_{t+1} = (1+\eta(s_{t+1},\epsilon_{t+1}))h_t$ in equilibrium, which implies that the solution to (11) also pins down the equilibrium plan $\{c_t, a_t, l_t\}$ of workers.

Equation (11) determines the household choices for given labor market institutions, (b, x, τ). To find feasible labor market institutions, we need to ensure that the government budget constraint (6) is satisfied. For the recursive equilibria considered here, the present value budget constraint (6) can be rewritten in a more convenient way. Specifically, define Ω as the vector of human capital shares of workers of type s defined as $\Omega_s = H_s/H$. We show in this paper that the equilibrium law of motion for Ω, which we denote by Φ, is

$$\Omega'_{s'} \;=\; \frac{\sum_s (1+\bar{\eta}_{s'})\pi_{s'|s}(l(S),S')\Omega_s}{\sum_{s,s'}(1+\bar{\eta}_{s'})\pi_{s'|s}(l(S),S')\Omega_s} \;, \tag{12}$$

where $\bar{\eta}_{s'} = \sum_{\epsilon'} \eta_{s',\epsilon'}\pi_{\epsilon'}$. Further, the present value of government deficits/surpluses becomes a function $PV_g = PV_g(\Omega_0, S_0)$, and can be found as the solution to the recursive equation

$$\begin{aligned} PV_g(\Omega,S) \;&=\; \tau Z \;-\; (b_{su} + \lambda(x_{su}))\,\frac{\Omega_{su}}{\Omega_e} \;-\; (b_{lu} + \lambda(x_{lu}))\,\frac{\Omega_{lu}}{\Omega_e} \\ &\quad + \frac{1}{1+r_w} \sum_{S'} (1 + g(\Omega,S,S'))PV_g(\Phi(\Omega,S,S'),S')\pi(S'|S) \;, \end{aligned} \tag{13}$$

where Φ is the law of motion for Ω given by (12) and g is the growth rate of output specified in equation (18) below. Note that in (13) we assume that the discount factor in (6) is given by $\nu_t = (1 + r_w)^{-t} \prod_{n=1}^{t}(1 + g_n)$, that is, we assume that the government can borrow and lend in international financial markets at the world interest rate r_w.

In summary, we have the following equilibrium characterization result:

Proposition 1. Suppose that the cost of financial intermediation α (the interest rate spread) is greater or equal to α_{min} given in (A2). Then the solution to (11) defines a recursive equilibrium with aggregate state S for given labor market institution (b, x, τ). The labor market institution is feasible if the government budget constraint (6) holds, where the present value function PV_g is the solution to the recursive equation (13) using the law of motion (12).

Proof: Appendix.

The proof of proposition 1 is based on the idea that workers will choose $a_t = 0$ if the spread between the borrowing rate and lending rate is sufficiently large. Note that the proof is non-standard since first-order conditions may not be sufficient due to the non-concavity of the objective function, a problem that is well-known in the literature on multi-period moral hazard problems with (unobserved) asset trade. See, for example, Abraham, Pavoni, and Koehne (2011) for a survey of the literature and a fairly general treatment of the two-period case. We show that in our model the first-order conditions are indeed sufficient, and we use this property of our model to prove that no-trade is an equilibrium with sufficiently high cost of financial intermediation. Our proof heavily relies on three key assumptions: i) homothetic preferences, ii) non-asset income that is proportional to human capital of workers, and iii) human capital that evolves subject to shocks that are proportional to human capital (proportional skill depreciation during unemployment).

To gain a better understanding of proposition 1, consider the special case in which there is only one type of unemployment, $s = u, e$, there are no wages shocks, $\epsilon = \bar{\epsilon}$, and $\{S_t\}$ is i.i.d. In this case, equation (11) becomes

$$\begin{aligned} v_u \quad = \quad \max_l \Big\{ \ln b - d(l) + \frac{\beta}{1-\beta} \left[\ln(1+\bar{\epsilon})\, \bar{\pi}_{e|u}(l) \; + \; \ln(1-\delta_h)\, (1 - \bar{\pi}_{e|u}(l)) \right] \\ + \beta \left[v_e \bar{\pi}_{e|u}(l) + v_u (1 - \bar{\pi}_{e|u}(l)) \right] \Big\} \qquad (14) \end{aligned}$$

$$
\begin{aligned}
v_e &= \ln\left((1-\tau)w\right) + \frac{\beta}{1-\beta}\left[\ln(1+\bar{\epsilon})\,(1-\bar{\pi}_{u|e}) \;+\; \ln(1-\delta_h)\,\bar{\pi}_{u|e}\right] \\
&\quad + \beta\left[v_e(1-\bar{\pi}_{u|e}) + v_u\bar{\pi}_{u|e}\right]
\end{aligned}
$$

where $\bar{\pi}_{u|e} = \pi_{u|e}(N)\pi(N) + \pi_{u|e}(R)\pi(R)$ denotes the mean job destruction rate and $\bar{\pi}_{e|u}(l) = \pi_{e|u}(l,N)\pi(N) + \pi_{e|u}(l,R)\pi(R)$ is the mean job finding rate. Thus, the solution to (14) only depends on the mean of the job destruction rate and the job finding rate, but not their volatilities. In other words, aggregate fluctuations in worker flow rates have no effect on equilibrium choices and welfare, a result that is driven by the property that expected utility is linear in probabilities – see Krebs (2007) for a general discussion of such neutrality results. Note further that the solution is independent of the aggregate state S, that is, the equilibrium effort choice, l, is constant over the cycle. Equation (14) is the Bellman equation associated with the maximization problem of a long-lived worker who moves between unemployment and employment, chooses search effort when unemployed, and consumes b when unemployed and $(1-\tau)w$ when employed.

3.5 Computation and Tractability

The equilibrium analysis conducted in this paper is based on proposition 1. Specifically, we use proposition 1 to compute and analyze recursive equilibria in two steps. First, for given labor market institution (b, x, τ) we solve the worker problem (11). Second, we vary the tax rate τ until the government budget constraint (6) is satisfied using the recursive equation (13) and the law of motions (12). Note that this approach simplifies our analysis for two reasons. First, it reduces the problem of solving the Bellman equation (9) to the much simpler problem of solving the intensive-form Bellman equation (11). Note that in (9) the individual worker makes a consumption-saving choice and an effort choice, whereas in (11) the worker only makes an effort choice. In other words, the fact that $a_t = 0$ in equilibrium means that we have found the optimal consumption-saving choice. Second, neither the cross-sectional distribution over asset holdings nor the cross-sectional distribution of human capital are relevant state variables. Clearly, these distributions are in general infinite-dimensional objectives, which means that in general approximation methods along the lines of Krusell and Smith (1998) are required for the equilibrium analysis. In contrast, in the current paper we do not rely on approximation methods since we compute the solution to the exact equilibrium conditions.

The solution to (11), (12), (13) determines the equilibrium values of search intensity and job finding rates, the tax level τ ensuring budget feasibility, and the equilibrium law of motion for Ω. The equilibrium evolution of unemployment and output (growth) can be computed from these variables as follows. The law of motion for the unemployment rate is

$$U'_{s'} = \sum_{s=su,lu} \pi_{s'|s}(l_s(S), S')\, U_s \; + \; \pi_{su|e}(S')(1 - U_{su} - U_{lu}) \; . \tag{15}$$

Further, aggregate output is given by $Y_t = ZH_{t,e}$, where aggregate human capital, $H_t = (H_{t,e}, H_{t,su}, H_{t,lu})$, evolves according to

$$H_{t+1,s'} = \sum_{s} (1 + \bar{\eta}_{s'}) \pi_{s'|s}(l_s(S_t), S_{t+1}) H_{ts} \; . \tag{16}$$

Note that equation (16) determines the equilibrium growth rate of aggregate human capital of employed workers, $g_{,t+1} = H_{e,t+1}/H_{et} - 1$, which is equal to the equilibrium growth rate of output: $H_{e,t+1}/H_{et} = Y_{t+1}/Y_t$. It follows from the definition of Ω and the equilibrium law of motion for Ω that this equilibrium growth rate is given by

$$1 + g(\Omega, S, S') = (1 + \eta_e) \sum_{s} \pi_{e|s}(l(S), S') \frac{\Omega_s}{\Omega_e} \; . \tag{17}$$

To see that expression (17) is the growth rate of output, consider the special case of $s = u, e$ (only one type of unemployment), $\delta_u = 0$ (no skill depreciation) and $\epsilon = 0$ (no wage growth). In this case, we have $\Omega_u = U$ and $\Omega_e = (1 - U)$, and (17) reduces to $1 + g = \pi_{e|e} + \pi_{e|u}\frac{U}{1-U}$, which is simply the change in the employment rate, that is, output growth equals employment growth. Further, if we set U equal to its steady state value, then we find $g = 0$. Thus, in an economy without wage growth for employed workers and without skill depreciation during unemployment, there is no steady state growth and changes in the steady-state values of the job destruction or job finding rate have no effect on steady state growth. This result is no longer valid in the general economy with wage growth for employed workers and/or skill depreciation, and this non-neutrality property is an important source of the output cost of recessions discussed in this paper – see also our discussion in Section 4.

4. Cost of Recessions

In this section, we discuss our approach to measuring the cost of recessions and provide a theoretical analysis of the effect of UI and JSA on the cost of recessions. Section 4.1 defines the welfare cost of recessions and discusses its relationship to the welfare cost of business cycles (Lucas 1987, 2003). Section 4.2 defines the output cost of recessions and discusses how it relates to the recent empirical literature that has estimated the losses in potential output associated with recessions (Ball, 2014, Blanchard, Cerutti, and Summers, 2015, and Hall, 2014). In Section 4.3 we present a decomposition result (Proposition 2) that clarifies the relationship between welfare cost of recessions and output cost of recessions. In Section 4.4 we show that an improvement in JSA and a reduction in UI lead to a reduction in the output cost of recessions (Proposition 3).

4.1 Welfare Cost of Recessions

In analogy to the welfare cost of business cycles (Lucas 1987, 2003), we define the welfare cost of recessions as the gain in social welfare that accrues when recessions are eliminated. More precisely, we consider a thought experiment in which we move from an economy with recessions and S'-dependent job destruction rates $\pi_{su,e}$ and job finding rates $\pi_{e|s}$ to an economy without recessions and job flow rates, $\hat{\pi}_{su|e}$ and $\hat{\pi}_{e|s}$, that are equal to the transition rates that prevail in normal times. Thus, we assume that we remove recessions without affecting the labor market in normal (or boom) times. We also assume that human capital shocks and the job finding function, which do not depend on macroeconomic shocks S, remain the same. In sum, the elimination of recessions amounts to:

$$\begin{aligned} \hat{\pi}_{su|e} &= \pi_{su|e}(N) \\ \hat{\pi}_{e|s}(l) &= \pi_{e|s}(l, N) \quad s = su, lu \\ \hat{\eta}_{s',\epsilon'} &= \eta_{s',\epsilon'} \ . \end{aligned} \tag{18}$$

Equation (18) shows how the elimination of recessions affects job destruction and job finding rates, and proposition 1 provides an algorithm to compute equilibria before and after the elimination of recessions. Let Δ stand for the welfare cost of recessions, that is, the difference, expressed in lifetime consumption units, between social welfare in the economy without recessions and social welfare in the economy with recessions. More precisely, let $\{c_t, l_t\}$ stand for the equilibrium allocation in the economy with recessions and $\{\hat{c}_t, \hat{l}_t\}$ for the equilibrium allocation in the economy without recessions. We then define the welfare cost of recessions as the number Δ solving

$$\sum_{s_0}\int_{h_0} W(\{c_t,l_t\}|h_0,s_0,\Omega_0,S_0)d\mu(h_0,s_0) \;=\; \sum_{s_0}\int_{h_0} W(\{(1+\Delta)\hat{c}_t,\hat{l}_t\}|h_0,s_0,\Omega_0,S_0)d\mu(h_0,s_0) \tag{19}$$

where $\mu(h_0, s_0)$ is the welfare weight the social planner assigns to workers of initial type (h_0, s_0) and $W(\{c_t, l_t\}|h_0, s_0, \Omega_0, S_0)$ is expected lifetime utility of a worker of type (h_0, s_0) defined in (3). Note that (19) takes into account the transition path, that is, we compare two economies with different future aggregate shock processes (different worker flow rates) and different tax rates τ necessary to satisfy the government budget constraint (6), but the same initial aggregate state (Ω_0, S_0) – recall that the expected present discounted value of government surpluses/deficits is a function of the initial state: $PV_g = PV_g((\Omega_0, S_0)$. Note further that S_0 is a relevant state because it affects both future worker flow rates and the tax rate, whereas Ω_0 is a relevant state variable only because it affects the tax rate necessary to satisfy (6). Finally, note that for the general analysis we do not need to impose the normalization $\int d\mu(h_0, s_0) = 1$, that is, we only need to assume that μ is a measure, but not necessarily a probability measure. If the social planner assigns equal weight to each individual worker, we have $\mu_{su} = U_{0,su}$, $\mu_{lu} = U_{0,lu}$, and $\mu_e = 1 - U_{0,su} - U_{0,lu}$.

For given initial state $(h_0, s_0, \Omega_0, S_0)$, expected lifetime utility is $W(\{c_t, l_t\}|h_0, s_0, \Omega_0, S_0) = V_{s_0}(h_0, \Omega_0, S_0)$, where V is the value function determined by the solution to the Bellman equation (9). Note that V depends on Ω_0 because Ω_0 affects the present value of government deficits/surpluses, PV_g, and therefore also affects the tax rate τ that is required to satisfy the government budget constraint (6). From proposition 1 we know that the equilibrium value function has the functional form $V_{s_0}(h_0, \Omega_0, S_0) = v_{s_0}(\Omega_0, S_0) + 1/(1-\beta)\ln h_0$. Using this representation, we find that the welfare cost of recessions (19) is given by the following expression:

$$\ln(1+\Delta(\Omega_0,S_0)) \;=\; (1-\beta)\sum_s \left[\hat{v}_s(\Omega_0,S_0) - v_s(\Omega_0,S_0)\right]\mu_s \;, \tag{20}$$

where the value function coefficients v_s are the solution to (11) for the economy with recessions and the value function coefficients $\hat{v}_s$ are the solution to (11) for the economy without recessions. Equation (20) shows that the welfare cost of recessions is independent of the initial distribution of human capital, a result that is a direct consequence of our assumption of homothetic preferences and skill shocks (depreciation rates during unemployment) that are proportional to the stock of human capital. It depends, however, on the aggregate state (Ω_0, S_0) that prevails when recessions are eliminated (the initial state) and the social welfare weights μ.

The welfare cost of recessions (19), respectively (20), is closely related to the welfare cost of business cycles as defined by Lucas (1987, 2003) for representative household economies and extended to economies with uninsurable idiosyncratic risk by, among others, Krebs (2003, 2007), Krusell and Smith (1999), and Krusell et al. (2009). In both cases, we compute the welfare cost/gain of moving from an economy with S-dependent fundamentals to another economy with S-independent fundamentals, where we use (18) to eliminate fluctuations. However, the two cases differ with respect to the way fluctuations are eliminated. To compute the welfare cost of business cycles, we eliminate aggregate fluctuations in a symmetric fashion. In contrast, to compute the welfare cost of recessions, we eliminate aggregate fluctuations in an asymmetric manner. In the Appendix we show how these two cases can be considered special cases of a generalized concept of the welfare cost of business cycles.

4.2 Output Cost of Recessions

The previous analysis used a welfare-based approach to evaluate the cost of recessions. Alternatively, we can compute the output losses associated with recessions. We define the output cost of recessions, Δ_y, as the present discounted value of the expected percentage gain in aggregate output associated with the elimination of recessions:

$$\begin{aligned}\Delta_y(Y_0, S_0) &\doteq (1-\beta)\, E\left[\sum_{t=0}^{\infty} \beta^t \frac{\hat{Y}_t - Y_t}{Y_t} | Y_0, S_0\right] \\ &\approx (1-\beta)\, E\left[\sum_{t=0}^{\infty} \beta^t \left(\ln \hat{Y}_t - \ln Y_t\right) | Y_0, S_0\right] ,\end{aligned} \tag{21}$$

where Y_t is aggregate output in the economy with recessions and $\hat{Y}_t$ is aggregate output in the economy without recessions.[19] We continue to use (18) to eliminate recessions. Thus, both cost concepts, the welfare cost of recessions and the output cost of recessions, compare the actual economy with a hypothetical economy without recessions. In addition, in both

[19] For the calibrated model economy, the approximation in (21) is very good in the sense that the two different methods/definitions yield results that differ from each other by less than 0.1 percent of the value of the output cost of recessions.

definitions (19) and (21) we condition on the initial state (Ω_0, S_0) to take account of the transitions path and we use the discount factor β to discount future utility, respectively output.

As in the case of the welfare cost of recessions, we use a recursive formula to compute the output cost of recessions. More precisely, recall that $Y_t = ZH_{t,e}$, where the aggregate stock of human capital, $H_{t,e}$, evolves according to (16). It is straightforward to show that the output cost of recessions (22) is equal to

$$\Delta_y(\Omega_0, S_0) \; = \; (1-\beta)\left[\hat{P}(\Omega_0, S_0) \; - \; P(\Omega_0, S_0)\right] \; , \tag{22}$$

where P is the expected present discounted value of output divided by current output Y_0. This P can be found as the solution to the recursive equation

$$\begin{aligned} P(\Omega, S) \quad &= \quad \frac{\beta}{1-\beta}\sum_{S'} \ln(1+g(\Omega, S, S'))\pi(S'|S) \\ &\quad + \beta \sum_{S'} P(S', \Phi(\Omega, S))\pi(S'|S) \end{aligned} \tag{23}$$

Here the equilibrium growth rates, g, are given by (17) and Φ, the equilibrium law of motion for Ω, is specified in (12). Further, $\hat{P}$ solves a corresponding recursive equation with equilibrium growth rates $\hat{g}$, and equilibrium law of motion, $\hat{\Phi}$.

We can interpret Δ_y as the present discounted value of the (percentage) output losses depicted in Figure 1 averaged over all recessions. This interpretation underscores the close relationship between our approach and recent empirical contributions that have computed the output cost of the Great Recession in the US (Atkinson, Luttrell, and Rosenblum, 2013, and Hall, 2014) and other advanced economies (Ball, 2014, and IMF, 2015) as well as the output cost of about 120 recessions that occurred over the last 50 years in 23 countries (Blanchard, Cerutti, and Summers, 2015). In this work, a trend path of aggregate output is constructed and then actual output after the recessions is compared to aggregate trend output, that is, actual output of the economy is compared to output in a hypothetical economy that never experienced a recession. In this sense, the current analysis provides the model-based analog of the empirical analysis conducted in Atkinson, Luttrell, and Rosenblum (2013), Ball (2014), Blanchard, Cerutti, and Summers (2015), Hall (2014), and IMF (2015). Note that this literature computes the output cost of one recession, whereas (21) computes the output cost of all (future) recessions. Note further that the focus in the empirical literature is on the permanent output losses associated with recessions, whereas the cost measure (21) compounds temporary and permanent output losses. In our quantitative analysis we also provide a decomposition of the output cost of recessions into a permanent component and a transitory component, and show that both components are important.

4.3 A Decomposition

We next discuss the relationship between the welfare cost of recessions (19) and the output cost of recessions (21). To this end, we show that the welfare cost of recessions (19) can be decomposed into the sum of the output cost of recessions (21) and two additional terms. The first term is the search cost of recessions, Δ_l, which we define as

$$\Delta_l(\Omega_0, S_0) \doteq (1-\beta)\sum_{s_0}\int_{h_0}\sum_{t=0}^{\infty}\beta^t\left(E[d(\hat{l}_t, s_t)|h_0, s_0, \Omega_0, S_0] - E[d(l_t, s_t)|h_0, s_0, \Omega_0, S_0]\right)d\mu(h_0, s_0)$$

where μ is vector of social welfare weights entering into the definition of the welfare cost of recessions (19). Note that the expectation indicates an averaging over individual histories, (s^t, ϵ^t), and aggregate histories, S^t. The search cost of recessions, Δ_l, captures the welfare change from effort adjustment that occurs when recessions are eliminated. This term has an ambiguous sign. It is positive when the elimination of recessions reduces search effort and negative when the elimination of recessions increases search effort. In our calibrated model economy, the search cost is negative, that is, recessions are times when search intensity is low.

The second term is the risk cost of recessions, Δ_r, which we define as

$$\begin{aligned}\Delta_r(\Omega_0, S_0) &= (1-\beta)\sum_{s_0}\int_{h_0}\sum_{t=0}^{\infty}\beta^t\left(\ln E[c_t|h_0, s_0, \Omega_0, S_0, S^t] - E[\ln c_t|h_0, s_0, \Omega_0, S_0, S^t]\right)d\mu(h_0, s_0)\\ &\quad - (1-\beta)\sum_{s_0}\int_{h_0}\sum_{t=0}^{\infty}\beta^t\left(\ln E[\hat{c}_t|h_0, s_0, \Omega_0, S_0] - E[\ln \hat{c}_t|h_0, s_0, \Omega_0, S_0]\right)d\mu(h_0, s_0)\end{aligned}$$

Note that the expression $\ln E[c_t|.] - E[\ln c_t|.]$ is a proper risk measure in the sense that it increases when c_t is replaced by a mean preserving spread. The risk cost of recessions, Δ_r, defines the welfare change caused by the change in risk when recessions are eliminated. This cost is positive in our calibrated model, that is, recession are times when risk is high.

Suppose we use as social welfare weights $\mu_s = \Omega_{0,s}$ for $s = su, lu, e$. In this case, it is straightforward to show that the welfare cost of recessions can be written as

$$\Delta(\Omega_0, S_0) \;=\; \Delta_y(\Omega_0, S_0) + \Delta_r(\Omega_0, S_0) + \Delta_l(\Omega_0, S_0) \tag{24}$$

Thus, we have:

Proposition 2. Suppose we use as welfare weights $\mu_s = \Omega_s$. Then the decomposition result (24) holds, that is, the welfare cost of recessions, Δ, is the sum of three components: the output cost of recessions, Δ_y, the risk cost of recessions, Δ_r, and the effort cost of recessions, Δ_l.

The decomposition (24) shows that there are two reasons why the welfare cost of recessions, Δ, differs from the output/consumption cost of recessions, Δ_y. First, the output cost of recessions does not take into account that the cost of recessions are unevenly distributed among risk-averse workers – this effect is captured by the term Δ_r. Second, the output cost of recessions neglects that there is a disutility of search effort – this effect is captured by the term Δ_l. In our quantitative analysis, we find that both cost terms, Δ_r and Δ_l, are non-negligible and that $\Delta_l < 0$ – search effort is low in recessions – and that $\Delta_r > 0$ – risk is high during recessions. Further, we find that the effort term dominates the risk term, $|\Delta_e| > \Delta_r$, so that the output cost of recessions exceeds the welfare cost of recessions. See Section 6 for more details.

4.4 Labor Market Institutions and the Cost of Recessions

The welfare cost of recessions, Δ, and output cost of recessions, Δ_y, depend on labor market institutions: $\Delta = \Delta(b, x)$ and $\Delta_y = \Delta_y(b, x)$. In this paper, we focus on the effect of changes in labor market institutions (i.e. labor market reforms) on these two cost concepts. In other words, we are concerned with the sign and magnitude of the derivatives $\frac{\partial \Delta}{\partial b}$, $\frac{\partial \Delta}{\partial x}$, $\frac{\partial \Delta_y}{\partial b}$, and $\frac{\partial \Delta_y}{\partial x}$. Note that we conduct a general analysis, that is, when we consider a change in b or x we always assume a corresponding change in τ so that the government budget constraint (6) holds.

In general, the effect of changes in the labor market institutions (b, x) on the welfare cost of recessions, Δ, is ambiguous. In contrast, for the case of the output cost of recessions, Δ_y, we can prove the following result:

Proposition 3. Suppose there are two employment states, $s = u, e$, there are no wages shocks, $\epsilon = \bar{\epsilon}$, job finding rates are independent of S and linear in effort, $\pi_{e|u}(l, x, S) = xl$, and the aggregate shock process, $\{S_t\}$, is i.i.d. If β is sufficiently small, we have

i) Job search assistance (JSA) reduces the output costs of recessions:

$$\frac{\partial \Delta_y}{\partial x} < 0$$

ii) Unemployment insurance (UI) increases the output costs of recessions

$$\frac{\partial \Delta_y}{\partial b} > 0$$

Proof Appendix.[20]

There is a simple intuition underlying proposition 3. An increase in x or a reduction in b increases job finding rates at all stages of the business cycles, that is, these changes in labor market institutions make the labor market more fluid. As a consequence, the economy becomes more resilient to adverse macroeconomic shocks. Specifically, the temporary output losses of recessions are diminished since higher job finding rates reduce the hike of the unemployment rate associated with recessions. In addition, the permanent output losses of recessions become smaller since higher job finding rates reduce the length of unemployment spells and therefore the skill losses during recessions. Thus, an improvement in JSA (an increase in x) or a reduction in UI (a decrease in b) reduce the output costs of recessions.

