IMF Economic Review
Vol. 61, No. 4

Macroeconomic Evaluation of Labor Market Reform in Germany

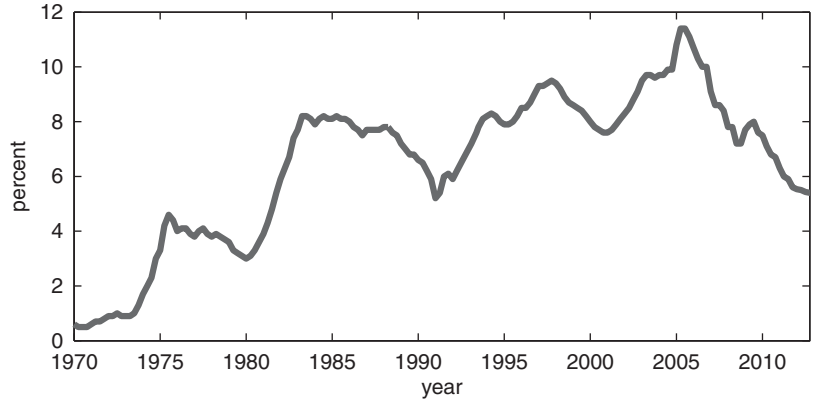
TOM KREBS and MARTIN SCHEFFEL*

In 2003–05 the German government implemented a number of far-reaching labor market reforms, the so-called Hartz reforms. At the heart of the reform package was the Hartz IV law, which resulted in a significant cut in the unemployment benefits for the long-term unemployed. The paper develops a macroeconomic model with search and incomplete markets, calibrates the model economy to German data and institutions, and uses the calibrated model economy to simulate the effects of the Hartz reforms, and in particular Hartz IV, on the German labor market. The paper finds that the Hartz IV reform reduced the noncyclical unemployment rate in Germany by 1.4 percentage points. Employed workers benefited from the Hartz IV reform in welfare terms, but unemployed workers lost. It further finds that the Hartz I–III reforms reduced the noncyclical unemployment rate in Germany by 1.5 percentage points. Finally, the authors' analysis suggests that the Hartz reforms contributed to the good performance of the German labor market during the Great Recession. [JEL E21; E24; D52; J24]]
IMF Economic Review (2013) **61,** 664–701. doi:10.1057/imfer.2013.19;
published online 5 November 2013

Over the period 1970–2005, unemployment in Germany had been steadily rising making the country a leading example of Eurosclerosis (see Figure 1). In response to the dismal labor market performance, in 2003–05, the

*Tom Krebs is Professor of Economics at Mannheim University and Martin Scheffel is Assistant Professor of Economics at Cologne University. The authors thank seminar participants at various institutions and conferences for useful comments. They thank the editors of this journal, two referees, and their discussant, Roman Duval, for many suggestions and insightful comments. The authors also thank the Center for European Research (ZEW), Mannheim, for supporting their work on labor market reform. Tom Krebs also thanks the German Science Foundation (DFG) for support under SFB884.

Figure 1. Quarterly Unemployment Rate, Germany 1970:Q1–2012:Q4



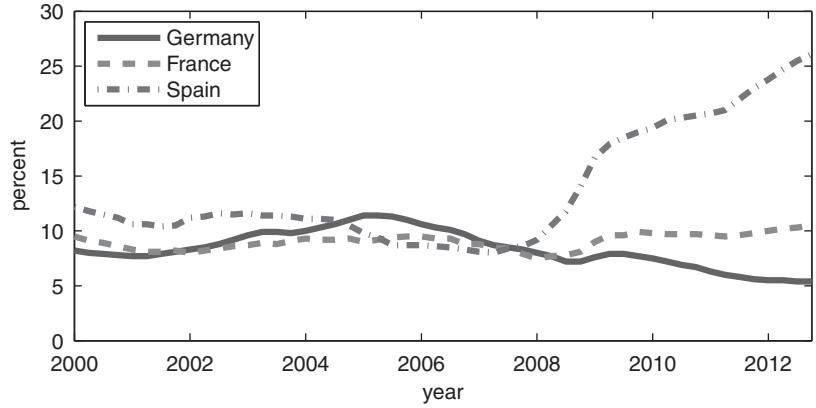
Source: OECD: 1970–90, quarterly unemployment rate for West Germany; 1991–2012, quarterly harmonized unemployment rate for Germany.

German government implemented a number of wide-ranging labor market reforms, the so-called Hartz reforms. At the heart of the reform package was the Hartz IV law implemented in January 2005, which amounted to a complete overhaul of the German unemployment benefit system and resulted in a significant reduction in the level of unemployment benefits for the long-term unemployed. After a short spike mainly because of a change in measurement procedure,[1] Germany's unemployment rate decreased from almost 11 percent in 2005 to 7.5 percent in 2008, mildly increased during the Great Recession, and then continued its downward trend reaching 5.5 percent at the end of 2012. In comparison, between 2008 and 2012, the unemployment rate in France increased by 3 percentage points and in Spain by almost 17 percentage points (see Figure 2). The story about the "sick man of Europe" had turned into a story about the "German labor market miracle."

In this paper, we ask how much of the observed decline in the unemployment rate in the period 2005–12 is a permanent reduction that can be attributed to the Hartz reforms, in particular Hartz IV. We further analyze the consequences for real wages and economic growth taking into account the adjustment of physical capital and human capital, and investigate how possible gains and losses have been distributed among different types of workers (employed, short-term unemployed, long-term unemployed). Finally, we ask to what extent the Hartz reforms have contributed to