Even for the special case considered in proposition 3, the effect of labor market institutions (x, b) on the welfare cost of recessions Δ is in general ambiguous. To see this, recall the decomposition result (24). Proposition 3 shows that an increase in x or a reduction in b reduce Δ_y. However, a reduction in b in general increase the risk cost of recessions, Δ_r, and has an ambiguous effect on the effort cost of recessions, Δ_e. Thus, the overall effect of b on

[20]The assumptions that there is only one unemployment state and no wage shocks simplify the proof, but are not essential. The same holds for the assumption that job finding rates are linear in search effort. In contrast, the assumptions that $\{S_t\}$ is i.i.d. and that β is sufficiently small are essential for our proof. The assumption that $\{S_t\}$ is i.i.d implies that search effort is independent of S – see equation (14). The assumption that β is small implies that only the current period and next period have to be considered in the proof.

Δ is ambiguous. In the case of JSA, one can show that an increase in x reduces Δ_r, but the effect on Δ_e is ambiguous. Thus, the overall effect of x on Δ is ambiguous. A formal proof that these results are robust in an appropriately defined parameter space goes beyond the scope of the current paper. For the calibrated model economy, we find that both an increase in x or a reduction in b increase the effort cost of recessions, Δ_e, and reduce the risk cost of recessions, Δ_r.

5. Calibration

In this section, we calibrate the model economy using German pre-reform data. We require the model economy to match the mean values of a number of macroeconomic variables before the reform. In particular, the calibrated model matches the average pre-reform values of the unemployment rate and the job finding rate. To compute the average values of these variables from the data, we use the relatively short period 2000-2004 since the German unemployment rate has seen a steady upward trend until the beginning of the 2000s – see Figure 5. In addition, the calibrated model economy reproduces the cyclical dynamics of the job finding rate and the job destruction rate during a typical pre-reform recession in Germany. To compute the cyclical component of pre-reform job finding and job destruction rates, we apply the HP-filter to data on job flow rates constructed in Jung and Kuhn (2014) for the sample period $1980 - 2004$.[21] Finally, we require the calibrated model to match the German unemployment insurance system before the reform and the empirical evidence about the search elasticity with respect to unemployment benefits.

5.1 General Specifications

The basic model period is one quarter. We continue to assume a two-state aggregate shock process $S \in \{R, N\}$, where R stands for recession and N for normal times. We use the standard OECD convention and define long-term unemployment as any unemployment spell that lasts longer than 12 months. Thus, we choose the probability $\pi_{lu|su}$ of transiting from

[21]We use the HP-filter to construct the cyclical component of job flow rates and unemployment rate. This approach is consistent with the theory in the sense that there are no hysteresis effects in job flow rates and unemployment rate according to the model. In contrast, the model implies a hysteresis effect in output, that is, recessions reduce output levels permanently. Thus, the application of an HP-filter, or any other standard filter, to extract a cyclical component is not appropriate.

$s = su$ to $s = lu$ equal to 0.25.

5.2 Search Technology and Mean Transition Rates

We use the following functional form for the job search technology

$$\begin{aligned} \pi_{e|su}(l_{su}, x_{su}, S') &= \Psi(S') x_{su}\, l_{su} \\ \pi_{e|lu}(l_{lu}, x_{lu}, S') &= \Psi(S') x_{lu}\, l_{lu}, \end{aligned} \tag{25}$$

where $\Psi(S')$ is an efficiency parameter that varies with business cycle conditions and x_{su} and x_{lu} are efficiency parameters that depend on the level of JSA. Our assumption that job finding rates are linear in individual search effort, l, is in line with Acemoglu and Shimer (2000). The search literature has also used an exponential specification (Krebs and Scheffel, 2013, Lentz, 2009, and Shimer and Werning, 2008) or a power function (Alvarez and Veracierto, 2001, and Ljungqvist and Sargent, 1998).[22]

We normalize the mean of Ψ to one and choose the cyclical variation in Ψ to match the observed fluctuations in job finding rates – see Section 5.8 below. We choose the values of the search efficiency parameters x_{su} and x_{lu} so that the implied average job finding probabilities match the observed average transition rates in the period 2000-2004 for the short-term unemployed and long-term unemployed, respectively. The values for the average quarterly transition probabilities are $\bar{\pi}_{e|lu} = 0.06$ and $\bar{\pi}_{e|su} = 0.24$ according to the data provided by the Federal Employment Agency (Bundesagentur fuer Arbeit), which yields $x_{su} = 0.127$ and $x_{lu} = 0.084$.

We also allow for transitions from long-term unemployment to short-term unemployment. One interpretation of this transition is that a long-term unemployed worker accepts a job offer and returns to unemployment within the same quarter. We choose the transition probability $\pi_{su|lu}$ to match a given fraction of long-term unemployed in the unemployment pool. According to the OECD statistics, the share of long-term unemployment was 50 percent for the period 2000-2004, a value we match if $\pi_{su|lu} = 0.190$. Finally, we choose the value of the average job destruction rate, $\bar{\pi}_{u|e}$, so that the model matches the average unemploy-

[22]We have solved the model using different functional form assumptions for individual search effort, and have found that the choice of a functional form had only small effects on our quantitative results as long as we re-calibrate the model to match a given target elasticity of job search. Results are available on request.

ment rate in the period 2000-2004. If we use the OECD definition of unemployment, this average unemployment rate was 10 percent, which yields an average job destruction rate of $\bar{\pi}_{u|e} = 0.167$, which is in line with the results reported in Jung and Kuhn (2014).

5.3 Search Preferences and Search Elasticity

We assume that dis-utility of search is

$$d_s(l) \;=\; d_0\, l^{\gamma} + d_{1,s}\;. \tag{26}$$

It is well-known that with the above specification the parameters x_{su} and x_{lu} in (25) and the parameter d_0 in (26) are not separately identified. We therefore choose a numerically convenient normalization of $d_0 = 1$. We further choose the normalization $d_{1,e} = 0$. The values of the remaining parameter $d_{1,su}$ and $d_{1,lu}$ are then chosen to ensure that i) the value of the disutility term d in equilibrium is the same for employed workers and short-term unemployed workers and that ii) short-term unemployed workers and long-term unemployed workers do not fundamentally differ with respect to their disutility: $d_{1,su} = d_{1,lu}$. In other words, differences between the value of employed workers and short-term unemployed workers derive solely from the difference in consumption paths and the (dis)-utility of unemployment is the same for short-term and long-term unemployed workers. In our robustness analysis in Section 7 we use alternative calibration targets to pin down the values of $d_{1,s}$.

We choose the curvature parameter γ to match a given value of the elasticity of the job finding rate (unemployment duration) with respect to benefit payments for the short-term unemployed.[23] Guided by the empirical evidence we summarize below, we choose a target (micro) elasticity of job search with respect to UI of -0.7 for the short-term unemployed, which yields a curvature parameter of $\gamma = 1.317$. Our target elasticity of -0.7 lies in the middle of the range chosen by the previous literature. For example, Krebs and Scheffel (2013) and Mitman and Rabinovich (2015) choose a value of -0.9 and Landais, Michaillat, and Saez (2015) choose a value of -0.5. Krause and Uhlig (2012) and Ljungqvist and Sargent

[23] More precisely, we target the elasticity $\frac{b_{su}}{\pi_{e|su}}\frac{\partial \pi_{e|su}}{\partial b_{su}}$, where the derivatives are computed numerically assuming a one percent change in b_{su} for fixed labor market conditions (partial equilibrium). Note that with linear search effort, as assumed in specification (25), we have $\frac{b_{su}}{\pi_{e|su}}\frac{\partial \pi_{e|su}}{\partial b_{su}} = \frac{b_{su}}{l_{su}}\frac{\partial l_{su}}{\partial b_{su}}$, that is, the elasticity of the job finding rate with respect to unemployment benefits is equal to the elasticity of search effort with respect to unemployment benefits.

(1998) do not report the implied elasticity, but their results suggest that it is larger than -0.7. Given the wide range of empirical estimates and the different assumptions made in the literature, we provide an extensive sensitivity analysis in Section 7.

Under certain assumptions, the parameter γ in (26) is closely related to the Frisch-elasticity of labor supply. Specifically, assume that workers' preferences over work and search are represented by a type-independent disutility function $\tilde{d} = (l + n)^\gamma$, where n is the time spent working and l is the time spent searching. Note that this disutility function is related to specification (26) through $d_e = \tilde{d}(\bar{n})$ and $d_s(l) = \tilde{d}(l)$ for $s = su, lu$, where $\bar{n}$ is the fixed number of hours an employed worker spends working. If employed workers do not search, $l = 0$ for $s = e$, and choose the number of hours worked, n, then it is straightforward to show that $\gamma = 1 + \frac{1}{\kappa}$, where κ is the Frisch-elasticity of the optimal choice of n. Given the value of $\gamma = 1.317$ in the baseline calibration, we find $\kappa = 3.155$. This value of κ is in line with the values used in the macroeconomic literature, but substantially higher than the empirical micro-literature has found (Trabandt and Uhlig, 2011). We therefore consider in our robustness analysis in Section 7 a calibration of the model with a value of κ that is significantly lower than the value used in the baseline calibration.

We conclude this subsection with a brief discussion of the empirical evidence regarding the search elasticity with respect to unemployment benefits.[24] For the US, there are a number of empirical micro studies estimating this search elasticity. The best known studies are Moffitt (1985) and Meyer (1990) who estimate an elasticity of around -0.9. Krueger and Meyer (2002) survey the literature and suggest an elasticity of -1.0, whereas Chetty (2008) suggests a value of -0.5. Card et al. (2015) provide new evidence using administrative data from the state of Missouri covering the period 2003-2013. Based on identification coming from a regression kink design, they find an elasticity of around 0.35 before the recession and an elasticity between 0.65 and 0.9 after the recession. Krueger and Mueller (2010) analyze time use data and find that the level of unemployment benefits has a large negative effect on the time unemployed workers spent searching for a job, a finding that provides additional evidence that UI affects search incentives. Finally, Farber and Valletta (2015) and Rothstein (2011) find that the recent benefit extension during the Great Recession in the US had only

[24]Here we focus on the micro-elasticity. The empirical literature regarding the wedge between micro-elasticity and macro-elasticity is discussed in Section 7. Note that this wedge is zero in our baseline model.

small effects on individual job finding rates, whereas Johnston and Mas (2016) find larger effects.

For Germany, Hunt (1995) finds estimates that are in line with the US estimates of Moffitt (1985) and Meyer (1990). Addison, Centeno and Portugal (2008), who use a structural search model and the European Community Household Panel (ECHP), find values of the search elasticity ranging from -1.14 to -1.66 for Germany. Consistent with these findings are the results reported in Hofmann (2012) and Mueller and Steiner (2008), who find that imposing benefit sanctions/reductions on long-term unemployed for non-compliance has significant effects on the unemployment-to-employment transition in Germany. With the exception of these last two studies, the empirical literature has focused on unemployed workers who are short-term unemployed according to our definition (less than one year of unemployment).

5.4 Skill Loss During Unemployment

There is substantial empirical evidence that job loss leads to subsequent lower wages and earnings, and that these wage losses increase with the duration of unemployment. For the US, Addison and Portugal (1989) use data drawn from the Displaced Worker Survey and find that an increase in the unemployment duration by 10% reduces wages between 0.8% and 1.4%. Using the same data, Neal (1995) finds that an additional week of unemployment reduces the wages by 0.37%, implying a monthly rate of wage loss of 1.5%. Further, using a structural approach Keane and Wolpin (1997) estimate rates of skill depreciation during unemployment that are even higher. These findings of substantial skill depreciation during unemployment are consistent with empirical results pointing to a negative effect of unemployment benefits on re-employment wages (Card, Chetty, and Weber, 2007).

In a recent study of middle-aged workers in Germany, Schmieder, Wachter, and Bender (2016) use a large administrative data set to implement a regression discontinuity (RD) design and find that each month out of work reduces reemployment wages by 0.8 percent (a quarterly depreciation rate of 2.4 %), pointing to substantial costs of long unemployment spells.[25] Their estimation strategy controls for possible changes in the reservation wage of

[25]Note that young workers might experience less direct skill depreciation during unemployment than middle-aged workers, but they also miss out on moving up the job ladder, an effect that empirical work has shown to be quite substantial and to vary with business cycle conditions (Heisz, Oreopoulos, and Wachter,

workers, and is therefore well suited to serve as a basis for calibrating the current model.

The empirical studies surveyed above estimate earnings losses for short-term unemployed workers. It seems plausible that skill depreciation is more severe for long-term unemployed workers, but empirical evidence on this issue is scarce. We therefore assume that the skill depreciation rates of short-term unemployed workers and long-term unemployed workers are the same: $\delta_{h,su} = \delta_{h,lu}$. Guided by the findings of the empirical literature, we set the skill depreciation parameter, $\delta_{h,su} = \delta_{h,lu}$, to a quarterly depreciation rate of 2.5%. This value is lower than the skill depreciation assumed in the baseline calibration of Ljungqvist and Sargent (1998). We study the effect of changes in the target value in our robustness analysis in Section 7.

5.5 Wage Growth and Wage Risk

Recall that ϵ is the percentage change in wages/earnings of employed workers – see equation (1). We assume that $\ln(1+\epsilon)$ is normally distributed with mean μ and variance σ^2. Clearly, in our model log wages/earnings follow a random walk with drift; this follows from the human capital equation (1) in conjunction with the assumption that ϵ is i.i.d. We choose the drift parameter, μ, so that the average annual growth rate of the economy is one percent. This target value is chosen as a compromise between the somewhat higher annual output growth in Germany and the somewhat lower wage growth rate over the sample period. We choose σ in line with empirical estimates of the permanent component of individual earnings risk. For the US, the random walk component of individual wages/earnings has been estimated by a number of empirical studies using data drawn from the PSID, and estimates of σ for the US are in the range of 0.15 for annual wage changes, which amounts to quarterly standard deviation of $0.15/2 = 0.075$. For Germany, Fuchs-Schuendeln, Krueger, and Sommer (2010) find similar values, and we therefore choose the value $\sigma = 0.075$.

5.6 Unemployment Benefits

We calibrate the unemployment benefit parameters, b_{su} and b_{lu}, as follows. The average net replacement rate for short-term unemployed workers in Germany was 0.63 in the period 2000-2004 (see Figure 2), which suggests a value of $b_{su} = 0.63$. In our model without

2012).

equilibrium asset holdings, this value for b_{su} implies that workers who move from employment to unemployment experience a consumption drop of 37 percent upon becoming unemployed. Clearly, a drop of this size is unrealistically large. For example, using US data Gruber (1997) finds that job loss is associated with an average consumption drop of at around $7-10$ percent. We are not aware of any study that provides corresponding estimates for Germany, but we note that in Germany the consumption drops in the case of job separation are most likely larger than the corresponding consumption drops in the US given that in Germany a larger part of job separations is due to events outside the control of workers (i.e. job displacement). For our baseline calibration we choose $b_{su} = 0.85$ (a consumption drop of 15 per cent) and conduct an extensive sensitivity analysis in Section 7.

We choose the unemployment benefit parameter b_{lu} to match the difference in the net replacement rate of the short-term unemployed and long-term unemployed, which in the model is equal to $\frac{b_{su}-b_{lu}}{(1-\tau)w}$. The OECD reports the net replacement rates for short-term and long-term unemployed workers in Germany for different groups of households, where long-term unemployment is defined as unemployment duration longer than one year. Krebs and Scheffel (2013) use the OECD data to compute a population-weighted average annual net replacement rate for the time period 2000-2010. For the period 2000-2004, this net replacement rate has been 0.63 for the short-term unemployed and 0.57 for the long-term unemployed, that is, we target a difference of 0.06 percentage points. This yields a parameter value of $b_{lu} = 0.79$.

5.7 Discount Factor and Cost of Financial Intermediation

We choose a quarterly discount factor of $\beta = 0.99$ in line with work in the real business cycle literature (Cooley, 1995). For our baseline calibration, the implied quarterly interest rate (lending rate) using (A1) is $r_f = 0.73\%$. Further, using (A2) we find that the minimal quarterly interest rate spread (cost of financial intermediation) that leads to the no-asset-trade equilibrium of proposition 1 is $\alpha_{min} = 0.36\%$. A quarterly spread of 0.36% between lending rate and borrowing rate is moderate compared to observed interest rate spreads, and we conclude that our equilibrium analysis is based on realistic values for the cost of financial intermediation. Note that Mehra, Piguillem, and Prescott (2011) use an annual interest rate spread of 2 percent when they calibrate a neoclassical growth model with cost of financial intermediation to the US economy.

5.8 Cyclical Variations in Job Finding and Job Destruction Rates

The job destruction process is defined by four parameters: the two transition probabilities, $\pi(R|R)$ and $\pi(N|N)$, and the two job destruction rates, $\pi_{su|e}(R)$ and $\pi_{su|e}(N)$. The already specified targets for the steady state unemployment rate and the steady state job finding rates (see above) determine the steady state job destruction rate and therefore impose one restriction on these four parameters. We impose three additional restrictions by requiring the model to match the frequency of recessions, and the persistence and severity of the hike in the job destruction rate during a typical recession in Germany. Finally, we set the value of the matching efficiency parameters $\Psi(N)$ and $\Psi(R)$ so that the normalization $\Psi(N)\pi(N) + \Psi(R)\pi(R) = 1$ is satisfied and the model matches the observed decline in the job finding rate during a typical pre-reform recession in Germany.

It remains to determine empirically the behavior of job finding rates and job destruction rates during pre-reform recessions in Germany. To this end, we use data on flow rates between employment and unemployment for the period 1980-2000 from Jung and Kuhn (2014) and identify recessions with a time in which the job destruction rate falls below the HP-trend for at least two quarters. See the Appendix for a detailed discussion of our approach and how it compares with alternative dating methods for recessions in Germany. We use the recession dates in conjunction with the cyclical component of job destruction rates and job finding rates to compute the average change in these flow rates during recessions. Details can be found in the Appendix.

Based on the approach just described, we find that in the period 1980-2000 in Germany there was a 30 percent chance of being in a recession and that the typical recession lasted for 8 quarters. Further, the job destruction rate increased on average by 9.43 percent and the job finding rate decreased on average by 6.55 percent during the typical recession. Using these targets, we find the parameter values $\pi(R|R) = 0.8750$, $\pi(N|N) = 0.9464$, $\pi_{su|e}(R) = 0.0182$, $\pi_{su|e}(N) = 0.0160$, $\Psi(N) = 1.0056$, and $\Psi(R) = 0.9869$.

Table A1 in the Appendix summarizes our choice of parameter values for the baseline calibration.

At this state, two comments are in order. First, in the calibrated model as well as in the German data, the job destruction rate is more volatile than the job finding rate. In other words, in Germany a recession is mainly characterized by an increase in job destruction accompanied by a mild decline in the job finding rate. This feature of the German labor market stands in contrast to the labor dynamics in the US, where job finding rate are strongly counter-cyclical. Jung and Kuhn (2014) provide a detailed comparison of the two labor markets and conclude that cyclical movements in the job destruction rate account for around 2/3 of the volatility of the unemployment rate in Germany, whereas they account for only 1/3 of the volatility of the unemployment rate in the US.

Second, in our calibrated model economy search effort is mildly pro-cyclical – it declines by 4.51 percent during a typical recession. In contrast, Christiano, Trabandt, and Walentin (2010), Gomme and Lkhagvasuren (2015), and Veracierto (2008) use search models calibrated to the US economy, and find that search effort is strongly pro-cyclical in the calibrated model economy. Clearly, the difference is explained by the difference in empirical targets (see the preceeding paragraph). Empirical evidence on the cyclicality of search time of non-employed workers is not conclusive. For example, using data drawn from the Current Population Survey (CPS) for the period 1994-2004), Shimer (2004) constructs measures of search intensity and shows that these measures are either a-cyclical or (slightly) counter-cyclical. Mukoyama, Patterson, and Sahin (2014) also find that search intensity is counter-cyclical based on their analysis of data drawn from the CPS and the American Time Use Survey (ATUS). In contrast, both DeLoach and Kurt (2013) and Gomme and Lkhagvasuren (2015) find that individual search intensity is pro-cyclical based on their analysis of data drawn from the CPS and the American Time Use Survey (ATUS). We are not aware of any empirical study of this issue based on German data.

5.9 Unemployment and Output Dynamics during Recessions

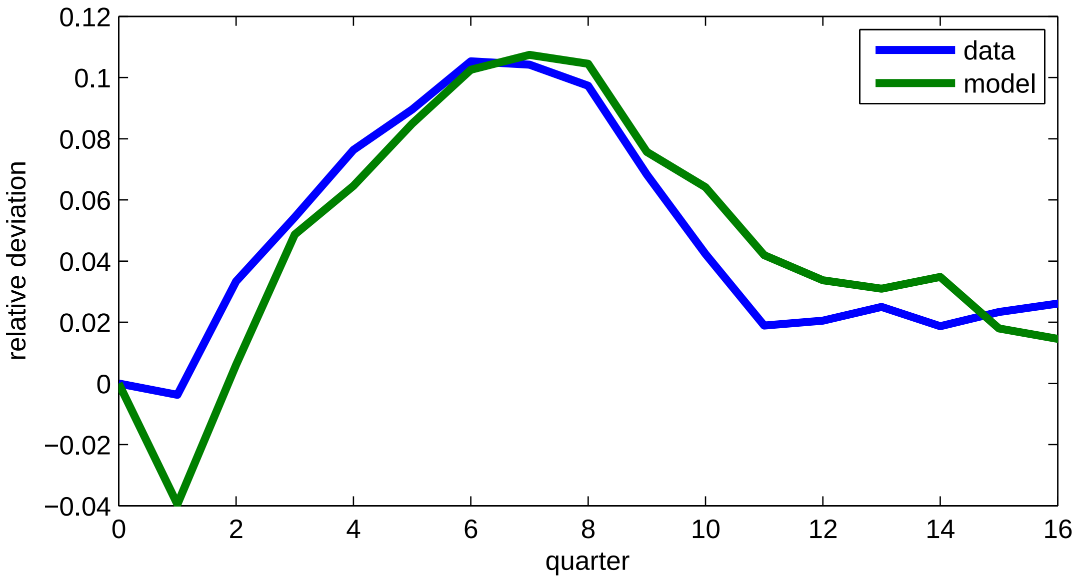
We now compute the dynamics of unemployment and output during recessions implied by the calibrated model economy and compare the results with the pre-reform data. To make this comparison meaningful, we construct from the data the cyclical component of the unemployment rate and output, and compare the model prediction with the observed movement of the cyclical component of unemployment and output during recessions. The data and the construction of the cyclical component are discussed in the Appendix.[26]

Figure 6 shows the unemployment dynamics during a typical pre-reform recession according to the model and the data. To construct the model prediction, we assume that the model economy is initially in steady state and then feed into the model a pathes of job destruction rates and matching efficiency that match the observed recession pathes of the cyclical component of job destruction rates and job finding rates. Figure 6 shows that the model matches well the unemployment dynamics observed during the typical pre-reform recession. Given that the model matches by construction the worker flow between unemployment and employment, this means that the flow of workers into and out of the labor force is not an important driver of the unemployment dynamics during recessions in Germany. In the Appendix, we show that the same holds for the employment dynamics, that is, the model matches equally well the employment dynamics during the typical pre-reform recession in Germany.

Figure 7 shows the output dynamics (relative to trend) during a typical pre-reform recession according to the model and the data. The figure shows that the calibrated model economy captures about two-thirds of the observed drop in output during the typical pre-reform recession. Thus, the main driver of the output dynamics during a typical pre-reform recession in Germany is the flow of workers between employment and unemployment. In contrast, changes in labor productivity and the number of hours worked per employed worker have a smaller impact on the output dynamics, though their impact is non-negligible. Figure 7 also shows that the calibrated model economy implies a somewhat stronger recovery than is observed in the data. In other words, the model under-states the observed hysteresis effect in output.

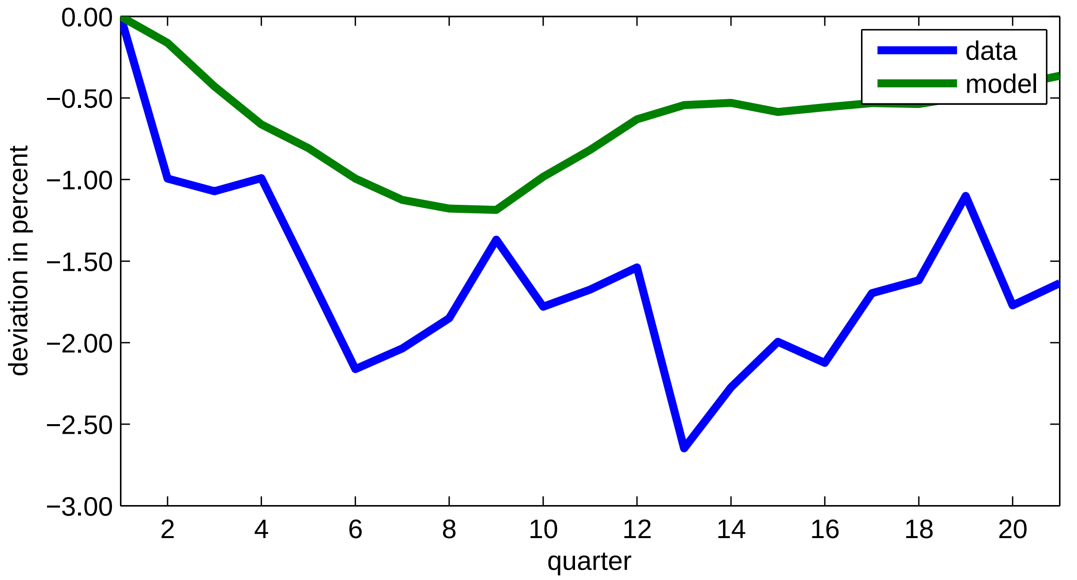
[26]We use an HP-filter to construct the cyclical components of job finding rates and job destruction rates as well as unemployment rates. In contrast, we do not apply the HP-filter to the output series since this is not a valid method in the presence of hysteresis effects. More precisely, applying the HP-filter means that by construction output reverts to its mean so that any impact of recessions on trend output is negated. Our approach of using two different detrending methods for different time series seems appropriate given that, according to the model, output displays hysteresis effects, but worker flow rates and unemployment do not.

Figure 6: Cyclical Unemployment during Pre-Reform Recessions: Data and Model



Notes: The blue line shows the cyclical component of the unemployment rate during the typical pre-reform recession (data). Unemployment in the typical pre-reform recession is the average over the three recessions starting in 1981Q2, 1992Q4, and 1995Q4. The cyclical component of unemployment is computed using the HP-filter. The green line shows the deviation of the unemployment rate from its long-run level in a pre-reform recession according to the model.

Figure 7: Output during Pre-Reform Recessions: Data and Model



Notes: The blue line shows output relative to its trend during the typical pre-reform recession (data). Output in the typical pre-reform recession is the average over the three recessions starting in 1981Q2, 1992Q4, and 1995Q4. Trend output is computed as the sample mean over the sample period 1980-2000. The green line shows output relative to its trend in a pre-reform recession according to the model.

Overall, we conclude that the calibrated model economy matches almost perfectly the unemployment dynamics during pre-reform recessions in Germany. Further, it matches reasonably well the output dynamics during pre-reform recessions in Germany.

6. Quantitative Results

In this section, we present the quantitative results based on the equilibrium analysis of the calibrated model economy. Recursive equilibria are computed using proposition 1 – see the Appendix for details. Section 6.1 discusses the effect of the Hartz III reform (improvement in JSA) and the Hartz IV reform (reduction in UI) on model parameters. Section 6.2 analyzes the effect of the two reforms on the steady-state component of the job finding rate, that is, their effect on labor market fluidity according to the calibrated model economy. Section 6.3 presents the dynamic response of the unemployment rate and output to an adverse shock that resembles the typical recession shock, and how this dynamic response has changed due to the Hartz III reform and the Hartz IV reform. Section 6.4 computes the output cost of recessions and discusses the effect of the Hartz III reform and the Hartz IV on this cost. Finally, Section 6.5 analyzes the welfare cost of recessions and how the two reforms have changed the welfare cost of recessions.

6.1 Reform Effects on Model Parameters

In Section 2 we discussed the empirical evidence regarding the effect of the Hartz III reform on matching efficiency and concluded that this reform increased matching efficiency by $7-16$ percent. Based on this evidence, we assume in the baseline scenario that the Hartz III reform increased matching efficiency by 8 percent, that is, in our quantitative analysis we simulate the effect of the Hartz III reform as an increase in the efficiency parameters x_{su} and x_{lu} by 8 percent. Clearly, this choice is relatively conservative given the available evidence. There is also evidence that this increase in job search efficiency did not increase the resource costs of providing job search assistance – total spending on active labor market policy per unemployed worker declined in the years after the Hartz III reform (Bach and Spitznagel, 2012). Thus, we assume that in our analysis below that the Hartz III reform increases x_{su} and x_{lu} by 8 percent without a change in the cost term, $\lambda(x)$, entering the government budget constraint.

An increase in matching efficiency by 8 percent is quite substantial, but not implausibly large for two reasons. First, there was significant potential for improvement in pre-reform Germany since JSA was basically non-existent before the reform since the Public Employment Agency had no incentive to provide good JSA before its restructuring in the wake of the Hartz III reform and private providers could not compete due to heavy regulations. Second, JSA has been shown to have substantial effects on re-employment rates of unemployed job seekers in many cases – see Card, Kluve, and Weber (2010) for a survey of the empirical literature. Of course, most of the empirical work on job search assistance is microeconomic in nature and does not take into account the possibility of negative externalities through equilibrium effects (Cahuc and Le Barbanchon, 2010). We discuss our results in the presence of such equilibrium effects in the robustness analysis in Section 7, where we also discuss the empirical literature on this issue. Here we only note that the empirical results of Fahr and Sunde (2009) and Klinger and Rothe (2012) regarding the change in matching efficiency caused by the Hartz III reform are based on a semi-aggregate approach that accounts for possible equilibrium effects within an occupation or region. Thus, our baseline scenario only overstates the effect of the Hartz III reform if there are strong negative externality effects across regions or occupations, which is somewhat unlikely given the low occupational and regional mobility in Germany (Jung and Kuhn, 2014).

As discussed in Section 2, the Hartz IV reform led to a substantial reduction in the unemployment benefits for the long-term unemployed, but did not change the unemployment benefits for the short-term unemployed. Figure 2 shows that the net replacement rate for the long-term unemployed decreased by 11 percentage points. Motivated by this evidence, we model the Hartz IV reform as a reduction in the benefit parameter b_{lu} by 11 percentage points keeping the benefit parameter b_{su} unchanged.

6.2 Long-Run Reform Effects on Job Finding Rates and Unemployment

In the previous section, we argued that the Hartz III reform improved the quality of JSA leading to an increase in matching efficiency by 8 percent and that the Hartz IV reform reduced UI for the long-term unemployed by 11 percentage points leading to an improvement in search incentives. This in turn leads to an increase in job finding rates at all stages of the business cycle – the German labor market has become more fluid. According to the baseline model, the Hartz III reform and the Hartz IV reform taken together led to an increase in the long-run quarterly job finding rate from 24 percent to 30.6 percent for the short-term unemployed and an increase from 6 percent to 8.7 percent for the long-term unemployed.[27] Thus, the two reforms increase the job finding rate permanently by almost 50 percent for the long-term unemployed and by roughly 30 percent for the short-term unemployed, which suggests a marked increase in the fluidity of the German labor market. Note that this model implication is in line with the available time series evidence – see Figure 3 and our discussion in Section 2.

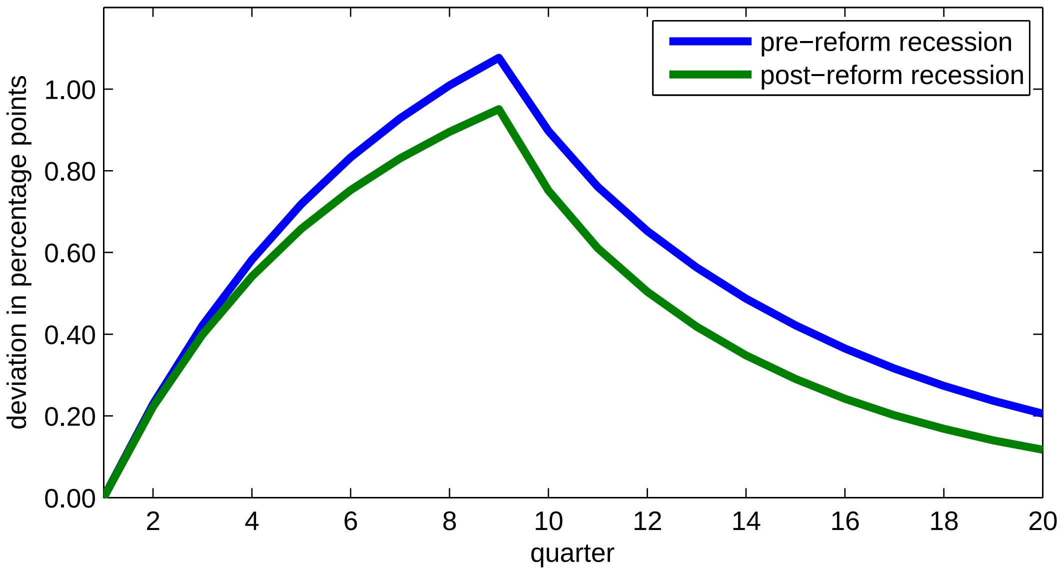
The reform-induced increase in the non-cyclical component of the job finding rates reduces unemployment at all stages of the business cycle. According to the baseline model, the two reforms (Hartz III plus Hartz IV) reduced the non-cyclical component of the unemployment rate by 2.4 percentage points. This unemployment reduction is quite substantial, but in line with the results reported in Krebs and Scheffel (2013) and bracketed by the effects found by Krause and Uhlig (2012), who find a larger unemployment effect, and Launov and Waelde (2013), who find a smaller unemployment effect. We relegate to the Appendix a detailed discussion of the long-run effects of the two labor market reforms on the various macroeconomic variables.

6.3 Reform Effects on Dynamic Response to Recession Shock

In this section, we use the model to simulate the pre-reform and post-reform unemployment and output response to an adverse macroeconomic shock that resembles the typical pre-reform recession shock in Germany. Specifically, we consider the steady state of the calibrated model economy without aggregate shocks and then compute the pre-reform and post-reform equilibrium response to an increase in the job destruction rate by 9.43 percent for 8 quarters and a decline in matching efficiency by 5.82 percent for 9 quarters. The hike in the job destruction rate and the implied decline in the job find rate match the corresponding values that occur during the typical pre-reform recession in Germany – see also our discussion in Section 5.

[27]Note that we compute long-run values (i.e. the non-cyclical component) by taking the average over business cycle conditions using the model economy with aggregate shocks. The results barely change when we compute steady state values of the model economy without aggregate shocks.

Figure 8: Cyclical Unemployment during Pre-Reform and Post-Reform Recessions (Model)



Notes: The blue line shows the cyclical component of the unemployment rate following a recession shock before the implementation of reform. The green line shows the cyclical component of the unemployment rate following a recessions shock after the implementation of the Hartz III and Hartz IV reforms. A recession shock is defined as an increase in the job destruction rate and a reduction in search efficiency of their recession values for eight quarters.

In Figure 8 we plot the response of the unemployment rate to the recession shock before and after the two reforms (Hartz III and Hartz IV) have been implemented. The figure shows that in both cases, before and after the two reforms, the unemployment rate rises in response to the shock for 8 quarters, and then declines slowly to converge back to its steady state level. In other words, there is no hysteresis effect in unemployment and labor market reforms do not affect the long-run response of unemployment to a temporary shock. However, labor market reforms do change the dynamics of unemployment following a recessions shock. Specifically, for the unreformed economy the increase in the unemployment rate peaks at a lower level than the peak for the reformed economy.[28] Further, in the reformed economy the

[28]The steady state unemployment rates pre-reform and post-reform are not the same, and the same holds for output growth. To facilitate the comparison, in Figure 8 we show the deviation from the pre-reform, respectively post-reform, steady state unemployment rate. Similarly, Figure 9 shows the deviation of output from pre-reform, respectively post-reform, steady state output growth.

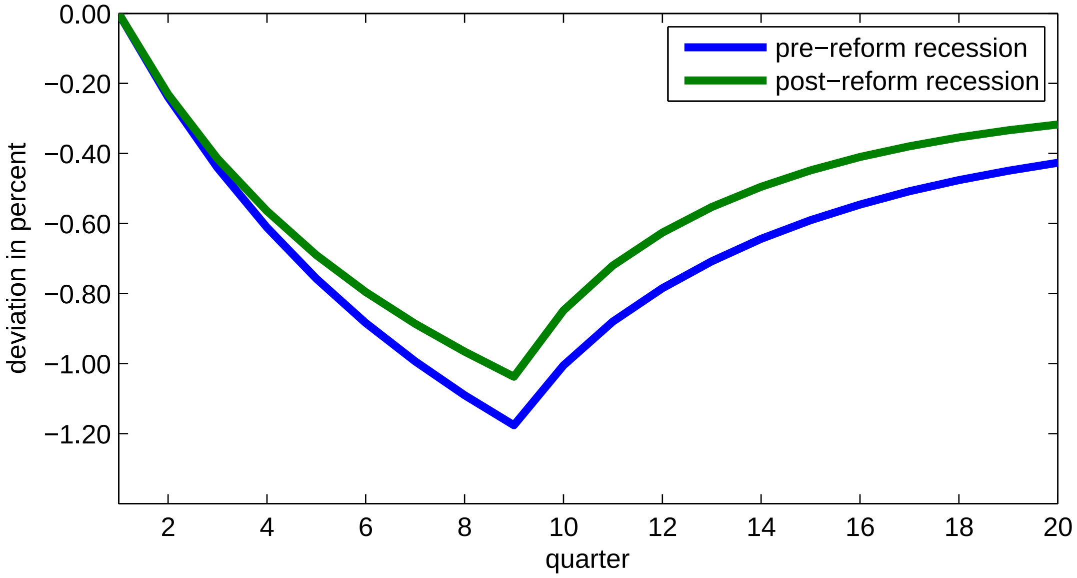
convergence to the steady state is substantially faster than in the unreformed economy so that the above-trend increase in the unemployment rate is smaller in the reformed economy than in the unreformed economy. Clearly, both effects are due to the reform-induced increase in job finding rates. Thus, we conclude that the increase in labor market fluidity brought about by the Hartz III and Hartz IV reforms have improved the cyclical performance of the German labor market significantly.

In Figure 9 we plot the response of output to a typical recession shock before and after the implementation of the two reforms. The figure shows that in both cases, before and after the Hartz III and Hartz IV reforms, aggregate output declines for eight quarters in response to the shock, and then recovers slowly to converge to a level that is lower than the pre-shock output level. In other words, recessions have a permanent effect on output (hysteresis), a result that is driven by the scarring effect of recessions. Figure 9 also shows that the two reforms, and the corresponding improvement in labor market fluidity, have changed the output response to a recession shock in two important ways. First, after reform implementation output recovers much more swiftly following a recession shock than before the reform. Second, the permanent output losses associated with recessions are smaller after the reform than before the reform. In other words, there is temporary shocks have a permanent effect on output and labor market reform reduces this hysteresis effect of temporary shocks. Overall, we conclude that the reform-induced increase in labor market fluidity has reduced both the temporary and the permanent outputs losses associated with recessions – the German economy has become more resilient to adverse macroeconomic shocks.

Our finding that recessions lead to substantial losses in potential output is in line with recent empirical evidence based on time series macro data.[29] Specifically, Atkinson, Luttrell, and Rosenblum (2013) and Hall (2014) suggest that the Great Recession had a non-negligible effect on the level of potential output in the US and Ball (2014) and IMF (2015) find similar effects for other advanced economies. Further, Blanchard, Cerutti, and Summers (2015) show that this result also holds for many previous recessions. A common conclusion drawn from these empirical findings is that optimal macroeconomic stabilization policy has to be

[29]Blanchard and Summers (1987) argue that insider-outsider models of the labor market give rise to hysteresis effects and Pissarides (1992) suggests, as we do, that skill depreciation during unemployment generates long-lasting effects of temporary shocks.

Figure 9: Output during Pre-Reform and Post-Reform Recessions (Model)



Notes: The blue line shows output relative to its trend following a recession shock before the implementation of reform. The green line shows output relative to its trend following a recessions shock after the implementation of the Hartz III and Hartz IV reforms. A recession shock is defined as an increase in the job destruction rate and a reduction in search efficiency of their recession values for eight quarters.

more aggressive (Blanchard, Cerutti, and Summers, 2015). Here we show that the presence of hysteresis effects implies that there is more need for reforms that make the labor market more fluid.

The empirical findings of the literature on job displacement also suggest substantial effects of recessions on potential output. Jacobson, LaLonde, and Sullivan (1993) show that the long-term earnings losses of US workers who were displaced during recessions are much higher than for workers who lost their job during normal economic times, and this finding has been corroborated by many subsequent studies. See, for example, Davis and Wachter (2011) for a recent study and a review of the literature and Guvenen et al. (2014) for related evidence on the cyclical nature of individual income risk. For Germany, Burda and Merton (2001) also find that the long-term earnings losses of displaced workers increase during recessions, but their estimates are relatively imprecise. According to our calibrated baseline model, the long-term earnings losses of unemployed workers increase by 7 percent in recessions relative to their value in normal times.

The dynamics depicted in Figures 8 and 9 is caused by a recession shock that changes both job destruction rates and job search efficiency. We find that most of the unemployment and output response shown in the two figures is driven by the hike in job destruction rate that occurs during recessions, and only a small part is due to the change in search efficiency. More precisely, if we consider a recession in which search efficiency does not change, then about 90 percent of the (pre- and post-reform) unemployment and output response depicted in Figures 8 and 9 still remains. This result is expected given that in Germany the cyclical component of the job separation rate is much larger than the cyclical component of the job finding rate, which implies that the cyclical variations in job search efficiency in the calibrated model economy are small – see also our discussion in Section 5.

6.4 Output Cost of Recessions

In the previous section we analyzed the output losses associated with a typical recession shock before and after the reform. We now turn to a discussion of the average output losses associated with many recessions shocks when these shocks are generated by the stochastic process generating the pre-reform, respectively post-reform, data. In other words, we now compute the output cost of recessions, Δ_y, according to (22). Table 1 summarizes the results assuming normal economic conditions at the time of the elimination of recessions, $S_0 = N$.

Table 1 shows that the output cost of recessions is substantial: 2.014 percent of lifetime consumption for our baseline model. Table 1 further shows that both the Hartz III reform (improvement in JSA) and the Hartz IV reform (reduction in UI) lead to a significant reduction in the output cost of recessions. Specifically, we find that the Hartz III reform reduces the output cost of recessions by 14.2 percent from 2.014 percent of lifetime consumption to 1.728 percent of lifetime consumption. Similarly, the Hartz IV reform reduces the output cost of recessions by 13.4 percent from 2.014 percent of lifetime consumption to 1.745 percent of lifetime consumption. Further, taken together the two reforms lead to a reduction of the output cost of recessions by 25.0 percent from 2.014 percent of lifetime consumption to 1.510 percent of lifetime consumption. Clearly, this is a substantial reduction, which is driven by the reform-induced increase in the non-cyclical component of the job finding rate and the corresponding improvement in labor market fluidity discussed before.

Table 1: Output Cost of Recessions (in Percent)

	Δ_y		Δ_y^{perm}	Δ_y^{trans}	Δ_y^{des}	Δ_y^{eff}
Pre Reform	2.014		0.651	1.362	1.857	0.156
Post Hartz-III-Reform	1.728	(14.2%)	0.550	1.178	1.698	0.030
Post Hartz-IV-Reform	1.745	(13.6%)	0.807	0.939	1.600	0.145
Post Hartz-III&IV-Reform	1.510	(25.0%)	0.515	0.995	1.483	0.027

Notes: Δ_y is the output cost of recessions in percent of lifetime consumption (potential output). The values in brackets are the percentage deviation from the pre-reform allocation. Δ_y^{perm} is the permanent component and Δ_y^{trans} is the transitory component of the output cost of recessions. Δ_y^{des} is the component of the output cost of recessions that is due to changes in job destruction rates and Δ_y^{eff} is the component of the output cost of recessions that is due to changes in matching efficiency.

There are two exogenous forces causing recessions and therefore generating the output cost of recessions: an increase in the job destruction rate and a decline in matching efficiency. Table 1 shows that most of the output cost of recessions is generated by the hike in job destruction rates during recessions, and only a small part is due to the decrease in matching efficiency. More precisely, when we decompose Δ_y into one part that measures the output cost of the increase in job destruction rates and a second part that measures the output cost due to the drop in matching efficiency, then the first part makes up more than 90 percent of the total cost. This result is not surprising given that cyclical fluctuation of job destruction rates are much larger than cyclical fluctuations in job finding rates in Germany – see our discussion in Section 5. Further, it accords well with our finding that recession shocks in Germany mainly affect output through their effect on job destruction rates – see our discussion in the previous section.

The output cost of recessions can be decomposed in a second way. Specifically, the output cost of recessions has a temporary component measuring the output losses due to the temporary employment drop during recessions and a permanent component corresponding to the losses in potential (long-run) output due to the scarring effect of recessions – see also Figure 7. To assess the relative importance of these two components, we compute the temporary output cost of recessions defined as the (expected) present discounted value of output losses generated by the employment drop during recessions. We find that the temporary cost component is about two thirds of the total cost and the permanent component about one third. Thus, both temporary cost and permanent cost are important components of the total cost of recessions, but the temporary cost is somewhat larger than the permanent cost.

We have also computed the output costs of recessions, Δ_y, assuming recession conditions at the time of the elimination of recessions, $S_0 = R$. Compared to the case $S_0 = N$ this increases the output cost of recessions slightly (from 2.014 percent to 2.043 percent of lifetime consumption), and the percentage reduction in Δ_y due to the Hartz III reform and the Hartz IV reform are almost identical (not reported here).

6.5 Welfare Cost of Recessions

Table 2 summarizes our quantitative results regarding the welfare cost of recessions. We compute the welfare costs of recessions, Δ, using equation (20) assuming normal economic conditions at the time of the elimination of recessions, $S_0 = N$. Further, we use as welfare weights $\mu_s = \Omega_{0,s}$ so that we can rely on the decomposition (25), but our results barely change if we use the more standard utilitarian welfare weights $\mu_s = U_{0,s}$ for $s = su, lu$ and $\mu_e = 1 - U_{0,su} - U_{0,lu}$.

The welfare cost of recessions is substantial, but considerably smaller than the output cost of recessions shown in Table 1. For example, pre-reform the welfare cost of recessions is 1.310 percent of lifetime consumption, whereas the output cost of recessions is 2.014 percent of lifetime consumption. To understand this difference, Table 2 also shows the risk cost of recessions, Δ_r, and the effort cost of recessions, Δ_e, as defined in Section 4. We find that the risk cost of recessions is 0.244 percent of lifetime consumption and the effort cost of recessions is -0.947 percent of lifetime consumption. In other words, recessions are times when risk is high (positive Δ_r) and effort goes down (negative Δ_e). Further, both cost components are non-negligible, but the effort cost/gain of recessions is larger than the risk cost of recessions. Thus, the welfare cost of recessions, Δ, which is sum of the three components Δ_y, Δ_r, and Δ_e according to the decomposition (25), is larger than the output cost of recessions.

Table 2: Welfare Cost of Recessions (in Percent)

	Δ		Δ_y	Δ_r	Δ_l
Pre Reform	1.310		2.014	0.244	−0.947
Post Hartz-III-Reform	1.205	(8.0%)	1.728	0.199	−0.722
Post Hartz-IV-Reform	1.277	(2.5%)	1.745	0.209	−0.676
Post Hartz-III/IV-Reform	1.181	(9.8%)	1.510	0.179	−0.508

Notes: All welfare changes are expressed in percent of equivalent variations in lifetime consumption and welfare weights are $\mu_{su} = \Omega_{su}$, $\mu_{lu} = \Omega_{lu}$, and $\mu_e = 1 - \Omega_{su} - \Omega_{lu}$. Δ is the welfare cost of recessions. The values in brackets are the percentage deviation from the pre-reform allocation. Δ_y is the output cost of recessions, Δ_r is the risk cost of recessions, and Δ_l is the effort cost of recessions.

Table 2 also shows that the Hartz III reform (improvement in JSA) reduced the welfare cost of recessions by 8.0 percent from 1.310 percent of lifetime consumption to 1.205 percent of lifetime consumption. This is a substantial reduction, but smaller than the reduction in the output cost of recessions induced by the Hartz III reform (compare Table 1 and Table 2). The main reason for this difference is that the Hartz III reform, while reducing the risk cost of recessions, increases the effort cost of recessions. Table 2 shows that the second effect dominates so that the effect of the Hartz III reform on the welfare cost of recessions is smaller than its effect on the output cost of recessions. In other words, the Hartz III reform has made the labor market more fluid decreasing both the output cost and welfare cost of recessions, but part of the increase in fluidity has come at the cost of higher search effort so that the reform effect on the welfare cost of recessions is smaller than reform the effect on the output cost of recessions.

Furthermore, the Hartz IV reform (reduction in UI) reduced the welfare cost of recessions by 2.5 percent from 1.310 percent of lifetime consumption to 1.277 percent of lifetime consumption. This is significantly smaller than the reduction in the output cost of recessions by 13.4 percent caused by the Hartz IV reform (compare Table 1 and Table 2). As in the case of the Hartz III reform, the difference arises because the Hartz IV reform increases the effort cost of recessions. This cost effect is very pronounced in the case of the Hartz IV reform so that the net effect of the reform on the welfare cost is small even though it reduces the output cost by a substantial amount.[30]

Finally, Table 2 reports the combined effect of Hartz III and Hartz IV on the welfare cost of recessions. These two reforms taken together reduced the welfare cost of recessions in Germany by 9.9 percent from 1.310 percent of lifetime consumption to 1.181 percent of lifetime consumption. Thus, the effect of this reform package on the welfare cost of recessions is non-negligible, but substantially smaller than its effect on the output cost of recessions. As before, the reason for the difference is that the reform package increases the effort cost of recessions. Note that the combined effect of these two reforms is somewhat lower than the sum of the individual effects of the two reforms, but this non-linearity is not very pronounced.

We find that the welfare cost of recessions is larger for unemployed workers than for employed workers, but that the difference is not very large. For example, the welfare cost of recessions is 1.313 percent of lifetime consumption for employed workers, 1.300 percent of lifetime consumption for short-term unemployed workers, and 1.271 percent of lifetime consumption for long-term unemployed workers. Further, the reform-induced reduction in the welfare cost of recessions are is very similar across the different worker types.

Table 2 assumes that recessions are eliminated in normal times, that is, we use $S_0 = N$ in equation (18). The welfare cost of recessions become larger when we assume that recessions are eliminated in a recession, that is, we assume $S_0 = R$ in equation (18). However, the effect of Hartz III and Hartz IV on the welfare cost of recession is similar to the previous case. Specifically, if we choose $S_0 = R$, the pre-reform welfare cost of recessions is 1.402 percent of lifetime consumption, and the two reforms taken together reduce this cost by 9.3 percent from 1.402 to 1.272 percent of lifetime consumption.

[30]Table 2 also shows that the Hartz IV reform reduces the risk cost of recessions, that is, the reduction in unemployment benefits due to Hartz IV leads to a reduction in the increase in consumption volatility during recessions. In general, the effect of a reduction in UI on the risk cost of recessions is ambiguous. On the one hand, a reduction in UI increases consumption volatility and therefore the risk cost of recessions. On the other hand, a reduction in UI increases search effort and job finding rates, which leads to a reduction in consumption volatility and a corresponding reduction in the risk cost of recessions. In our calibrated model economy, the second effect dominates so that a reduction in UI reduces the risk cost of recessions.

7. Robustness Analysis

In this section, we report the main results of our robustness analysis. Section 7.1 summarizes the results when calibration targets are changed. Section 7.2 considers extensions of the model with vacancy posting by firms along the lines of the standard search and matching framework of Diamond-Mortensen-Pissarides. In this version of the model, search externalities drive a wedge between the macro-elasticity of job search and the micro-elasticity of job search. Section 7.3 discusses the literature on the wedge between macro-elasticity and micro-elasticity. Finally, Section 7.4 analyzes an extension in which changes in UI affect match quality and therefore wages.

7.1 Changes in Calibration Targets

We have conducted an extensive sensitivity analysis with respect to changes in the calibration targets. In each case, we change one target and re-calibrate the model so that the model matches all remaining targets. In this section, we summarize the main results of this analysis – details are available on request.

There are number of calibration targets, including the pre-reform level of unemployment benefits b_{su} and b_{lu}, that have only small effects on our main results. The benefit parameters b_{su} and b_{lu} have a substantial effect on the welfare difference between employment and unemployment, but they only have a very small effect on the output cost of recessions and a modest effect on the welfare cost of recessions. Further, the effect of the Hartz III reform and the Hartz IV reform on the output cost and welfare cost of recessions barely change.

There are three parameter dimensions where a change in calibration target has a substantial effect on the quantitative results: i) changes in the curvature parameter of the disutility function (26), ii) changes in the level of skill depreciation during unemployment, δ_h, and iii) changes in target value of the elasticity of job search. In the first two cases, the cost of recessions is substantially reduced, but the effects of the two labor market reforms on the cost of recessions is (in percent) very similar to effects according to the baseline model. In the third case, both the cost of recessions and the effects of the two reforms on the cost of recessions is reduced. However, in all three cases our main results still hold qualitatively as long as the parameter variations are within an empirically plausible range. We discuss the three cases next.

Recall that in the baseline model, we choose the curvature parameter, γ, in (28) to match the elasticity of job search with respect to unemployment benefits yielding $\gamma = 1.317$ and implying a Frisch elasticity of labor supply of 3.155 – see also our discussion in Section 5. This value of the Frisch elasticity is in line with the values used in the macroeconomic literature, but substantially higher than the values the empirical micro-literature has estimated (Trabandt and Uhlig, 2011). We therefore consider an alternative parameterization with $\gamma = 2$, in which case the implied Frisch elasticity is one – a value that is in line with the micro-level empirical evidence (Trabandt and Uhlig, 2011). For this calibration, we choose the disutility parameter $d_{1,su} = d_{1,lu}$ to match the target for the search elasticity. We find that this version of the model implies a cost of recessions that is smaller than the cost in the baseline model, but that the reform-induced reduction in the cost of recessions expressed in percent is very similar to the baseline case. For example, in this case the Hartz III reform and Hartz IV reform taken together reduce the output cost of recessions by 22.6 percent from 1.836 percent of lifetime consumption to 1.422 percent of lifetime consumption and reduce the welfare cost of recessions by 9.8 percent from 0.954 percent of lifetime consumption to 0.861 percent of lifetime consumption. Thus, for this calibration of the model the percentage reduction in the output and welfare cost of recessions caused by the Hartz III and Hartz IV reforms is almost identical to the percentage reduction according to the baseline calibration – compare Tables 1 and 2.

In the baseline model, we choose a quarterly rate of skill depreciation during unemployment of $\delta_h = 0.025$. If we half this value and choose instead a value of $\delta_h = 0.0125$, then the cost of recessions is substantially reduced (the scarring effect of recessions is now smaller), but the effects of the Hartz III reform and the Hartz IV reform on the cost of recessions are similar to the corresponding effect according to the baseline calibration. For example, the Hartz III reform and Hartz IV reform taken together reduce the output cost of recessions by 22.9 percent from 1.313 percent of lifetime consumption to 1.013 percent of lifetime consumption and reduce the welfare cost of recessions by 3.1 percent from 0.920 percent of lifetime consumption to 0.892 percent of lifetime consumption (see Tables 1 and 2 for comparison).

Finally, a change in the target elasticity of job search has a substantial effect on both the cost of recessions and the extent to which the two labor market reforms affect the cost of recessions. For example, suppose we reduce this target elasticity from its baseline value of -0.7 to a value of -0.5, which is the value chosen in Landais, Michaillat, and Saez (2015). In this case, the Hartz III reform and Hartz IV reform taken together reduce the output cost of recessions by 19.6 percent from 1.832 percent of lifetime consumption to 1.473 percent of lifetime consumption and reduce the welfare cost of recessions by 8.2 percent from 1.294 percent of lifetime consumption to 1.188 percent of lifetime consumption. This is a non-negligible reduction – see Tables 1 and 2 for comparison. Thus, in line with previous results in the literature, we find that the elasticity of job search with respect to unemployment benefits is an important summary statistics that has a substantial impact on our results.

7.2 Search and Matching with Vacancy Posting (DMP-Model)

In this section, we consider an extension of the model that introduces vacancy posting and matching along the lines of the standard Diamond-Mortenson-Pissarides model (Mortensen and Pissarides, 1994). The details of the model are discussed in the Appendix. On the worker side (labor supply), the model is identical to the model discussed in Section 3. In addition, we assume that firms try to fill open job positions with different skill requirements by posting vacancies (labor demand). As in Pissarides (2009) and Mortensen and Nagypal (2007), firms incur a cost of posting vacancies (job advertising cost) plus a cost of filling vacancies (training cost).[31] The match surplus is split between workers and firms according to Nash bargaining and the matching of unemployed workers and open positions is summarized by a matching function, which we discuss in more detail below. In contrast to most work in the matching literature, we assume that the productivity of producing firms, Z, remains constant over the cycle. In other words, as in the baseline model we have only one source of aggregate fluctuations in the labor market, namely exogenous variations in job destruction rates. This assumption ensures that the results reported in this section are comparable to the results of the baseline model – variations in the productivity parameter Z would introduce an additional source of the cost of recessions that is absent in the baseline model. Finally, firms are owned by entrepreneurs/capitalists who consume the profits in equilibrium.

[31] Using firm-level data for Germany, Muehlemann and Pfeifer (2013) show that training costs are an important part of the total cost of hiring a new worker.

We follow the bulk of the macro literature and use a matching function that exhibits a constant elasticity of job matching with respect to a one-dimensional index of labor market tightness, which we denote by Θ (see, for example, Petrongolo and Pissarides, 2001, for a survey of the literature). In our case with endogenous search effort, this means that the specification (25) for the job finding rates of workers becomes

$$\pi_{e|s}(l, x_s, S, \Theta) \; = \; x_s \, l \, \Theta^{1-\eta} \;\; , \;\; s = su, lu \;\; , \tag{27}$$

where η is the elasticity of job matching with respect to Θ. We further follow Gomme and Lkhagvasuren (2015), Mitman and Rabinovich (2015), and Petrongolo and Pissarides (2001), and use $V/(U \times L)$ as an index of labor market tightness, where V is the number of vacancies posted by firms and $U \times L$ measures the aggregate search intensity of all workers:

$$\Theta \; \doteq \; \frac{V}{x_{su} L_{su} U_{su} + x_{lu} L_{lu} U_{lu}} \tag{28}$$

Note that this specification of the matching technology assumes that short-term and long-term unemployed workers search in the same labor market. Note also that specification (27) implies that the job filling rate of firms is $\pi_f(\Theta) \; = \; \Theta^{-\eta}$. Equation (A18) in the Appendix specifies the matching function that is associated with our specification of job finding rates (27) and job filling rates $\pi_f(\Theta) \; = \; \Theta^{-\eta}$ using (28) as a measure of labor market tightness. Finally, we note that the model generates endogenous variations in matching efficiency through the endogenous link between aggregate shocks and labor market tightness giving rise to an equilibrium relationship $\Theta = \Theta(S)$ – see the Appendix for details. Clearly, this equilibrium relationship is analogous to the exogenous function $\Psi(S)$ entering into the job-finding function (25) of the baseline model.

In the Appendix, we discuss the equilibrium conditions for the extended model with search and matching, where the matching process is described by (27) and (28) and firms post vacancies. We also show that the model preserves its tractability, that is, in equilibrium workers do not self-insure and neither the asset distribution nor the human capital distribution are relevant state variables. Because of space limitations we relegate a detailed discussion of the equilibrium conditions to the Appendix.

We next turn to the calibration of the extended model. Most of the parameters of the extended model already appear in the baseline model, and we choose the values of these parameters to match the same targets matched by the baseline model – see Section 5 for the calibration of the baseline model. The extended model has four new parameters: the elasticity of job matching with respect to labor market tightness, ψ, the bargaining power of workers, and two parameters defining the cost of posting and filling job vacancies. Petrongolo and Pissarides (2001) survey the relevant empirical studies estimating ψ and we follow their suggestion using a value of $\psi = 0.5$. We follow the search and matching literature and choose the bargaining parameter so that the Hosios condition is satisfied, that is, we choose the bargaining power equal to ψ. Finally, we choose the two parameters determining the cost of posting and filling job vacancies so that the model matches the observed average job filling rate and the observed decline in job finding rates during a typical pre-reform recession in Germany. Note that in Germany the cyclical variation in the job finding rate is relatively modest – a decline from 24.67 percent in normal times to 22.43 percent during recessions.

The main findings for the extended model are shown in Table 3 and can be summarized as follows. First, the model extension increases the output cost and welfare cost of recessions relative to the baseline model. Second, the result that the output cost of recessions is substantially larger than the welfare cost of recessions still holds. Third, the model extension increases the effect of the Hartz IV reform (reduction in UI) on the output cost and welfare cost of recessions. Finally, according to the extended model, the effect of the Hartz III reform (improvement in JSA) on the output cost and welfare cost of recessions is small, whereas in the baseline model this reform has a substantial impact on the cost of recessions. The main reason for these findings is that the extended model introduces a vacancy-posting channel (labor demand) that is absent in the baseline model. We next discuss the economic intuition underlying this channel.[32]

In the extended model with costly vacancy posting by firms and Nash wage bargaining, any change in labor market institutions or job destruction rates changes wages and therefore profits of firms. Further, any change in profits leads to a change in vacancy posting, which then affects labor market tightness and therefore job finding rates. In the case of

[32] According to the extended model, the Hartz IV reform reduced the non-cyclical unemployment rate by 1.72 percentage points. In contrast, the model implies that the Hartz III reform reduced the long-run unemployment rate by only 0.22 percentage points. Krause and Uhlig (2012) also find that an increase in matching efficiency (Hartz III reform) has only moderate effects on unemployment.

Table 3: Output Cost of Recessions (in Percent) – Diamond-Mortensen-Pissarides

	Δ_y^{DMP}		Δ^{DMP}	
Pre Reform	2.712		2.178	
Post Hartz-III-Reform	2.646	(2.4%)	2.159	(0.9%)
Post Hartz-IV-Reform	2.108	(22.3%)	2.002	(8.1%)
Post Hartz-III/IV-Reform	2.069	(23.7%)	1.996	(8.4%)

Notes: Δ_y^{DMP} is the output cost of recessions in percent of lifetime consumption (potential output) and Δ^{DMP} is the welfare cost for the Diamond-Mortensen-Pissarides specification. The values in brackets are the percentage deviation of the respective cost from the pre-reform allocation.

an exogenous increase in the job destruction rate (a recession shock), the expected present discounted value of firm profits goes down, which weakens the bargaining position of firms so that wages go up.[33] This in turn leads to a decline in vacancy posting and labor market tightness, which reduces job finding rates of workers. Thus, the vacancy-posting channel introduces an additional source of the cost of recessions and the extended model therefore implies a larger output cost and welfare cost of recessions than the baseline model. In the case of a reduction in UI (Hartz IV reform), the lifetime utility of workers declines and the bargaining position of workers is weakened, which leads to a reduction in wages. The wage reduction increases profits and vacancy posting by firms so that job finding rates rise. Thus, the extended model introduces an additional channel through which the Hartz IV reform increases labor market fluidity, and the extended model therefore implies a larger effect of the Hartz IV reform on the output cost and welfare cost of recessions than in the baseline model. Finally, in the case of an improvement in matching efficiency (Hartz III reform), the lifetime utility of workers increases and the bargaining position of workers is strengthened,

[33]In the extended model, the value function of the firm and the value function of the worker determine wages, and any change in labor market institutions affects both value functions through equilibrium adjustments (indirect effects). In our discussion, we focus on the direct effect of a change in labor market institutions on the value functions neglecting the indirect equilibrium effects. It turns out that in our calibrated model economy, this line of reasoning always leads to the correct qualitative result.

which leads to an increase in wages. The wage hike reduces profits and vacancy posting by firms so that job finding rates decline. Thus, the extended model introduces an additional channel through which the Hartz III reform reduces labor market fluidity, and the extended model therefore implies a smaller effect of the Hartz III reform on the output cost and welfare cost of recessions than in the baseline model.[34]

The discussion shows that the response of wages to changes in labor market institutions determines to what extent the vacancy-posting channel affects the results. In particular, we find that the extended model predicts that the Hartz III reform (an increase in matching efficiency) has only a modest net effect on the long-run job finding and unemployment rate because it leads to a substantial rise in wages. The time series evidence indicates that the Hartz reforms (Hartz I-IV) have reduced wages (see Krebs and Scheffel, 2013, for a discussion), which goes against the presence of a strong positive effect of the Hartz III reform on wages. However, this type of evidence does not differentiate among the various components of the Hartz reforms. To the best of our knowledge, there is no paper that provides empirical evidence on the wage effect of the Hartz III reform. However, we do have evidence that vacancy posting by firms has remained constant in the period from January 2004 (the date of the implementation of the Hartz III reform) to January 2005 (the date of the implementation of the Hartz IV reform) despite unfavorable business cycle conditions and has been rising thereafter – see Figure 4. Thus, the available time series evidence on wages and vacancy posting suggests the Hartz III reform and the related increase in matching efficiency have not reduced job finding rates, but more empirical evidence is needed to draw firm conclusions regarding the strength of this vacancy-posting channel in the case of an improvement in matching efficiency.

7.3 Wedge between Micro- and Macro-Elasticity

We next turn to a discussion of an important difference between the baseline model and the extended model: In the baseline model, the micro-elasticity and macro-elasticity with respect to changes in UI or JSA coincide, whereas in the extended model these two elasticities differ

[34] Note that this argument is distinct from the argument that public JSA crowds out private search because unemployed workers search less intensively when they receive public JSA (Pissarides, 1979). Using French data, Fougere et al. (2009) find no evidence for this type of crowding out effect.

since there are equilibrium effects on the job finding rate due to changes in labor market tightness, Θ.

In the case of a change in UI (Hartz IV reform), there are three distinct equilibrium effects. An increase in UI i) increases U and therefore reduces job finding rates, ii) reduces L and therefore increases job finding rates, and iii) increases vacancy posting and therefore increases job finding rates. Clearly, the net effect is ambiguous. In our calibrated model economy, we find that the effect of variations of $U \times L$ on job finding rates is small so that the positive effect through variations in V dominates. Thus, the macro-elasticity of job search is larger than the micro-elasticity: -0.8 vs -0.7.

In the case of a change in JSA (Hartz III reform), there are also three equilibrium effects affecting job finding rates through a change in labor market tightness. An improvement in matching efficiency (JSA) leads to i) a reduction in U and therefore an increase in job finding rates, ii) an increase in L and therefore a reduction in job finding rates, and iii) a reduction in vacancy posting and therefore a reduction in job finding rates. Clearly, the net effect is ambiguous. In our calibrated model economy, we find that the effect of variations of $U \times L$ on job finding rates is small so that the negative effect through variations in V dominates. Further, the negative vacancy-posting channel is substantial leading to a large difference between the micro- and macro elasticity of job search with respect to JSA. Specifically, in the calibrated model economy, the micro-elasticity of job search with respect to JSA is 0.41, whereas the corresponding macro-elasticity is only 0.08.

A comparison of the baseline results with the results obtained using the extended model shows that the wedge between micro- and macro elasticity is an important determinant of the costs of recessions and the effects of UI and JSA on the costs of recessions. This finding is in line with previous results on the design of optimal UI. For example, Landais, Michaillat, and Saez (2015) conclude that optimal UI should be counter-cyclical based on the analysis of a matching model with endogenous search effort that displays a macro-elasticity that is smaller than the micro-elasticity. In contrast, Mitman and Rabinovich (2015) find that optimal UI should be pro-cyclical based on an analysis of a Diamond-Mortensen-Pissarides model with endogenous search effort that displays a macro-elasticity that is more than twice as large as the micro-elasticity.

The empirical evidence on the wedge between micro-elasticity and macro-elasticity is mixed. On the one hand, Lalive, Landais, and Zweimueller (2015) find evidence of crowding out effects in their analysis of the search effect of unemployment benefit extensions for Austrian workers suggesting that the macro-elasticity exceeds the micro-elasticity. On the other hand, Hagedorn, Mitman, and Manovskii (2013) use exogenous variation in unemployment benefit extensions across US states and estimate a macro-elasticity much larger than existing estimates of the micro-elasticity. Similarly, Fredriksson and Soderstrom (2008) exploit variations in unemployment benefit generosity across US states and find very large macro-elasticities. For the case of JSA, Blundell et al. (2004) find no significant spillover effect in the UK, but recent work by Crepon et al. (2013) has shown that these effects can be substantial for young, educated job seekers in France. Thus, the empirical evidence is mixed and additional work is needed to draw firm conclusions regarding the strength of the individual externalities and the implied plausibility of the various specifications of the matching technology.[35]

7.4 Unemployment Insurance and Match Quality

We now consider an extension of the baseline model in which UI has a positive effect on productivity and wages by encouraging unemployed workers to search for high productivity jobs, a channel that has been studied by Acemoglu and Shimer (1999, 2000). We capture this effect in our extended model by assuming that after the Hartz IV reform (reduction in UI) unemployed workers who find a job lose x percent of their productivity (human capital h). We set x to be consistent with the results reported in Acemoglu and Shimer (1999), who analyze a calibrated version of an unemployment model with two types of jobs, namely good jobs with high productivity and bad jobs with low productivity. According to their calibrated model economy, a reduction in unemployment benefits, b, by 10 percent leads to an increase in productivity by somewhat more than 1 percent. The Hartz IV reform we study here reduced the benefits for half of the unemployed workers (the long-term unemployed) by roughly 20 percent and did not change the unemployment benefits for the other half of unemployed workers (the short-term unemployed) – see Section 2. Thus, we model the effect

[35]Note that the empirical results of Fahr and Sunde (2009) and Klinger and Rothe (2012) regarding the change in matching efficiency caused by the Hartz III reform are based on a semi-aggregate approach that accounts for possible equilibrium effects within an occupation or region.

of the Hartz IV reform by assuming that it led to a productivity (human capital) loss of 1 percent occurring any time an unemployed worker finds a job.

We find that in this version of the model the Hartz IV reform reduces the output cost of recessions from 2.014 percent of lifetime consumption to 1.877 percent of lifetime consumption. This cost reduction is substantially less than the cost reduction in the baseline model, which is not surprising given that any productivity losses induced by the Hartz IV reform increase the output cost of recessions. We further find that this productivity channel is strong enough so that the Hartz IV reform increases the welfare cost of recessions from 1.310 percent to 1.338 percent in the extended version of the model. Thus, we conclude that the introduction of an endogenous match quality channel can significantly alter the effect of UI on the cost of recessions. We note however that the empirical literature (Card, Kluve, and Weber, 2007, Schmieder, Wachter, and Bender 2016) has found mixed results regarding the effect of UI on post-displacement wages.

8. Conclusion

In this paper, we develop a tractable incomplete-market model with search unemployment and used the framework to analyze the effect of two labor market institutions, UI and JSA, on the output cost and welfare cost of recessions. The theoretical analysis shows that an improvement in JSA or a reduction in UI lead to a decrease in the output cost of recessions, but that the effect on the welfare cost of recessions is in general ambiguous. We also use a version of the model calibrated to German data to analyze the quantitative effects of the German labor market reforms of 2003-2005, which improved JSA (Hartz III reform) and reduced UI, on the costs of recessions. We find that both the Hartz III reform (improvement in JSA) and the Hartz IV reform (reduction in UI) have led to a substantial improvement in labor market fluidity and a corresponding reduction in the output cost of recessions in Germany. Further, both reforms have also reduced the welfare cost of recessions in Germany, but this cost reduction is significantly weaker than the corresponding reduction in the output cost of recessions.

There are at least three important topics for future research. First, future work should apply the analysis to different countries. For example, there are several European countries that have implemented labor market reforms in the last three decades. Further, there are signs that the fluidity of the US labor market has been diminished,[36] and the approach taken in this paper can shed light on the potential gains of reforming the US labor market.

A second topic of future research consists of the broadening of the policy instruments available to the government. Specifically, in this paper we confined attention to unemployment insurance systems that are very simple (benefit payments proportional to labor income). There is a large literature that analyzes the optimal path of unemployment insurance payments when search effort is unobservable (Hopenhayn and Nicolini, 1997, Pavoni, 2009, and Shimer and Werning, 2007). Work in this literature does not impose any prior restrictions on the class of unemployment insurance systems beyond incentive-compatibility and resource feasibility. In contrast, in the current paper we confine attention to a parametric class of unemployment insurance systems and ask how parametric changes within this class affect the welfare costs of recessions. Extending our approach to the study of more general unemployment insurance systems is an important topic for future research.

A final topic for future work is the joint analysis of optimal stabilization policy and optimal long-run policy in one general framework. Specifically, the results derived in this paper suggest that short-run and long-run policy choices interact in an interesting way, and that this type of interaction is quantitatively important. However, the previous literature has all too often studied optimal government policy over the cycle (macroeconomic stabilization policy) separately from the optimal choice of long-run policy (structural reform). A general analysis of the interaction of these two policy dimensions and the implication of optimal government policy is an important topic for future research.

[36] See, for example, Davis and Haltiwanger (2014) for a survey of the empirical evidence supporting this view.

References

Abraham, A., N. Pavoni, and S. Koehne (2011) "On the First-Order Approach in Principal-Agent Models with Hidden Borrowing and Lending," *Journal of Economic Theory* 146: 1331-1361.

Acemoglu, D., and R. Shimer (1999) "Efficient Unemployment Insurance," *Journal of Political Economy* 107: 893-928.

Acemoglu, D., and R. Shimer (2000) "Productivity Gains from Unemployment Insurance," *European Economic Review* 44: 1195-1224.

Addison, J., Centeno, M., Portugal, P. (2008) "Unemployment Benefits and Reservation Wages: Key Elasticities from a Stripped-Down Job-Search Model," IZA Discussion Paper No. 3357.

Addison, J., and Portugal, P (1989), "Job Displacement, Relative Wage Changes, and Duration of Unemployment," *Journal of Labor Economics* 7: 281-302.

Alvarez, F., and U. Jermann (2004) "Using Asset Prices to Measure the Cost of Business Cycles," *Journal of Political Economy* 112: 1223-1256.

Alvarez, F., and N. Stokey (1998) "Dynamic Programming with Homogenous Functions," *Journal of Economic Theory* 82: 167-189.

Alvarez, F., and M. Veracierto (2001) "Severance Payments in an Economy with Frictions," *Journal of Monetary Economics* 47: 477-498.

Atkeson, A., and C. Phelan (1994) "Reconsidering the Cost of Business Cycles with Incomplete Markets," *NBER Macroeconomcis Annual* 9.

Atkinson, T., D. Luttrell, and H. Rosenblum (2013) "How Bad was It? The Costs and Consequences of the 2007-2009 Financial Crisis," FRB-Dallas Staff Paper.

Auerbach, A., and Y. Gorodnichenko (2012) "Measuring the Output Responses to Fiscal Policy," *AEJ - Economic Policy* 4: 1-27.

Bach, H., and E. Spitznagel (2012) "Druck auf Oeffentliche Budgets Laesst Nach," *IAB-Kurzbericht* 8/2012.

Ball, L. (2014) "Long-Term Damage for the Great Recession in OECD Countries," *NBER Working Paper* 20185.

Barlevy, G. (2004) "The Cost of Business Cycles under Endogenous Growth," *American*

Economic Review 94: 964-990.

Beaudry, P., and C. Pages (2001) "The Cost of Business Cycles and the Stabilization Value of Unemployment Insurance," *European Economic Review* 45: 1545-1572.

Blanchard, O., Cerutti, E., and L. Summers (2015) "Inflation and Activity – Two Explorations and Their Monetary Policy Implications," *NBER Woring Paper* 21726.

Blanchard, O, and L. Summers (1987) "Hysteresis in Unemployment," *European Economic Review* 31: 288-295.

Blanchard, O., and J. Wolfers (2000) "The Role of Shocks and Institutions in the Rise of European Unemployment: The Aggregate Evidence," *Economic Journal* 100: 1-33.

Blundell, R., M. Costa Dias, C. Meghir, and J. van Reenen (2004) "Evaluating the Employment Impact of a Mandatory Job Search Program," *Journal of the European Economic Association* 2: 569-606.

Blundell, R., L.Pistaferri, and I. Preston (2008) "Consumption Inequality and Partial Insurance," *American Economic Review* 98: 1887-1921.

Bohn, H. (1995) "The Sustainability of Budget Deficits in a Stochastic Economy," *Journal of Money, Credit, and Banking* 27: 257-271.

Bundesagentur fuer Arbeit (2005) "Der Uebergang von der Arbeitslosen- und Sozialhilfe zur Grundsicherung fuer Arbeitssuchende," Sonderbericht.

Bundesagentur fuer Arbeit (2011) "Der Arbeitsmarkt in Deutschland: Sockel- und Langzeitarbeitslosigkeit," Arbeitsmarktberichterstattung.

Burda, M., and A. Mertens (2001) "Estimating Wage Losses of Displaced Workers in Germany," *Labour Economics* 8: 15-41.

Burda, M., and J. Hunt (2011) "What Explains the German Labor Market Miracle in the Great Recession," *Brooking Papers on Economic Activity* Spring 2011.

Cahuc, P., and T. Le Barbanchon (2010) "Labor Market Policy Evaluation in Equilibrium: Some Lessons of the Job Search and Matching Model," *Labour Economics* 17: 196-205.

Card, D., J. Kluve, J., and A. Weber (2010) "Active Labour Market Policy Evaluation: A Meta-Analysis," *Economic Journal* 120: 452-477.

Card, D., R. Chetty, and A. Weber (2007) "Cash-On-Hand and Competing Models of Intertemporal Behavior: New Evidence from the Labor Market," *The Quarterly Journal of*

Economics 122: 1511-1560.

Card, D., A. Johnston, P. Leung, A. Mas, and Z. Pei (2015) “The Effect of Unemployment Benefits on the Duration of Unemployment Insurance Receipt: New Evidence form a Regression Kink Design in Missouri, 2003-2013,” *American Economic Review* 105: 126-130.

Cerra, V., and S. Saxena (2008) “Growth Dynamics: The Myth of Economic Recovery” *American Economic Review* 98: 439-457.

Chetty, R. (2008) “Moral Hazard vs Liquidity and Optimal Unemployment Insurance,” *Journal of Political Economy* 116: 173-234.

Cho, J., Cooley, T.,a nd H. Kim (2015) “Business Cycle Uncertainty and Economic Welfare,” *Review of Economic Dynamics* 18: 185-200.

Constantinides, G., and D. Duffie (1996) “Asset Pricing with Heterogeneous Consumers,” *Journal of Political Economy* 104: 219-240.

Cooley, T. (1995) *Frontiers of Business Cycle Research*, Princeton University Press.

Crepon, B., E. Duflo, M. Gurgand, R. Rathelot, and P. Zamora (2013) “Do Labor Market Policies Have Displacement Effects: Evidence from a Clustered Randomized Experiment,” *The Quarterly Journal of Economics* 128: 531-580.

Cristiano, L., M. Trabandt, and V. Walentin (2012) “Involuntary Unemployment and the Business Cycle,” *Working Paper*.

Dao, M., and P. Loungani (2010) “The Human Cost of Recessions: Assessing It, Reducing It,” *IMF Staff Position Notes* SPN/10/17.

Davis, S., and J. Haltiwanger (2014) “Labor Market Fluidity and Economic Performance,” *NBER Working Paper* 20479.

Davis, S., and T. Wachter (2011) “Recessions and the Cost of Job Loss,” *Brooking Papers on Economic Activity* 43: 1-72.

DeLoach, S., and M. Kurt (2013) “Discouraged Workers: Estimating the Impact of Macroeconomic Shocks on the Search Intensity of the Unemployed,” *Journal of Labor Research* 34: 433-454.

Den Haan, W., and P. Sedlacek (2014) “Inefficient Continuation Decisions, Job Creation Costs, and the Cost of Business Cycles,” *Quantitative Economics* 5: 297-349.

Den Haan, W., Rendahl, P., and M. Riegler (2015) “Unemployment (Fears) and Deflationary Spirals," *CEPR Discussion Paper* 10814.

Engblom, N., E. Detragiache, and F. Raei (2015) "The German Labor Market Reforms and Post-Unemployment Earnings," *IMF Working Paper* 15/162.

Fahr, R., and U. Sunde (2009) "Did the Hartz Reforms Speed Up the Matching Process? A Macro-Evaluation Using Empirical Matching Functions," *German Economic Review* 10: 284-316.

Farber, H., and R. Valletta (2015) "Do Extended Unemployment Benefits Lengthen Unemployment Spells? Evidence from Recent Cycles in the US Labor Market," *Journal of Human Resources* 50: 873-909.

Fougere, D., Pradel, J., and M. Roger (2009) "Does the Public Employment Service Affect Search Effort and Outcomes," *European Economic Review* 53: 846-869.

Fredriksson, P. and M. Sderstrm (2008) "Do Unemployment Benefits Increase Unemployment? New Evidence on an Old Question," *IFAU Working Paper Series* 2008:15.

Fuchs-Schuendeln N., D. Krueger, and M. Sommer (2010) "Inequality Trends for Germany in the Last Two Decades: A Tale of Two Countries," *Review of Economic Dynamics* 13: 103-132.

Gali, J., M. Gertler, and J. Lopez-Salido (2007) "Markups, Gaps, and the Welfare Costs of Business Fluctuations," *Review of Economics and Statistics* 89: 44-59.

Glover, A., J. Heathcote, D. Krueger, and V. Rios-Rull (2014) "Intergenerational Redistribution in the Great Recession," *NBER Working Paper* 16924.

Gomes, J., J. Greenwood, and S. Rebelo (2001) "Equilibrium Unemployment," *Journal of Monetary Economics* 48: 109-152.

Gomme, P., and D. Lkhagvasuren (2015) "Worker Search Effort as an Amplification Mechanism," *Journal of Monetary Economics* forthcoming.

Gornemann, N., K. Kuester, and M. Nakajima (2016) "Doves for the Rich, Hawks for the Poor? Distributional Consequences of Monetary Policy," *CEPR Discussion Papers* 11233.

Grabka, M., and C. Westermeier (2014) "Persistently High Wealth Inequality in Germany," *DIW Economic Bulletin* 6.2014.

Gruber, J. (1997) "The Consumption Smoothing Benefits of Unemployment Insurance," *American Economic Review* 87: 192-205.

Guvenen, F., Ozkan, S., and J. Song (2014) "The Nature of Counter-Cyclical Risk," *Journal of Political Economy* 122: 621-660.

Hagedorn, M., F. Karahan, I. Manovskii, and K. Mitman (2013) "Unemployment Benefits and Unemployment in the Great Recession: The Role of Macroeffects," *NBER Working Paper* 19499.

Hairault, J., F. Lagot, and S. Osotimehim (2010) "Matching Frictions, Unemployment Dynamics, and the Cost of Business Cycles," *Review of Economic Dynamics* 13; 759-779.

Hall, R. (2014) "Quantifying the Lasting Harm to the U.S. Economy from the Financial Crisis," *NBER Macroeconomic Annuals* 29.

Hansen, G., and A. Imrohoroglu (1992) "The Role of Unemployment Insurance in an Economy with Liquidity Constraints and Moral Hazard," *Journal of Political Economy* 100: 118-142.

Hartz, P., N. Bensel, J. Fiedler, H. Fischer, P. Gasse, W. Jann, P. Kraljic, I. Kunkel-Weber, K. Luft, H. Schartau, W. Schickler, H.-E. Schleyer, G. Schmid, W. Tiefensee, and E. Voscherau (2002) "Moderne Dienstleistungen am Arbeitsmarkt, *Bericht der Kommission*.

Heisz, A., Oreopoulos, P., and T. Wachter (2012) "The Short-Term and Long-Term Career Effects of Graduating in a Recession: Hysteresis and Heterogeneity in the Market for College Graduates," *American Economic Journal: Applied* 4: 1-29.

Hertweck, M., and O. Sigrist (2012) "The Aggregate Effects of the Hartz Reforms in Germany," *University of Basel Working Papers* 2013/01.

Hofmann, B. (2012) "Short- and Long-Term ex Post Effects of Unemployment Insurance Sanctions," *Journal of Economics and Statistics* 232: 31-60.

Hopenhayn, H., and J. Nicolini (1997) "Optimal Unemployment Insurance," *Journal of Political Economy* 105: 412-438.

Hunt, J. (1995) "The Effect of Unemployment Compensation on Unemployment Duration in Germany," *Journal of Labor Economics* 13: 88-120.

IAB (2011) ...

IMF (2012) *World Economic Outlook, October 2012*.

IMF (2015) *World Economic Outlook, April 2015*, Chapter 3: "Where Are We Headed: Perspectives on Potential Output".

Imrohoruglu, A. (1989) "Cost of Business Cycles with Indivisibilities and Liquidity Constraints," *Journal of Political Economy* 97: 1364-1383.

Jacobi, L., and J. Kluve (2006) "Before and After the Hartz Reforms: The Performance of Active Labor Market Policy in Germany," *IZA Discussion Paper* 2100.

Jabobson, L, R. LaLonde, and D. Sullivan (1993) "Earnings Losses of Displaced Workers," *American Economic Review* 83: 685-709.

Johnston, A., and A. Mas (2016) "Potential Unemployment Insurance Duration and Labor Supply: The Individual and Market-level Response to Benefit Cuts," *NBER Working Paper* 22411.

Jung, P., and K. Kuester (2011) "The (Un)Importance of Unemployment Fluctuations for Welfare," *Journal of Economic Dynamics and Control* 35: 1744-1768.

Jung, P., and K. Kuester (2014) "Optimal Labor Market Policy in Recessions," *American Economic Journal: Macroeconomics* 7: 124-156.

Jung, P., and M. Kuhn (2014) "Labor Market Institutions and Worker Flows: Comparing Germany and the US?", *Economic Journal* 124: 1317-1342.

Kaplan, M., and G. Violante (2014) "A Model of the Consumption Response to Fiscal Stimulus Payments," *Econometrica* 82: 1199-1239.

Keane, M., and K. Wolpin (1997) "The Career Decision of Young Men," *Journal of Political Economy* 105: 473-522.

Klinger S., and T. Rothe, 2012. "The Impact of Labour Market Reforms and Economic Performance on the Matching of the Short-Term and the Long-Term Unemployed," *Scottish Journal of Political Economy* 59: 90-114.

Krause, M., and H. Uhlig (2012) "Transitions in the German Labor Market: Structure and Crisis," *Journal of Monetary Economics* 59: 64-79.

Krebs, T. (2003) "Growth and Welfare Effects of Business Cycles with Economies with Idiosyncratic Human Capital Risk," *Review of Economic Dynamics* 6: 846-68.

Krebs, T. (2007) "Job Displacement Risk and the Cost of Business Cycles," *American Economic Review* 97: 664-686.

Krebs, T., and M. Scheffel (2013) "Macroeconomic Evaluation of Labor Market Reform in Germany," *IMF Economic Review* 61: 664-701.

Krueger, D., Mitman, K., and F. Perri (2016) "On the Distribution of the Welfare Losses of Large Recessions," *NBER Working Paper* 22458.

Krueger, A., and B. Meyer (2002) "Labor Supply Effects of Social Insurance," *Handbook of Public Economics*.

Krueger, A., and A. Mueller (2010) "Job Search and Unemployment Insurance: New Evidence from Time Use Data," *Journal of Public Economics* 94: 298-302.

Krusell, P., T. Mukoyama, A. Sahin, and A. Smith (2009) "Revisiting the Welfare Effects of Eliminating Business Cycles," *Review of Economic Dynamics* 12: 393-402.

Krusell, P., and A. Smith (1998) "Income and Wealth Heterogeneity in the Macroeconomy," *Journal of Political Economy* 106: 867-896.

Krusell, P., and A. Smith (1999) "On the Welfare Effects of Eliminating Business Cycles," *Review of Economic Dynamics* 2: 245-272.

Lalive, R., C. Landais, and J. Zweimueller (2015) "Market Externalities of Large Unemployment Insurance Extension Programs," *American Economic Review* 105: 3564-3596.

Landais, C., P. Michaillat, and E. Saez (2015) "A Macroeconomic Theory of Optimal Unemployment Insurance," *NBER Working Paper* 16529.

Launov, A., and K. Waelde (2013) "Estimating Incentive and Welfare Effect of Nonstationary Unemployment Benefits," *International Economic Review* 54: 1159-1198.

Lentz, R. (2009) "Optimal Unemployment Insurance in an Estimated Job-Search Model with Savings," *Review of Economic Dynamics* 12: 37-57.

Lucas, R. (1987) *Models of Business Cycles*, Blackwell Publishing.

Lucas, R. (2003) "Macroeconomic Priorities," *American Economic Review* 93: 1-14.

Ljungqvist, L., and T. Sargent (1998) "The European Unemployment Dilemma," *Journal of Political Economy* 106: 514-550.

Mehra, R., F. Piuillem, and E. Prescott (2011) "Costly Financial Intermediation in Neoclassical Growth Theory," *Quantitative Economics* 2: 1-36.

Meyer, B. (1990) "Unemployment Insurance and Unemployment Spells," *Econometrica* 58: 757-782.

Mitman, K, and S. Rabinovich (2014) "Do Unemployment Benefits Explain the Emergence of Jobless Recoveries?", mimeo.

Mitman, K., and S. Rabinovich (2015) "Optimal Unemployment Insurance in an Equilibrium Business Cycle Model," *Journal of Monetary Economics* 71: 99-118.

Moffitt, R. (1985) "Unemployment Insurance and the Distribution of Unemployment Spells," *Journal of Econometrics* 28: 85-101.

Mortensen, D., and C. Pissarides (1994) "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies* 61: 397-415.

Mortensen, D. and E. Nagypal (2007) "More on Unemployment and Vacancy Fluctuations," *Review of Economic Dynamics* 10: 327-347.

Muehlemann, S., and H. Pfeifer (2013) "The Structure of Hiring Costs in Germany: Evidence from Firm-Level Data," *IZA Working Paper* 7656.

Mueller, K., and V. Steiner (2008) "Imposed Benefit Sanctions and the Unemployment-to-Employment Transition: The German Experience," *DIW Discussion Paper 792*.

Mukoyama, T., C. Patterson, and A. Sahin (2014) "Job Search Behavior over the Business Cycle," *FRB New York Staff Reports* 689.

Neal, D. (1995) "Industry-Specific Human Capital: Evidence from Displaced Workers," *Journal of Labor Economics* 13: 653-677.

Pavoni, N. (2009) "Optimal Unemployment Insurance with Human Capital Depreciation and Duration Dependence," *International Economic Review* 50: 323-362.

Petrongolo, B., and C. Pissarides (2001) "Looking into the Black Box: A Survey of the Matching Function," *Journal of Economic Literature* 39: 390-431.

Pissarides, C. (1979) "Job Matching with State Employment Agencies and Random Search," *Economic Journal* 89: 818-833.

Pissarides, C. (1992) "Loss of Skill During Unemployment," *Quarterly Journal of Economics* 107: 1371-1391.

Pissarides, C. (2009) "The Unemployment Volatility Puzzle: Is Wage Stickiness the Answer," *Econometrica* 77: 1339-1369.

Reinhart, C., and K. Rogoff (2014) "Recovery from Financial Crises: Evidence from 100 Episodes," *American Economic Review* 104: 50-55.

Pfeiffer, F., and H. Winterhager (2006) "Vermittlungsgutscheine und Beauftragung Dritter im Vergleich," *Zeitschrift fuer Arbeitsmarktforschung* 39: 425-445.

Rothstein, J. (2011) “Unemployment and Job Search in the Great Recession,” *Brooking Papers on Economic Activity*: 143-214.

Schmieder, J., T. Wachter, and S. Bender (2016) “The Effect of Unemployment Benefits and Non-Employment Duration on Wages,” *American Economic Review* 106: 739-777.

Schirwitz, B. (2009) “A Comprehensive German Business Cycle Chronology,” *Empirical Economics* 37: 287-301

Shimer, R. (2004) “Search Intensity,” mimeo.

Shimer, R., and I. Werning (2008) “Liquidity and Insurance for Unemployed Workers,” *American Economic Review* 98: 1922-1942.

Stokey, N., R. Lucas, with E. Prescott (1989) *Recursive Methods in Economic Dynamics*, Harvard University Press.

Storesletten, K., C. Telmer, and A. Yaron (2001) “The Welfare Cost of Business Cycles Revisited: Finite Lifes and Cyclical Variations in Idiosyncratic Risk,” *European Economic Review* 45: 1311-39

Streufert, P. (1990) “Stationary Recursive Utility and Dynamic Programming under the Assumption of Biconvergence,” *Review of Economic Studies* 57: 79-97.

Tallarini, T. (2000) “Risk-Sensitive Real Business Cycles,” *Journal of Monetary Economics* 45: 507-532.

Trabandt, M., and H. Uhlig (2011) “The Laffer Curve revisited,” *Journal of Monetary Economics* 58: 305-327.

Uhlig, H. (1996) “A Law of Large Numbers for Large Economies,” *Economic Theory* 8: 41-50.

Veracierto, M. (2008) “On the Cyclical Behavior of Employment, Unemployment and Labor Force Participation,” *Journal of Monetary Economics* 55: 1143-1157.

VoxEU (2014) “Secular Stagnation: Facts, Causes, and Cures,” *E-Book* eds. R. Baldwin and C. Teulings.

Winterhager, H., A. Heinze, and A. Spermann (2006) “Deregulating Job Placement in Europe: A Microeconometric Evaluation of an Innovative Voucher System in Germany,” *Labour Economics* 13: 505-517.

Wolf, M. (2015) “In the Long Shadows of the Great Recession,” *Financial Times* November 11, 2015.

Wunsch, C. (2005) "Labour Market Policy in Germany: Institutions, Instruments and Reforms since Unification," *University of St. Gallen Department of Economics Working Paper Series 2005-06*.

Online Appendix

A.1 Proof of Proposition 1

We first show that $a_t = 0$ is an optimal choice for workers. For simplicity, we assume that employed workers have the strongest incentive to save and short-term unemployed workers have the strongest incentive to dissave. The equilibrium characterization for the other cases is accordingly. Define the interest rate

$$1 + r_f(S) = \frac{1}{\beta}\left(\sum_{s',\epsilon',S'} \frac{\phi_e}{\phi_{s'}(1+\eta_{s',\epsilon'})}\pi_{\epsilon'}\pi_{s'|e}(S')\pi(S'|S)\right)^{-1} \tag{A1}$$

and the miniumum transaction cost

$$\begin{aligned}\alpha_{min} &= \max_S \left\{ \frac{1}{\beta}\left(\sum_{s',\epsilon'} \frac{\phi_{su}}{\phi_{s'}(1+\eta_{s',\epsilon'})}\ \pi_{\epsilon'}\pi_{s'|su}(l_{su}(S))\right)^{-1}\right.\\ &\quad \left. - \frac{1}{\beta}\left(\sum_{s',\epsilon',S'} \frac{\phi_e}{\phi_{s'}(1+\eta_{s',\epsilon'})}\pi_{\epsilon'}\pi_{s'|e}(S')\pi(S'|S)\right)^{-1}\right\}\end{aligned} \tag{A2}$$

where $l_{su}(S)$ is the equilibrium effort choice of short-term unemployed workers. Note that the term in brackets in (A1) is the expected intertemporal marginal rate of substitution for employed workers, $s_t = e$. Thus, if first-order conditions are necessary and sufficient, then for an interest rate, r_f, given by (A1) the choice $a_t = 0$ is an optimal choice for employed workers. Note further that the two terms in brackets in (A2) are the expected intertemporal marginal rate of substitutions of employed workers and short-term unemployed workers, respectively. Thus, if first-order conditions are necessary and sufficient, then for a lending rate r_f given by $(A1)$ and any borrowing rate that is equal or larger than $r_f + \alpha_{min}$, where α_{min} is given by (A2), it is optimal for short-term unemployed workers and long-term unemployed workers to choose $a_t = 0$. Clearly, first-order conditions are necessary, but they might not be sufficient. We now show that first-order conditions are also sufficient, which proves that $a_t = 0$ is an optimal worker choice.

To ease the notation, we confine attention to the case without aggregate shocks and constant interest rate $r_{ft} = r_f$. We consider an extended household maximization problem with endogenous choice of human capital. Specifically, suppose that the household can transform one unit of the good into $\nu(s)$ units of human capital and denote the (resource) cost of human capital investment by i. Thus, the extended household maximization problem is the problem of choosing $\{c_t, a_t, h_t, i_t, l_t\}$ so as to maximize (3) subject to the sequential budget constraint

$$\begin{aligned} a_{t+1} &= \begin{cases} (1+r_f)a_t + \phi(s_t) - c_t - i_t & if\ a_{t+1} \geq 0 \\ (1+r_f+\alpha)a_t + \phi(s_t) - c_t - i_t & if\ a_{t+1} < 0 \end{cases} \\ h_{t+1} &= (1+\eta(s_{t+1}, \epsilon_{t+1}))\,(h_t + \nu_t i_t) \end{aligned} \tag{A3}$$

where η and ϕ are the same functions as in the basic household decision problem of maximizing (3) subject to (2) and (1).

Clearly, if $\{c_t^*, a_t^*, h_t^*, i_t^*, l_t^*\}$ solves the extended household maximization problem with $i_t^* = 0$, then $\{c_t^*, a_t^*, l_t^*\}$ solves the basic household decision problem for given $\bar{h}_t = h_t^*$. In particular, if $\{c_t^*, a_t^*, h_t^*, i_t^*, l_t^*\}$ solves the extended household maximization problem with $i_t^* = 0$ and $a_t^* = 0$, then $\{c_t^*, a_t^*, l_t^*\}$ with $a_t^* = 0$ solves the basic household decision problem for given $\bar{h}_t = h_t^*$. Thus, the first part of proposition 1 is proved if we can construct a solution $\{c_t^*, a_t^*, h_t^*, i_t^*, l_t^*\}$ to the extended household maximization problem with $i_t^* = 0$ and $a_t^* = 0$. We now show how to construct such a plan if the interest rate, r_f, is given by (A1) and the financial intermediation cost is not less than α_{min} defined in (A2).

Define the following new variables:

$$\begin{aligned} \tilde{c}_t &= \nu_t\, c_t \\ w_{t+1} &= (1+r_{t+1})\left[\frac{h_{t+1}}{1+\eta_{t+1}} + \nu_t a_{t+1}\right] \\ \theta_{a,t+1} &= \frac{\nu_t\,(1+r_{t+1})a_{t+1}}{w_{t+1}} \\ \theta_{h,t+1} &= \frac{(1+r_{t+1})h_{t+1}}{(1+\eta_{t+1})w_{t+1}} \\ 1+r_{t+1} &= \begin{cases} \theta_{a,t+1}\left(\frac{\nu_{t+1}}{\nu_t}(1+r_f)\right) + \theta_{h,t+1}(1+\eta_{t+1})(1+\phi_{t+1}\nu_{t+1}) & if\ \theta_{at} \geq 0 \\ \left(\frac{\nu_{t+1}}{\nu_t}(1+r_f+\varphi)\right) + \theta_{h,t+1}(1+\eta_{t+1})(1+\phi_{t+1}\nu_{t+1}) & if\ \theta_{at} < 0 \end{cases} \end{aligned}$$

Here w is the value of total wealth, financial and human, including asset payoffs in period $t+1$, θ is the share of total wealth invested in financial assets, and r is the total return on investment (in human and physical capital). Note that $h_{t+1}/(1+\eta_{t+1}) + \nu_t a_{t+1}$ is total wealth excluding asset payoffs in period $t+1$. Using the new definitions, the household budget constraint (A1) can be written as

$$
\begin{aligned}
w_{t+1} &= (1 + r(\theta_{a,t+1}, \theta_{h,t+1}, s_{t+1}, \epsilon_{t+1}))\,(w_t - c_t) \\
&\quad \theta_{a,t+1} + \theta_{h,t+1} \;=\; 1 \\
&\quad w_{t+1} \geq 0 \;\;,\;\; \theta_{h,t+1} \geq 0
\end{aligned}
\tag{A4}
$$

The extended household maximization problem is to choose a plan $\{c_t, w_t, \theta_{at}, \theta_{ht}, l_t\}$ that maximizes (3) subject to (A4).

The Bellman equation associated with the extended household maximization problem reads

$$
\begin{aligned}
V(w,s) \quad &= \quad \max_{c,\theta'_a,\theta'_h,w',l} \left\{ ln\,\tilde{c} - \ln \nu(s) - d(l,s) + \beta \sum_{s',\epsilon'} V(w',s')\pi(\epsilon')\pi(s'|s,l) \right\} \\
s.\,t. \quad & w' \;=\; (1 + r(\theta'_a, \theta'_h, s', \epsilon'))(w - c) \\
& \theta'_a + \theta'_h \;=\; 1 \\
& w' \geq 0 \;\;,\;\; \theta'_h \geq 0
\end{aligned}
\tag{A5}
$$

where the effort choice, l, is only relevant if $s = su, lu$. The extended household maximization problem has the feature that probabilities depend on choices, in contrast to the class of problems analyzed in Stokey and Lucas (1989). However, one can show using standard arguments that the principle of optimality still applies. Thus, without loss of generality we can confine attention to solving (A5) (subject to a corresponding transversality condition).

Note that the proof of the principle of optimality requires one non-standard argument, namely the construction of an appropriate function space for a maximization problem that is naturally unbounded. To deal with this issue, one can, for example, follow Streufert (1990) and consider the set of continuous functions B_W that are bounded in the weighted sup-norm $||V|| \doteq sup_x |V(x)|/W(x)$, where $x = (w, \theta, s)$ and the weighting function W is given by $W(x) = |L(x)| + |U(x)|$ with U an upper bound and L a lower bound, and endow this function space with the corresponding metric. Thus, B_W is the set of all functions, V, with $L(x) \leq V(x) \leq U(x)$ for all $x \in \mathbf{X}$. A straightforward but tedious argument shows that confining attention to this function space is without loss of generality. More precisely, one can show that there exist functions L and H so that for all candidate solutions, V, we have $L(x) \leq V(x) \leq H(x)$ for all $x \in \mathbf{X}$.[37]

The Bellman equation (A5) has a simple solution. More precisely, the optimal portfolio choice, (θ'_a, θ'_h), is independent of wealth, w, and consumption and next-period wealth are linear functions of current wealth:

$$
\begin{aligned}
c &= (1-\beta)w, \\
w' &= \beta(1 + r(\theta', s', \epsilon'))w \; .
\end{aligned}
\tag{A6}
$$

Moreover, the value function has the functional form

$$
V(w,s) \;=\; \tilde{V}(s) + \frac{1}{1-\beta} \ln w \tag{A7}
$$

and the optimal portfolio choice and optimal search effort are the solution to the intensive-form Bellman equation

$$
\begin{aligned}
\tilde{V}(s) &= \max_{\theta'_a, \theta'_h, l} \Big\{ B - \nu(s) - d(l,s) + \frac{\beta}{1-\beta} \sum_{s',\epsilon'} ln\,(1 + r(\theta'_a, \theta'_h, s', \epsilon'))\pi(\epsilon')\pi(s'|s,l) \\
&\quad + \beta \sum_{s'} \tilde{V}(s')\pi(s'|s,l) \Big\}, \qquad \text{(A8)} \\
\theta'_a + \theta'_h &= 1 \;\; , \;\; \theta'_h \;\geq\; 0
\end{aligned}
$$

where B is a constant. It is straightforward to show that this solution satisfies the relevant transversality condition.

Clearly, the maximization problem (A8) is a convex problem (concave objective function and convex choice set), and first-order conditions are therefore necessary and sufficient. These first-order condition read

$$
\begin{aligned}
0 &\leq \sum_{s',\epsilon'} \frac{(1 + \eta(s',\epsilon'))(1 + \phi(s')\nu(s')) \;-\; \frac{\nu(s')}{\nu(s)}(1 + r_f)}{1 + r(\theta'_a, \theta'_h, s', \epsilon')} \pi(\epsilon')\pi(s'|s,l) \quad if\ \theta'_a \geq 0 \qquad \text{(A9)} \\
0 &\geq \sum_{s',\epsilon'} \frac{(1 + \eta(s',\epsilon'))(1 + \phi(s')\nu(s')) \;-\; \frac{\nu(s')}{\nu(s)}(1 + r_f + \alpha_{min})}{1 + r(\theta'_a, \theta'_h, s, s')} \pi(s'|s,l) \quad if\ \theta'_a \leq 0
\end{aligned}
$$

[37] Alvarez and Stokey (1998) provide a different, but related argument to prove the existence and uniqueness of a Bellman equation for a class of unbounded problems similar to the one considered here, but without moral hazard.

where the first inequality has to hold with equality if $\theta'_a > 0$ and the second inequality has to hold with equality if $\theta'_a < 0$. Note that the numerator is the excess return of human capital investment over the return to financial investment and that $(1+r)^{-1}$ is the marginal utility of consumption. Thus, equation (A9) says that expected marginal utility weighted returns are equalized across assets, a well-known optimality condition in portfolio choice theory.

Suppose the human capital productivity parameter ν is chosen as

$$\nu(s) = \frac{1-\beta}{\beta}\frac{1}{\phi(s)} \tag{A10}$$

Using this condition and substituting $\theta'_a = 0$ and $\theta'_h = 1$ into (A8) yields:

$$\begin{aligned} 1 &\geq \beta \sum_{s',\epsilon'} \frac{\phi(s)}{\phi(s')} \frac{1+r_f}{1+\eta(s',\epsilon')} \pi(\epsilon')\pi(s'|s,l) \\ 1 &\leq \beta \sum_{s',\epsilon'} \frac{\phi(s)}{\phi(s')} \frac{1+r_f+\varphi}{1+\eta(s',\epsilon')} \pi(\epsilon')\pi(s'|s,l) \end{aligned} \tag{A11}$$

Clearly, if the interest rate, r_f, is set according to (A1) and the financial intermediation cost is at least as large as α_{min} given in (A2), then (A11) is satisfied (and holds with equality if the cost is equal to φ_{min}). Straightforward algebra shows that in this case the value function (A7) reduces to (10) and equation (A8) becomes (9). Further, in this case the optimal plan given by (A6) is simply $c_t = \phi(s_t)h_t$ and $h_{t+1} = (1+\eta(s_{t+1},\epsilon_{t+1}))h_t$. This completes the proof that $a_t = 0$ is an optimal choice for workers.

It remains to be shown that (12) is the equilibrium law of motion for the state Ω. To see this, note that

$$\begin{aligned} \Omega_{t+1}(s_{t+1}) &= \frac{E[h_{t+1}|s_{t+1},S^{t+1}]\pi(s_{t+1}|S^{t+1})}{E[h_{t+1}|S^{t+1}]} \\ &= \frac{E[(1+\bar{\eta}(s_{t+1}))h_t|s_{t+1},S^{t+1}]\pi(s_{t+1}|S^{t+1})}{E[(1+\bar{\eta}(s_{t+1}))h_t|S^{t+1}]} \\ &= \frac{\sum_{s_t} E[(1+\bar{\eta}(s_{t+1}))h_t|s_t,s_{t+1},S^{t+1}]\pi(s_t|s_{t+1},S^{t+1})\pi(s_{t+1}|S^{t+1})}{\sum_{s_t,S_t,s_{t+1}} E[(1+\bar{\eta}(s_{t+1}))h_t|s_t,s_{t+1},S^{t+1}]\pi(s_t|s_{t+1},S^{t+1})\pi(s_{t+1}|S_{t+1})} \\ &= \frac{\sum_{s_t}(1+\bar{\eta}(s_{t+1}))\pi(s_{t+1}|s_t,S^{t+1})E[h_t|s_t,S^t]\pi(s_t|S^t)}{\sum_{s_t,s_{t+1}}(1+\bar{\eta}(s_{t+1}))\pi(s_{t+1}|s_t,S^{t+1})E[h_t|s_t,S^t]\pi(s_t|S^t)} \\ &= \frac{\sum_{s_t}(1+\bar{\eta}(s_{t+1}))\pi(s_{t+1},S_{t+1}|s_t)\Omega_t(s_t)}{\sum_{s_t,s_{t+1}}(1+\bar{\eta}(s_{t+1}))\pi(s_{t+1},S_{t+1}|s_t)\Omega_t(s_t)} \end{aligned} \tag{A12}$$

This completes the proof of proposition 1.

A.2 Proof of Proposition 3

We prove the proposition for the case of a change in UI. The proof for the case of changes in JSA follows similar lines. We begin with a partial equilibrium analysis (fixed tax rate τ) and then consider the general equilibrium effects (adjustment of τ to esnsure the government budget constraint holds.

The intensive-from Bellman equation (14) yields as a solution a triple (v_e, v_u, l). The first-order condition associated with the maximization problem reads:

$$d'(l) \;=\; \frac{\beta}{1-\beta+\beta\left(\pi_{e|u}(l)+\bar{\pi}_{u|e}\right)}\left[\ln\left(\frac{(1-\tau)w}{b}\right) + d(l) + \frac{\beta}{1-\beta}\ln\frac{1+\bar{\epsilon}}{1-\delta_h}\right]\frac{\partial \pi_{e|u}(l)}{\partial l} \tag{A13}$$

Equation (A13) implicitly defines a function $l = l(b, \bar{\pi}_{u|e})$, the optimal search effort as a function of unemployment benefits, b, and mean job destruction rate, $\bar{\pi}_{u|e}$. Implicit differentiation of (A13) with respect to b and $l = l(b, \bar{\pi}_{u|e})$ shows that for sufficienctly small β this function satisfies

$$\frac{\partial l}{\partial b} < 0 \quad ; \quad \frac{\partial^2 l}{\partial \bar{\pi}_{u|e}\partial b} > 0 \quad . \tag{A14}$$

Thus, an increase in unemployment benefits reduces search incentives and this dis-inentive effect becomes larger (in absolute value) for higher job destruction rate.

Solving the recursive equation (23) forward yields:

$$\begin{aligned}\Delta_y(\Omega; b) \;=\; &\beta\left[\ln(1+\hat{g}(\Omega, N; b)) - \sum_{S'}\ln(1+g(\Omega, S'; b))\pi(S')\right]\\ &+ \beta^2\left[\ln(1+\hat{g}(\Phi(\Omega, N), N; b)) - \sum_{S', S''}\ln(1+g(\Phi(\Omega, S'), S''))\pi(S'')\pi(S')\right]\\ &+ \dots\end{aligned} \tag{A15}$$

where g is the output growth rate in the economy with recessions and $\hat{g}$ is the output growth rate in the economy without recessions – see equation (17) for the formula of the equilibrium growth rate. Note that in (A15) we used the fact that l is independent of S. A straightforward but lengthy argument shows that we can bound the derivative of g with respect to b independently of β. Thus, there is function $K = K(\beta)$ that is independent of β so that

$$\frac{\partial \Delta_y}{\partial b}(\Omega, b) = \beta \frac{\partial}{\partial b}\left[\ln(1+\hat{g}(\Omega, N; b)) - \sum_{S'} \ln(1+g(\Omega, S'; b))\pi(S')\right] + \beta^2 K(b) \qquad \text{(A16)}$$

where g and $\hat{g}$ are functions of benefit levels b through the effort choice: $l = l(b)$. Clearly, the formula (A16) implies that for sufficiently small β the sign of $\frac{\partial \Delta_y}{\partial b}$ is determined by the first term in (A16). Differentiation of this term using the growth rate formula (17) yields:

$$\frac{\partial}{\partial b}\left[\ln(1+\hat{g}(\Omega, N; b)) - \sum_{S'} \ln(1+g(\Omega, S'; b))\pi(S')\right] = \qquad \text{(A17)}$$

$$\frac{\frac{\partial \pi_{e|u}}{\partial l}(\hat{l})\,\frac{\partial \hat{l}}{\partial b}}{\pi_{e|e}(N) \;+\; \pi_{e|u}(\hat{l})\Omega} - \frac{\frac{\partial \pi_{e|u}}{\partial l}(l)\,\frac{\partial l}{\partial b}}{\bar{\pi}_{e|e} \;+\; \pi_{e|u}(l)\Omega}$$

Using (A14) and that $\frac{\partial \pi_{e|u}}{\partial l}$ is a constant shows that the expression (A17) has a positive sign. Thus, we have $\frac{\partial \Delta_y}{\partial b} > 0$.

A.3 Bounded Government Debt

In this section, we construct for any fiscal policy $\{G_t, T_t\}$ induced by a labor market institution (b, x, τ) another fiscal policy $\{G'_t, T'_t\}$ with bounded government debt process that generates the same equilibrium effort choice, and for which equilibrium welfare is arbitrarily close to equilibrium welfare in the original economy. To this end, we extend the tax policy and allow the government to levy, in addition to the linear labor income tax τ, a linear consumption tax/subsidy τ_{ct}, that is, if the household consumes c_t he pays consumption taxes $\tau_{ct}c_t$ (if $\tau_{ct} > 0$) or receives a consumption subsidy $\tau_{ct}c_t$ (if $\tau_{ct} < 0$). We assume that the consumption tax/subsidy depends on public debt/assets, D_t. Specifically, $\tau_{ct}(D_t) = 0$ if debt/assets D_t are smaller than a given upper bound, $|D_t| < \bar{D}Y_t$, and $\tau_{ct}(D_t) = \tau_c$ otherwise. We choose τ_c large enough so that $|D_{t+1}| < |D_t|$ whenever $|D_t| \geq \bar{D}Y_t$. For this extended model, the arguments used to prove proposition 1 apply and therefore our equilibrium characterization results holds, mutatis mutandis. Note that for the extended model only the intensive-form Bellman equation (10) changes – there is an extra term $\ln(1+\tau_c)$ on the right-hand-side when $|D_t| > \bar{D}Y_t$. Note also that the government budget constraint in the extended model holds if and only if (b, x, τ) satisfies the government budget constraint (13) since the revenue from this tax/subsidy is zero in expectations.

The proposed consumption tax/subsidy limits the accumulation of public debt/assets without distorting effort choices and therefore gives rise to the same equilibrium effort choice. To see this, note that even though the intensive-form Bellman equation (11) is affected by this consumption tax, the solution l to in not affected since the differences in continuation values $v_e(U', S') - v_{su}(U', S')$ and $v_e(U', S') - v_{lu}(U', S')$ are unaffected.

The proposed consumption tax/subsidy changes the equilibrium consumption allocation since $c_t = \frac{\phi(s_t)}{1+\tau_{ct}}$ and $\tau_{ct} \neq 0$ if $|D_t| > \bar{D}Y_t$ in the new economy. However, we can always make this difference in the equilibrium consumption allocation inessential in the sense that equilibrium welfare in the two economies is arbitrarily close. To see this, note that for $\bar{D}$ large enough we can push the event $\tau_{ct} \neq 0$ far enough out into the future to ensure that the effect on individual welfare (3) is arbitrarily small. This completes the proof.

A.4 Computation of Equilibria

Note that for given aggregate state and tax rate, the household problem (11) is independent of the underlying wealth distribution, which facilitates the computational burden of solving the problem substantially. In general, we first solve the household problem (11) for given tax rate and then check whether the induced present value budget constraint of the government (13) is satisfied. Specifically, the computation of the recursive equilibrium proceeds as follows:

Step 1: Let N denote the number of grid points used for the grid over the wealth shares Ω. Set up a grid for short-term and long-term unemployed, $G_{\Omega,su} = \{\Omega_{su,1}, \ldots, \Omega_{su,N}\}$ and $G_{\Omega,lu} = \{\Omega_{lu,1}, \ldots, \Omega_{lu,N}\}$ such that the ensuing wealth allocation when there are only normal times and the ensuing wealth allocation when there are only recessions are in the interior of the grid $G_{\Omega,su} \times G_{\Omega,lu}$. Furthermore, fix an initial wealth allocation Ω_0.

Step 2: Provide an initial guess for the labor-income tax τ.

Step 3: Solve the household problem for given tax rate τ, i.e. find effort choices and value function coefficients that solve problem (11). Specifically, the first-order conditions and the respective plan equations of (11) read

$$\frac{\partial d_s(l_s(S), s)}{\partial l_s} = \beta \sum_{s', \epsilon', S'} \left(\frac{1}{1-\beta} \ln(1 + \eta_{s',\epsilon'}) + v_{s'}(S') \right) \pi_{\epsilon'} \frac{\partial \pi_{s'|s}(l_s(S')}{\partial l_s} \pi(S'|S)$$

$$
\begin{aligned}
v_s(S) \;&=\; \ln \phi_s - d_s(l) + \frac{\beta}{1-\beta} \sum_{s',\epsilon',S'} \ln(1+\eta_{s',\epsilon'})\, \pi_{\epsilon'} \pi_{s'|s}(l,S') \pi(S'|S) \\
&\quad + \beta \sum_{s',S'} v_{s'}(S') \pi_{s'|s}(l,S') \pi(S'|S)
\end{aligned}
$$

This is a system of 10 equations in 10 unknowns $(l_{su}(S), l_{lu}(S), v_e(S), v_{su}(S), v_{lu}(S))$ for $S = \{N, R\}$ and we use a standard quasi-Newton algorithm to solve it.

step 4: Given the effort choices $l_s(S)$, we compute the evolution of the wealth distribution for each wealth allocation on the grid $G_{\Omega,su} \times G_{\Omega,lu}$ – see equation (12). Then, we compute the government's present value budget constraint $PV(\Omega, S)$ for an arbitrary wealth allocation by iterating over the recursive equation (13) and using linear interpolation to obtain the continuation values $PV(\Omega', S')$.

step 5: Given $PV(\Omega, S)$, we use linear interpolation to compute the value of the present value budget constraint evaluated at the initial wealth allocation Ω_0. If $PV(\Omega_0, S)$ is sufficiently close to zero, we found an equilibrium; otherwise, we refine our guess for the equilibrium tax rate τ and return to step 3.

In order to avoid unnecessary updating of τ, we use a standard bisection algorithm on the present value budget constraint to solve for the equilibrium allocation.

Note that the algorithm just described is also applicable for computing the transitional dynamics. Specifically, we compute the equilibrium allocation for any specific labor market institution conditional on the initial wealth allocation and use the effort choice in conjunction with the law of motion for wealth shares (12) and the law of motion of unemployment (15) to compute the transition dynamics for all economically relevant variables.

A.5 Model Extension with Matching and Vacancy Posting

We assume that for each skill level, h, there is a labor market in which workers of type h and firms requiring a worker of type h are matched. As in the baseline model, a match produces Zh or 0 and the transition probability from the productive to the unproductive state is equal to the job destruction rate, $\pi_{su,e}(S')$. We continue to assume that the productivity parameter, Z, is constant over the cycle and that the exogenous transition rate from productivity Z to productivity 0, which is equal to the job destruction rate $\pi_{e|su}(S')$, varies with business cycle conditions. Note that despite the absence of fluctuations in the productivity parameter Z the calibrated model matches the observed cyclical variations in job finding rates through endogenous variations in labor market tightness (see below).

The total number of matches in a period, N, is given by

$$N \;=\; \left(x_{su}L_{su}U_{su} + x_{lu}L_{lu}U_{lu}\right)^{\psi} V^{1-\psi} \tag{A18}$$

It is straightforward to show that the matching function (A18) implies a job finding rate for workers given by (27) and a vacancy filling rate for firms given by $\pi_f(\Theta) = \Theta^{-\psi}$, where Θ is the labor market tightness defined in (28).

The worker decision problem in the extended model is the same as the worker decision problem in the baseline model with (27) as job finding rate. Mutatis mutandis, the characterization of the solution to the worker problem remains the same.

We next turn to the firm's decision problem. We assume that there is a cost of filling a vacancy of type h that is equal to $(\kappa_0 + \kappa_1\pi_f(\Theta))h$. The first term represents the cost of posting a vacancy – this cost is paid regardless of the success of the search. The second term represents the cost of forming a new firm-worker match – this cost is only paid if the search has been successful and can be interpreted as negotiation cost plus training cost. Mortensen and Nagypal (2007) and Pissarides (2009) argue that this cost is an important component of the total cost of filling job vacancies and show that the introduction of this cost into the standard DMP model can resolve the unemployment volatility puzzle for the US economy.

Let J_e stand for the value of a firm with a filled job and J_u the value of a firm with an unfilled job (vacany). The firm's value function satisfies the following recursive equation:

$$\begin{aligned} J_e(h,\Theta,S) \;&=\; Z(S)h - w(S)h \\ &\quad + \beta_f \sum_{\epsilon',S'} \pi(\epsilon')\left[J_e(h',\Theta',S')(1-\pi_{su|e}(S')) + J_u(h',\Theta',S')\pi_{su|e}(S')\right]\pi(S'|S) \\ J_u(h,\Theta,S) \;&=\; -\left(\kappa_0 + \kappa_1\pi_f(\Theta)\right)h + \beta_f \sum_{S'} \left[J_e(h',\Theta',S')\pi_f(\Theta) + J_u(h',\Theta',S')(1-\pi_f(\Theta))\right]\pi(S'|S)\;, \end{aligned} \tag{A19}$$

where β_f is the discount factor of the firm owner (see below). Next period's human capital level, h', is given by the human capital accumulation equation (1) and next period's labor market tightness is determined through an endogenous law of motion $\Theta' = \Theta'(\Theta, S, S')$. Free entry of firms requires zero profit:

$$J_u(h, \Theta, S) \;=\; 0 \,. \tag{A20}$$

We can find the equilibrium for the extended model using the guess-and-verify method. Specifically, suppose current labor market tightness is a function of the current business cycle conditions, $\Theta = \Theta(S)$. In this case, Θ is not an additional state variable and the law of motion for Θ reduces to the function $\Theta' = \Theta(S')$. Suppose further that the solution to the worker problem is given as before and the firm value function is $J_s = \tilde{J}_s(S)h$ for $s = e, u$. Substituting this guess into (A19) and (A20) yields the following equation system:

$$\begin{aligned} \kappa_0 + \kappa_1 \pi_f(\Theta(S)) &= \beta(1+\bar{\epsilon})\pi_f(\Theta(S)) \sum_{S'} \tilde{J}_e(S')\pi(S'|S) \\ \tilde{J}_e(S) &= Z(S) - w(S) + \beta(1+\bar{\epsilon}) \sum_{S'} \tilde{J}_e(S')(1-\pi_{su|e}(S'))\pi(S'|S) \,. \end{aligned} \tag{A21}$$

For given wage function $w = w(S)$, the second part of (A21) determines the values $\tilde{J}_e(S)$ for $S = N, R$ and the first part of (A21) then determines the values $\Theta(S)$ for $S = N, R$.

Wages are determined through Nash bargaining. More precisely, for given S the wage $w(S)$ is the solution to

$$\max_w \left\{ (V_e(h,S) - V_{su}(h,S))^{\tilde{\psi}} \, (J_e(h,S) - J_u(h,S))^{1-\tilde{\psi}} \right\} \tag{A22}$$

where $\tilde{\psi}$ is a parameter measuring the bargaining power of workers. Using the equilibrium characterization of the value functions V and J, we find that the maximization problem (A22) is equivalent to the maximization problem:

$$\max_w \left\{ \tilde{\psi} \ln\left(\tilde{V}_e(S) - \tilde{V}_{su}(S)\right) (1-\tilde{\psi}) \ln \tilde{J}_e(S) \right\} . \tag{A23}$$

Taking the first-order conditions with respect to w in (A23) yields:

$$w(S) \;=\; \frac{\tilde{\psi}\tilde{J}_e(S)}{(1-\tilde{\psi})(\tilde{V}_e(S) - \tilde{V}_{su}(S))}. \tag{A24}$$

The equation system (A21) and (A24) determines the equilibrium values of $\tilde{J}_e(S)$, $\Theta(S)$, and $w(S)$ for $S = N, R$ (recall that $\tilde{J}_u(S)$ is already pinned down by the free-entry condition (A20)). Note that the efficiency requires $\tilde{\psi} = \psi$.

Finally, we assume that each firm is owned by an entrepreneur/capitalist with discount factor β_f and utility function that is linear in consumption. These entrepreneurs may buy and sell the risk-free asset, but as in the case of workers, if the cost of financial intermediation is large enough, they will not do so and simply consume the firm's profit in equilibrium.[38]

A.6 Calibration Values

Table A1 summarizes the calibrated parameters and their values.

Table A1: Calibration

preferences	d_0	γ	$d_{1,su}$	$d_{1,lu}$	β
	1.0000	1.3173	-2.3319	-2.3319	0.9900
search technology	x_{su}	x_{lu}	$\Psi(N)$	$\Psi(R)$	
	0.1269	0.0842	1.0056	0.9869	
individual transition probabilities	$\pi(su\|e;N)$	$\pi(su\|e;R)$	$\pi(lu\|su)$	$\pi(su\|lu)$	
	0.0160	0.0182	0.2500	0.1900	
aggregate transition probabilities	$\pi(N\|N)$	$\pi(R\|R)$			
	0.9464	0.8750			
skill loss/depreciation	$\delta_{h,su}$	$\delta_{h,lu}$	μ_ϵ	σ_ϵ	
	0.0250	0.0250	-0.0051	0.0750	
unemployment benefit	b_{su}	b_{lu}			
	0.8500	0.7900			

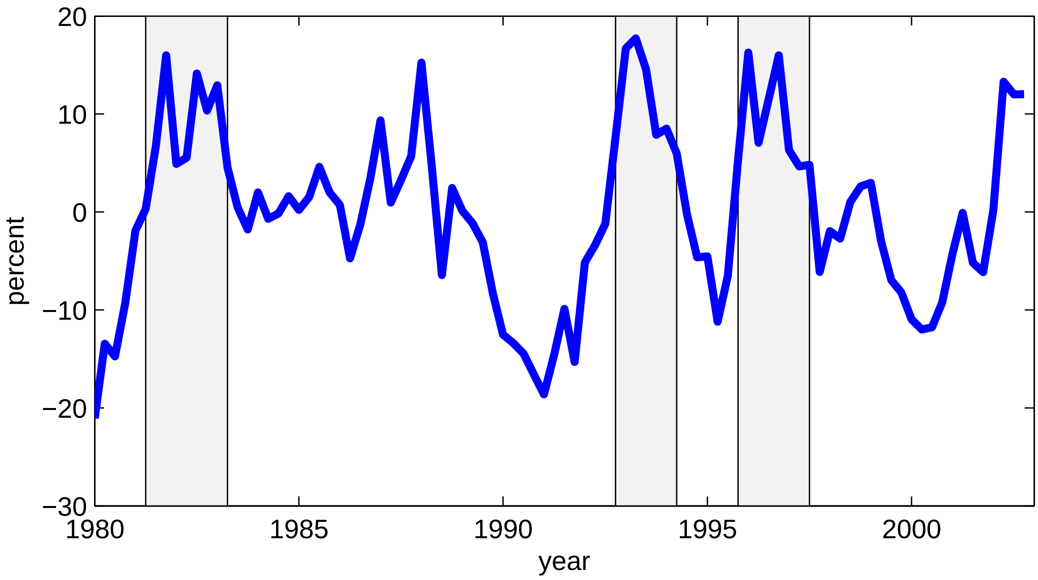
[38]Alternatively, we can assume that shares in firms are traded in the stock market, but workers do not participate in the stock market.

A.7 Data Analysis and Recession Dates

A.7.1 Worker Flow Data

We use three different data sources for the construction of the worker flow rates (job destruction and job finding rates). First, Jung and Kuhn (2014) provide flow rates for the period 1980 - 2004. Second, the German Employment Agency (IAB) publishes stock and flow data in its monthly reports for the period 2005 - 2015. Third, in a special report (IAB, 2011) the German Employment Agency provides additional evidence on job finding rates conditional on unemployment duration (i.e. short-term and long-term unemployment) for the period 2000 - 2010.

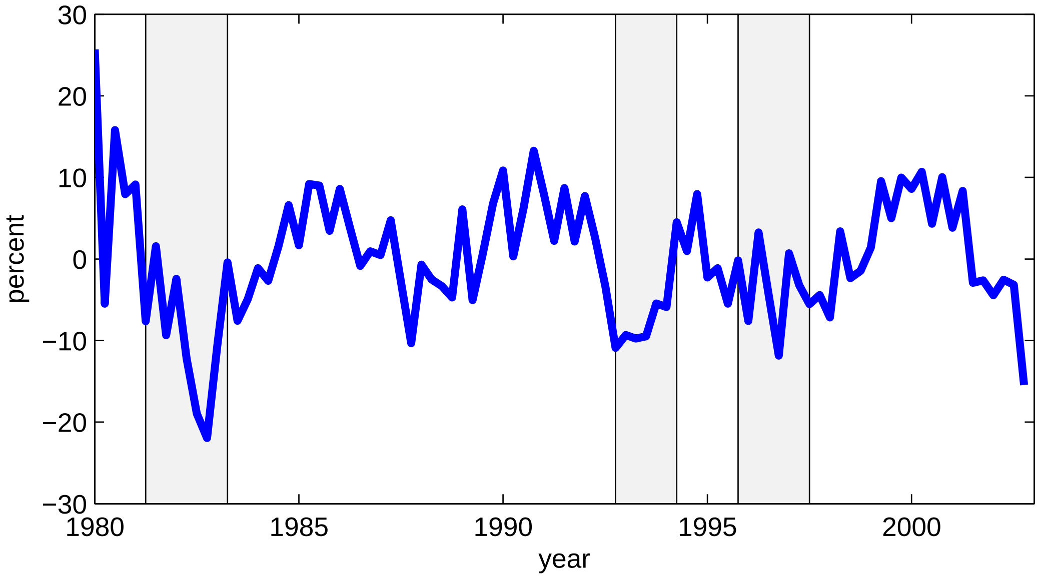
Figure A1: Cyclical Component of Job Destruction Rate 1980 - 2003



Notes: Data are seasonally adjusted job flow rates taken from Jung and Kuhn (2014). We further adjust for transitions out of the labor force, aggregate to quarterly frequency, and HP-filter with smoothing parameter 1600. Recession periods are highlighted by shaded areas.

To construct a time series of the cyclical movements in job destruction and job finding rates for the pre-reform period, we use the transitions rates from Jung and Kuhn (2014), who compute employment transition rates from the IAB Employment Panel for West Germany for the period 1980-2004. As the years 2003 and 2004 are already affected by the first stages of the German labor market reform (Hartz I-III reforms), we drop the observations for these two years. Jung and Kuhn (2014) construct seasonally adjusted monthly transition rates across employment states including the transition in and out of the labor force. We adjust for the transition in and out of the labor force, aggregate to a quarterly frequency, and then use a HP-filter with smoothing parameter 1600 to de-trend the time series. The resulting time series of the cyclical component of job finding and job destruction rates are depicted in Figures A1 and A2.

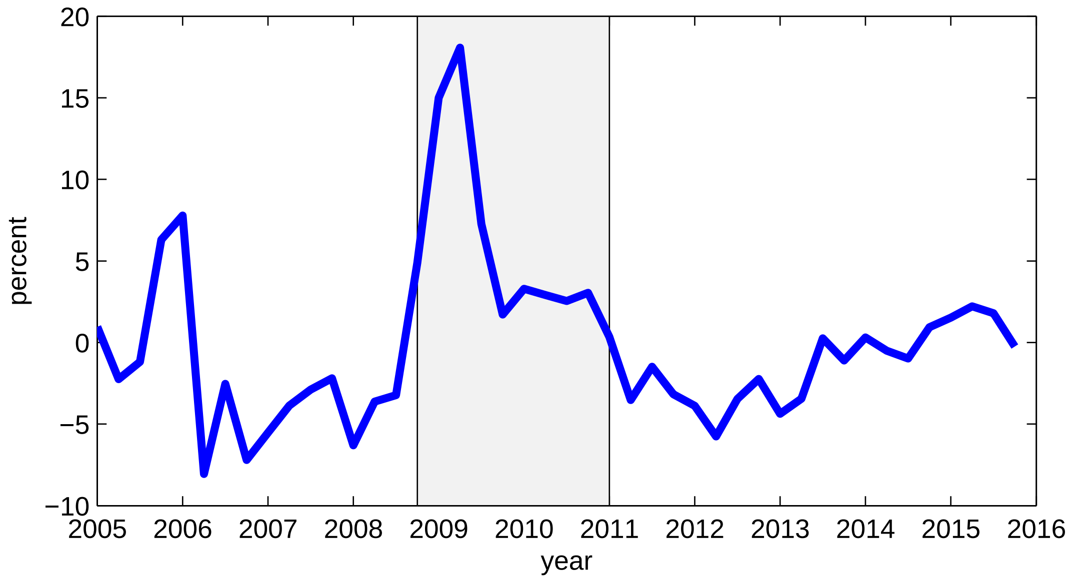
Figure A2: Cyclical Component of Job Finding Rate 1980 – 2003



Notes: Data are seasonally adjusted job flow rates taken from Jung and Kuhn (2014). We further adjust for transitions out of the labor force, aggregate to quarterly frequency, and HP-filter with smoothing parameter 1600. Recession periods are highlighted by shaded areas.

To construct a time series of cyclical movements in job destruction and job finding rates for the Great Recession (post-reform), we use monthly labor market stock and flow data for the period 2005 - 2015 from the German Employment Agency. Until 2011, flows are concisely provided in the March issue *Arbeitsmarkt in Zahlen – Aktuelle Daten*. For flow data 2012 - 2015, we use the monthly publications *Arbeitsmarkt in Zahlen – Arbeitslose nach Rechtskreise*. The time series for employment and unemployment stocks are from the March issue *Arbeitsmarkt in Zahlen – Eckwerte des Arbeitsmarktes* for the years 2012, 2014 and 2016. We compute monthly job finding rates by dividing the number of transitions from unemployment to employment in a month by the number of unemployed workers in

Figure A3: Cyclical Component of Job Destruction Rate 2005 – 2015

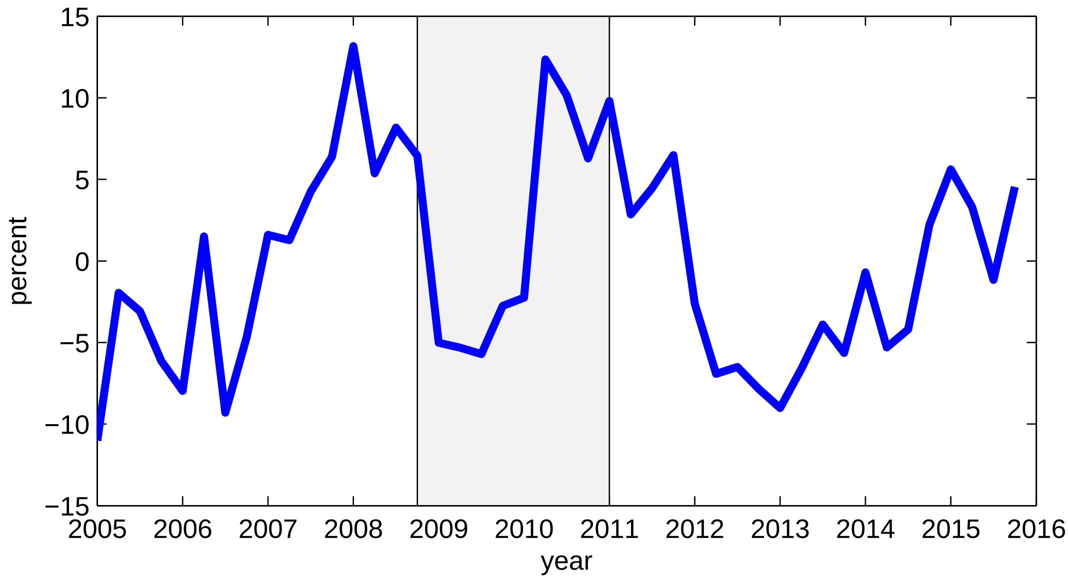


Notes: Data on employment and worker flows are taken from "Arbeitsmarkt in Zahlen Arbeitslosenstatistik" published monthly by the German Employment Agency. We use the data to compute monthly job separation rates, apply the US Census Bureau's X-13ARIMA-SEATS to seasonally adjust, aggregate to quarterly frequency, and HP-filter with smoothing parameter 1600. Great recession is highlighted by shaded area.

that month. Similarly, we compute monthly job destruction rates by dividing the number of transitions from employment to unemployment in a month by the number of employed workers in that month. We then apply the US Census Bureau's X-13ARIMA-SEATS to seasonally adjust the resulting times series of job finding and job destruction rates, aggregate to quarterly frequency, and then use a HP-filter with smoothing parameter 1600 to de-trend the time series. The resulting time series of the cyclical component of job finding and job destruction rates for the period 2005-2015 are depicted in Figures A3 and A4.

Finally, the job finding rates depicted in Figure 3 are drawn from the special report of the German Employment Agency (2011). In this report, the German Employment Agency provides seasonally adjusted monthly job finding rates for short-term unemployed (less than 1 year) and long term unemployed (more than 1 year), which we aggregate to quarterly frequency.

Figure A4: Cyclical Component of Job Finding Rate 2005 – 2015



Notes: Data on unemployment and worker flows are taken from "Arbeitsmarkt in Zahlen Arbeitslosenstatistik" published monthly by the German Employment Agency. We use the data to compute monthly job finding rates, apply the US Census Bureau's X-13ARIMA-SEATS to seasonally adjust, aggregate to quarterly frequency, and HP-filter with smoothing parameter 1600. Great recession is highlighted by shaded area.

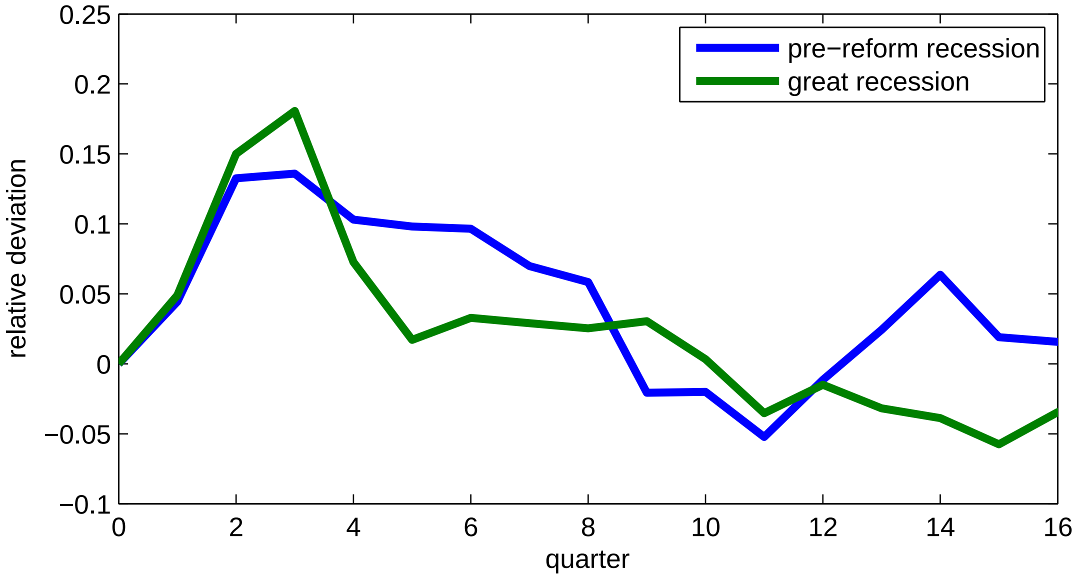
A.7.2 Recession Dates

We use the behavior of the cyclical component of the observed job destruction rate shown in Figures A1 and A3 to date recessions, which is motivated by the fact that this variable is the main driver of business cycles according to our model. We define a recession as any period in which the cyclical component of the job destruction rate declines for at least two periods. For the pre-reform sample period 1980 - 2002, this procedure identifies three recessions: 1981Q2 - 1983Q2, 1992Q4 - 1994Q2, and 1995Q4 - 1997Q3. Schirwitz (2009) conducts a comprehensive statistical analysis of the German business cycle and also identifies in her "Consensus Chronology" these three recessions as the recessions in Germany over the sample 1980 - 2002. For the post-reform sample period 2005 - 2015, our method identifies the Great Recession as the only recession with dates 2008Q4 - 2010Q1.[39]

[39] In contrast to the US, no quasi-official business cycle dating committee exists in Germany. This means

Figure A5 shows the dynamics of the cyclical component of the job destruction rate during the typical pre-refrom recession and the Great Recession, where the cyclical component of the job destruction rates are taken from Figures A1 and A3, respectively. For the typical pre-reform recession we average over the three pre-reform recessions. Figure A6 shows the corresponding dynamics of the cyclical component of the job finding rate during the typical pre-refrom recession and the Great Recession.

Figure A5: Cyclical Component of Job Destruction Rate during Recessions



Notes: The blue line shows the cyclical component of the job destruction rate during the typical pre-reform recession (see also Figure A1) and the green line shows the cyclical component of the job destruction rate during the Great Recession (see also Figure A3). Job destruction rates during the typical pre-reform recession are computed as the average over the three recessions starting in 1981Q2, 1992Q4, and 1995Q4.

Figures A5 and A6 reveal two interesting features of the German labor market. First, during the typical pre-reform recession, the hike in the job destruction rate is substantially larger than the decline in the job finding rate. In other words, the typical recession in

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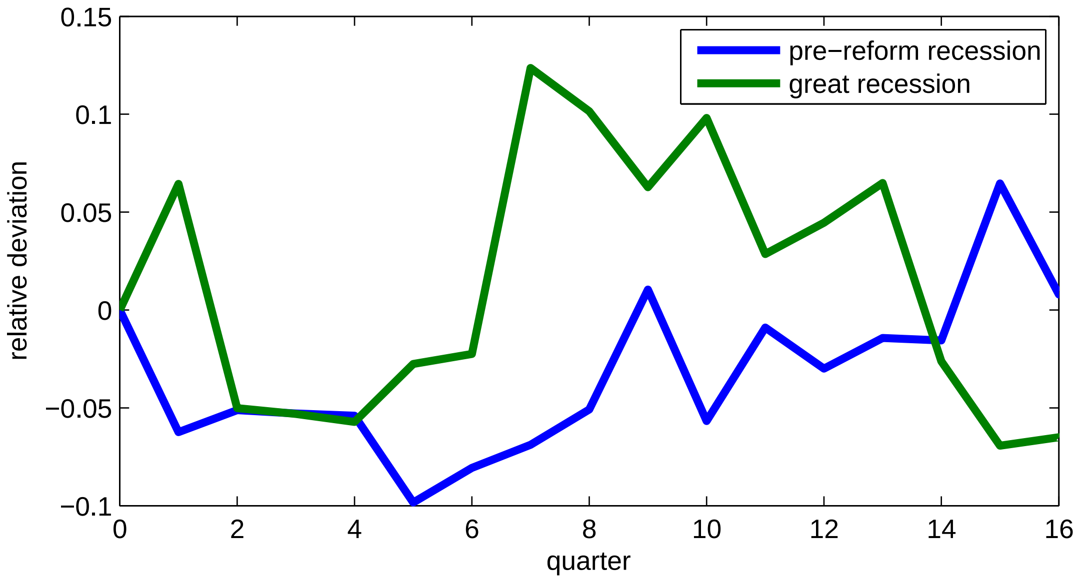
that papers on the German business cycle rely on different methods to identify the recession dates. The contribution of Schirwitz (2009) is to use a variety of statistical methods to identify those recessions episodes that are robust to small changes in the methodology. Note that we cannot include the recession 2002-2004 in our pre-reform sample since part of it overlaps with the Hartz reforms.

Figure A6: Cyclical Component of Job Find Rate during Recessions



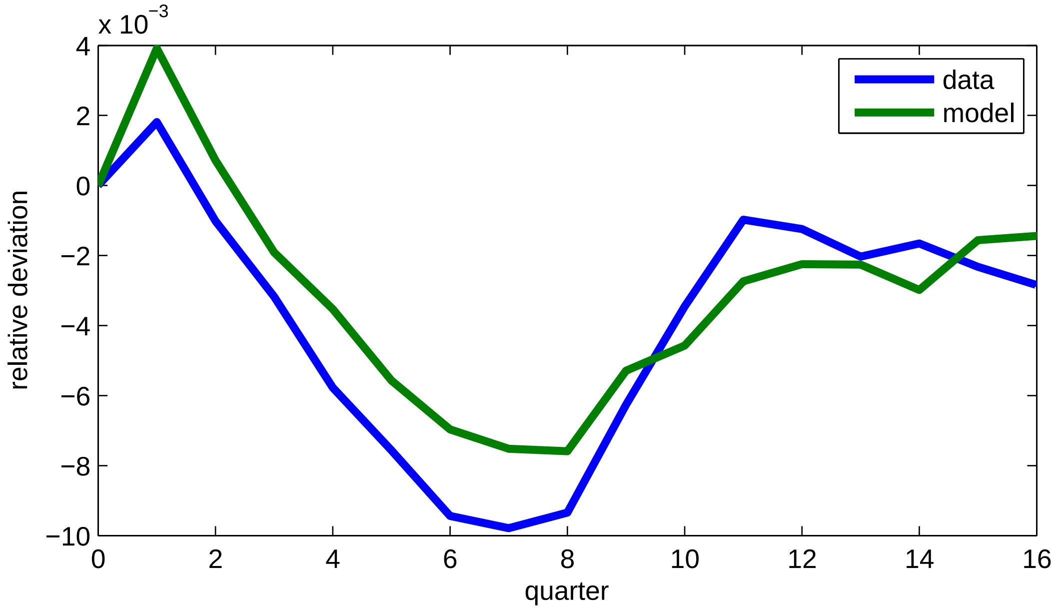
Notes: The blue line shows the cyclical component of the job finding rate during the typical pre-reform recession (see also Figure A2) and the green line shows the cyclical component of the job finding rate during the Great Recession (see also Figure A4). Job finding rates during the typical pre-reform recession are computed as the average over the three recessions starting in 1981Q2, 1992Q4, and 1995Q4.

Germany is mainly driven by a hike in the job destruction rate, and to a lesser extent by a decline in the job finding rate – see also Jung and Kuhn (2014) on this point. Second, the cyclical movements of job destruction and job finding rates during the Great Recession have been similar to the corresponding movements of job destruction and job finding rates during the typical pre-reform recession. However, the Great Recession was somewhat shorter than the average pre-reform recession in Germany and the hike in the job destruction rate during the Great Recession slightly more pronounced. Put differently, in terms of cyclical movements of worker flows, the Great Recession in Germany looks not too different from a typical pre-reform recession in Germany.

A.7.3 Unemployment and Employment

In its publication *Arbeitsmarkt in Zahlen – Arbeitslosigkeit im Zeitverlauf*, issue April 2016, the German Employment Agency publishes long time series for the unemployment rate on monthly basis. While the observation between years 1950 and 1990 only includes West Germany, the time series since 1991 comprises West and East Germany. However, the German Employment Agency already adjusts for the data break caused by the change in coverage 1991. We seasonally adjust the time series using the X-13ARIMA-SEATS algorithm and aggregate to quarterly frequency. The resulting unemployment series for the period 1970 - 2016 are depicted in Figure 5 (green line). Alternatively, in Figure 5 we also report the OECD harmonized unemployment rate for the same time period and the same restriction on regional coverage (blue line). The monthly data are already seasonally adjusted and we aggregate to quarterly frequency.

Figure A7: Cyclical Employment during Pre-Reform Recessions: Data and Model



Notes: The blue line shows the cyclical component of employment during the typical pre-reform recession (data). Employment in the typical pre-reform recession is the average over the three recessions starting in 1981Q2, 1992Q4, and 1995Q4. The cyclical component of employment is computed using the HP-filter. The green line shows the deviation of employment from its long-run level in a pre-reform recession according to the model.

Figure 6 shows the dynamics of the cyclical component of the unemployment rate during recessions in the data. To generate the data points in Figure 6, we use a HP-filter with smoothing parameter 1600 to de-trend the quarterly time series of unemployment and then compute the change of the cyclical component of the unemployment rate during the three pre-reform recessions. Finally, we average the unemployment pathes over the three pre-reform recessions. Figure 6 further shows the dynamics of the unemployment rate implied by the flow rates depicted in Figures A5 and A6 (using the flow equation for the unemployment rate). Figure A7 makes the corresponding comparison for the employment dynamics.

The main result that emerges is that the two time series depicted in Figure 5, respectively A7, are quite close to each other. Since the model matches by construction the cyclical movements of workers between employment and unemployment, this means that the unemployment dynamics, respectively employment dynamics, during pre-reform recessions in Germany is mainly driven by worker flows between employment and unemployment. In other words, movements in and out of the labor force are not an important driver of the unemployment or employment dynamics during recessions (see also Jung and Kuhn, 2014, for a similar result regarding the business cycle dynamics in Germany).

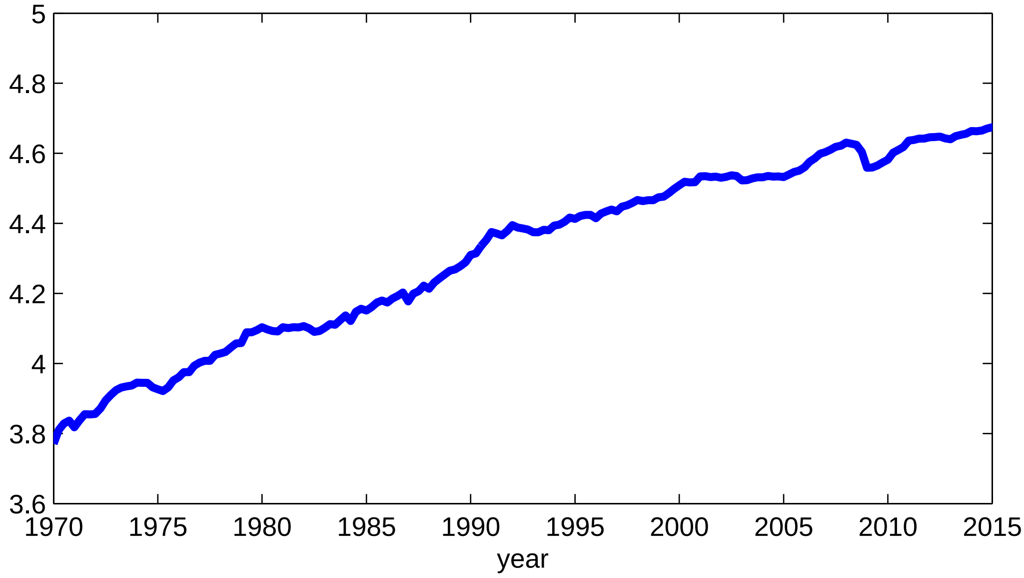
A.7.4 Output

The Federal Statistical Office provides seasonally adjusted GDP data on quarterly frequency. The data are shown in Figure A8.

We use the GDP data to construct the output dynamics during recessions depicted in Figures 1 and 7 as follows. For the pre-reform recessions, we use as recessions dates the dates defined by the cyclical variations in job destruction rates, that is, we use the recessions dates 1981Q2 - 1983Q2, 1992Q4 - 1994Q2, and 1995Q4 - 1997Q3 – see the discussion above.[40] For each of the three recessions starting in 1981Q2, 1992Q4 and 1995Q4, we compute the cumulative deviation from trend output, where trend output is defined by average output growth over the sample period 1980-2000. We then compute the the output dynamics for a typical recession by taking the average over the (cumulative) output deviations of the three recessions restarting in 1981Q2, 1992Q4 and 1995Q4. In a similar vein, we characterize the Great Recession as the (cumulative) output deviation from trend growth over the period 2005-2015, where the starting date of the Great Recession is 2008Q4.

[40] We use this method because in our model output movements are mainly driven by variations in job destruction rates. Dating recessions based on the deviation of output from its trend yields very similar results.

Figure A8: Log of Real GDP 1970 – 2015



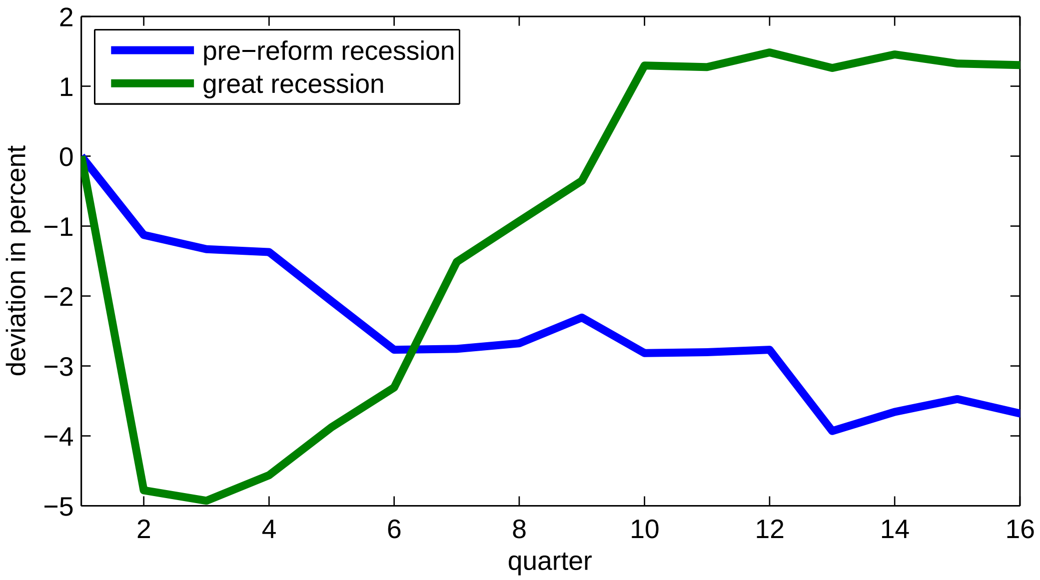
Notes: Quarterly and seasonally adjusted real GDP published by the Federal Statistical Office.

In Figures 1 and 7 we compute trend output growth using the mean of the growth rate observed over the entire sample period. Blanchard, Cerutti, and Summers (2015) have proposed an alternative approach to computing the trend path of output when hysteresis effects might exist. Figure A9 shows output dynamics during recessions in Germany using the method proposed by Blanchard et al. (2015).[41] A comparison of Figures 1 and A9 shows that these two methods yield similar results.

Note that we do not use the HP filter to remove the trend component from output since this is not a valid approach in the presence of hysteresis effects. This means that we use two different methods to construct the recession dynamics. For job destruction rates, job finding rates, and unemployment rates, we construct from the data a cyclical component using the HP-filter removing possible hysteresis effects. In contrast, for output we do not apply this method to construct the output dynamics during recessions depicted in Figures 1

[41]The data in Figure A9 are constructed using the adjustment proposed in Blanchard et al. (2015) to take into account slow-moving changes in long-run trends. German output growth has been steadily declining since the 1970s until the mid 2000s, which suggests that the adjustment is necessary to obtain meaningful results.

Figure A9: Output during Pre-Reform Recessions and Great Recession



Notes: Real GDP relative to its trend during the typical pre-reform recession (blue line) and the Great Recession (green line). Real GDP in the typical pre-reform recession is the average over the three recessions starting in 1981Q2, 1992Q4, and 1995Q4. Trend output is computed using the method proposed by Blanchard, Cerutti, and Summers (2015).

and 6. Our approach seems to be appropriate given that the model implies hysteresis effects in output even though job flow rates and unemployment do not display hysteresis.

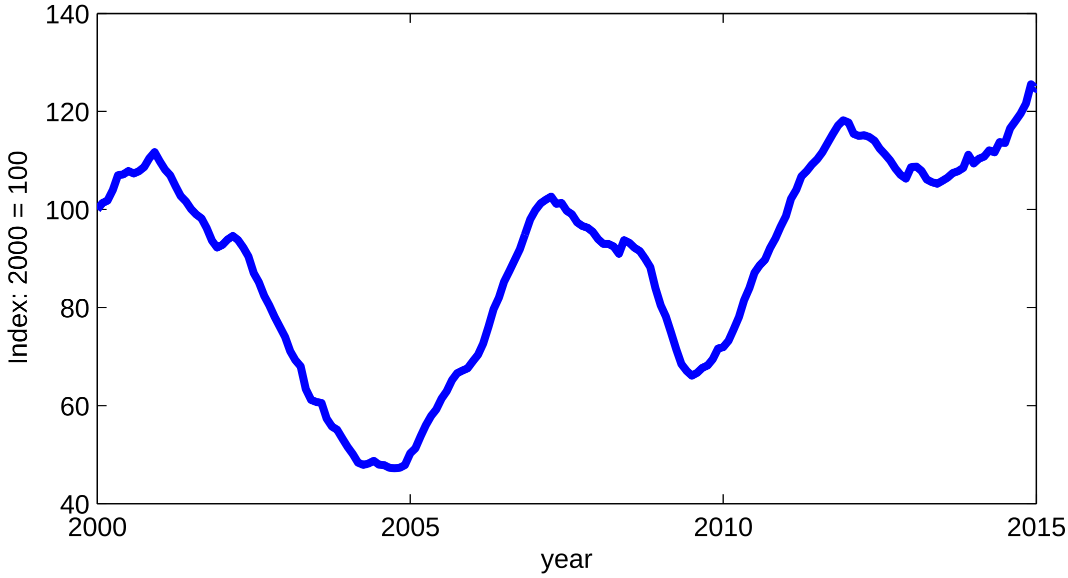
A.7.5 Job Vacancy Posting

Table A10 depicts the seasonally adjusted series of vacancies published by the German Employment Agency.

A.8: Long-Run Effects of Labor Market Reform

In this section, we discuss the effect of the Hartz III reform and the Hartz IV reform long-run values of unemployment and output. To this end, we compute the average value of unemployment and welfare before and after the reforms using the stationary distribution over aggregate states to take the average. We have also computed steady state values of an economy without aggregate shocks, and the effects are quantitatively very similar. Table A2 summarizes our long-run results.

Figure A10: Vacancies 2000 - 2015



Notes: Monthly data published by the German Employment Agency. We seasonally adjust the data using the US Census Bureaus X-13ARIMA-SEATS.

Table A2 shows that both the improvement in JSA (Hartz III) and the reduction in UI (Hartz IV) increase long-run values of the job finding rate substantially. This increase in the fluidity of the German labor market reduces the long-run unemployment rate. Specifically, the Hartz III reform reduced the unemployment rate by 1.4 percentage points in the long-run and the Hartz IV reform by 1.2 percentage points. We also find that the two reforms taken together have reduced the long-run unemployment rate in Germany by 2.4 percentage points.[42] These results are in line with the findings in Krebs and Scheffel (2013). For the Hartz IV reform, Krause and Uhlig (2012) find even larger unemployment effects. In contrast, Launov and Waelde (2013) find that the Hartz IV reform had only small effects on the unemployment rate, but their finding is mainly driven by their assumption that the Hartz IV reform had only a negligible effect on the average net replacement rate. Note that the model accounts for somewhat more than half of the observed reduction in non-cyclical unemployment – see Figure 5 and the corresponding discussion in Section 2.

[42]The total effect of the two reforms is somewhat less than the sum of the individual effects because of non-linearities.

Table A2: Long-Run Effects of German Labor Market Reform

	$\pi_{e\|su}$	$\pi_{e\|lu}$	$U_{su}+U_{lu}$	g
Pre Reform	0.240	0.060	10.011	1.000
Post Hartz-III-Reform	0.277	0.072	8.613	1.127
Post Hartz-IV-Reform	0.267	0.073	8.817	1.107
Post Hartz-III&IV-Reform	0.306	0.087	7.639	1.217

Notes: Long-run values are computed by averaging over aggregate states using the stationary equilibrium distribution. $\pi_{e|su}$ *and* $\pi_{e|lu}$ *stand for the job finding rates of the short-term unemployed and long-term unemployed, respectively.* $U_{su}+U_{lu}$ *is the unemployment rate and* g *is the annualized growth rate of potential output in percent.*

We next consider the effect of labor market reform on long-run (potential) output. In our model with skill depreciation, unemployment leaves permanent scars, and a higher job finding rate reduces this scarring effect. Given the assumption that skill depreciation is proportional to the existing stock of human capital and that output is linear in human capital, this scaring effect implies that labor market reforms have an impact on long-run output growth. We find that the effect of the Hartz III reform and the Hartz IV reform on long-run output growth is non-negligible. Specifically, according to our baseline calibration, the Hartz III and Hartz IV reform increased long-run output growth from 1.5 percent to 1.63 percent and 1.60 percent, respectively.

A.9 Welfare Cost of Business Cycle

In this section, we discuss the relationship between the welfare cost of recessions used in this paper and the welfare cost of business cycles as defined by Lucas (1987, 2003) for representative household economies and extended to economies with uninsurable idiosyncratic risk by, among others, Krebs (2003, 2007), Krusell and Smith (1999), and Krusell et al. (2009). In both cases, the formula (20) is used to compute the welfare cost/gain of moving from one economy with S-dependent fundamentals to another economy with S-independent fundamentals. However, the approaches differ in the way they eliminate aggregate fluctuations. To compare the two approaches, it is useful to replace (16) by the general formula

$$\begin{aligned}\hat{\pi}_{su|e} &= \sum_{S'} \pi_{su|e}(S')\rho_e(S') \\ \hat{\pi}_{e|s}(l, x_s, U, L) &= \sum_{S'} \pi_{e|s}(l, x_s, U, L, S')\rho_s(S') \qquad s = su, lu \\ \hat{\eta}_{s',\epsilon'} &= \eta_{s',\epsilon'}\end{aligned}$$

where $\rho(S')$ is a general weighting distribution.

Krebs (2003, 2007), Krusell and Smith (1999), and Krusell et al. (2009) use a weighting distribution $\rho_e(S') = \pi(S'|e)$, where $\pi(S'|e) = \pi(e, S')/\pi(e)$ is the probability that the aggregate state S' occurs conditional on e in the economy with business cycles. Put differently, business cycles are eliminated in a symmetric way so that the S'-dependent job destruction rates are replaced by a constant job destruction rate with the same (conditional) mean. The focus in this paper, however, is on the welfare cost of recessions, in which case $\rho(R) = 0$ and $\rho(N) = 1$. In other words, business cycles are eliminated in an asymmetric fashion so that the S'-dependent job destruction rates are replaced by a constant job destruction rate with a lower mean.

In Table A3 we report the welfare cost of business cycles for the different weighting schemes ρ, where we assume $\rho_s(N) = \rho(N)$ and $\rho = 1$ stands for $\rho(N) = 1$ and $\rho = 0$ means $\rho(N) = \pi(N)$. The results are as follows. First, using fully symmetric elimination of business cycles ($\rho = 0$), the welfare cost of business cycles is quite small, 0.028 percent of lifetime consumption. This result is the net effect of two forces working in the opposite direction. On the one hand, risk aversion suggests a positive welfare cost of fluctuations in labor market risk. On the other hand, variations in job finding rates in conjunction with the ability of workers to adjust search effort suggest a negative welfare cost – volatility in job finding rates is good. The second effect has been emphasized in Gomes, Greenwood, Rebelo (2001) and Cho, Cooley, and Kim (2015).

Table A3: Welfare Cost of Business Cycles

	$\rho = 1.00$	$\rho = 0.66$	$\rho = 0.33$	$\rho = 0.00$
Pre Reform	1.310	0.872	0.442	0.017
Post Hartz-III-Reform	1.205	0.807	0.417	0.032
Post Hartz-IV-Reform	1.277	0.853	0.438	0.027
Post Hartz-III&IV-Reform	1.181	0.794	0.415	0.040

Notes: Δ is the welfare cost of business cycles in percent of equivalent variations in lifetime consumption. If $\rho = 1.00$, elimination of business cycles is completely asymmetric (welfare cost of recessions) and if $\rho = 0.00$, elimination of business cycles is completely symmetric.

Table A3 also shows that the welfare cost of business cycles increases with the degree of asymmetry used in the elimination of business cycles and reaches its maximum for $\rho(N) = 1$, in which case the welfare cost of business cycles coincides with the welfare cost of recessions shown in Table 2. Further, with the exception of the case of fully symmetric elimination of business cycles, Table A3 shows that in all cases the Hartz III reform and the Hartz IV reform reduce the welfare cost of business cycles, and that the percentage reduction in the welfare cost of business cycles is roughly the same for all values of ρ. Thus, the main quantitative results of this paper are very similar when we replace the concept of the welfare cost of recessions by the more general concept of the welfare cost of business cycles. Intuitively, the value function of individual households is approximately linear in job finding rates (expected utility preferences) for all methods ρ, and the Hartz III reform and the Hartz IV reform always increase these job finding rates by the same amount regardless of ρ.

It is common to interpret the welfare cost of business cycles as the potential gains from stabilization policy (Lucas 1987, 2003). If this interpretation is adopted, an asymmetric weighting scheme, $\rho_e(N) > \pi(N|e)$, amounts to the assumption that stabilization policy affects the business cycle asymmetrically. There are at least three reasons why this can be the case. First, Auerbach and Gorodnichenko (2012) provide empirical evidence that fiscal multipliers are substantially larger in recessions than in booms. If output and job destruction rates are positively correlated, then this finding implies that stabilization policy has an asymmetric effect on the labor market and can change the average job destruction rate. In line with this empirical finding, Gali, Gertler, and Lopez-Salido (2007) show that in a simple New-Keynesian model efficiency losses due to mis-pricing during a recession are not offset by the efficiency gains in a boom. Second, Beaudry and Pages (2001) provide a theoretical argument that implicit contracts lead to an asymmetric response of the labor market, though they focus on the earnings losses of displaced workers. Third, papers by Further, Hairault, Langot, and Osotimehin (2010) and Jung and Kuester (2011) have shown that in standard search and matching models a mean-preserving reduction in the volatility of aggregate productivity shocks can reduce the mean job destruction rate and therefore the mean unemployment rate.

A.10 Empirical Evidence on Hartz III

In 2003-2005, the German government enacted a number of far-reaching labor market reforms, the so-called Hartz reforms. [43] These reforms consisted of four laws that were implemented in three steps in January 2003 (Hartz I+II), January 2004 (Hartz III), and January 2005 (Hartz IV). In this section, we review the empirical studies analyzing the effect of Hartz III and Hartz IV on job finding rates.

January 1, 2004, Hartz III was enacted. This reform restructured the Public Employment Agency with the goal to improve the efficiency of the job placement services for the unemployed. The best known empirical studies about the effects of Hartz III on matching efficiency are Fahr and Sunde (2009) and Klinger and Rothe (2012), who use labor market flow data to estimate the efficiency parameter of a matching function for the German labor market before and after the Hartz III reform. Fahr and Sunde (2009) find that Hartz III

[43] Note that until 1997 the legal basis of German labor market policy was the Employment Promotion Act (Arbeitsfoerderungsgesetz). In addition to passive income support for the unemployed it strongly emphasized the need for public training and job creation programs for both the employed and unemployed. In 1998 the Employment Protection Act was replaced by the Social Code III (Sozialgesetzbuch III), which shifted the attention away from public sector training and job creation programs towards helping the unemployed job seeker to find private-sector employment as quickly as possible. In this sense the enactment of the Social Code III in 1998 foreshadowed the paradigm shift in German labor market policy that took place in the period 2003-2005. Note also that in 2002 the German government enacted the so-called JOB-AQTIV amendment that implemented a number of reform measures that are often considered part of the Hartz reforms.

increased the efficiency parameter of the estimated matching function by 11.6 percent for manufacturing occupations and around 5 percent for non-manufacturing occupations according to their most preferred specification (column 4 of table 5). Klinger and Rothe (2012), who do not distinguish between manufacturing and non-manufacturing, find an increase in matching efficiency around 5 percent (see their table 2). These numbers are likely to understate the true effect on matching efficiency for two reasons. First, Fahr and Sunde (2009) and Klinger and Rothe (2012) are likely to under-estimate the true effect of Hartz III on matching efficiency since they only consider data until January 2006, and any effect of the Hartz reforms that materialized after this date is not captured by their estimation. Second, the introduction of vouchers in (2002) injected an element of competition in the market for placement services thereby improving the efficiency of the Public Employment Agency, an effect that is not captured by the empirical work on vouchers or the empirical work on Hartz III.

Empirical work using micro data support the view that the introduction of vouchers for job placement services had positive effects on matching efficiency. Winterhager, Heinze, and Spermann (2006) use a very rich administrative data set provided by the Federal Employment Agency to analyze the efficiency improvements generated by the market-based approach to job placement introduced with the Hartz reforms. Specifically, they apply propensity score matching to estimate the effect of the job placement voucher scheme comparing voucher recipients to a matched control group of non-recipients. They define treatment in the evaluation design as receipt of a first voucher during the unemployment spell in May and June 2003, and outcome as employment within 12 months after voucher issue. The main finding of Winterhager, Heinze, and Spermann (2006) is that 12 months after the receipt of a voucher, 27.09 percent of the recipients are in regular employment, whereas only 20.60 percent of the matched control group are employed. Thus, the average treatment effect on the treated amounts to an increase in the job finding rate by around 30 percent - a very large effect indeed. Their results are in line with the finding of Pfeiffer and Winterhager (2006), who find strong evidence for positive effects of vouchers for job placement services on re-employment probabilities.

There is additional evidence suggesting that matching efficiency in Germany has been low before the reform and that the potential for substantial efficiency gains was large. First, Jung and Kuhn (2014) find that the cyclical properties of the German job separation and job finding rates can only be explained by the standard matching function approach if matching efficiency in the German labor market is much lower than in the US. Second, substantial gains in matching efficiency are plausible given that in Germany i) job search assistance before the reform was basically non-existent (private providers could not compete because of heavy regulation and the public provider had no incentive to provide good services) and ii) well-executed job search assistance has been shown to have substantial effects on re-employment rates of unemployed job seekers (see Card, Kluve, and Weber, 2010, for a survey). In addition, Hertweck and Sigrist (2012) provide evidence that the German Beveridge curve shifted inwards around the mid 2000s and estimate that the Hartz reforms taken together (Hartz I-IV) increased matching efficiency by 20 percent. Finally, Launov and Wealde (2013) use a calibrated search and matching model of the German labor market to argue that the estimated efficiency gains due to Hartz III have reduced steady state unemployment by almost 2 percentage points.

Finally, we note that the empirical work on job search assistance surveyed above is microeconomic in nature and does not take into account the possibility of negative externalities through equilibrium effects (Cahuc and Le Barbanchon, 2010). In a recent study, Crepon et al. (2013) have shown that these effects can be substantial using data for young, educated job seekers in France. However, the empirical results of Fahr and Sunde (2009) and Klinger and Rothe (2012) are based on a semi-aggregate approach that accounts for possible equilibrium effects within an occupation or region. This leaves open the possibility of equilibrium effects across regions or occupations, but these effects are likely to be small in our case given the low levels of regional and occupational mobility in Germany (Jung and Kuhn, 2014).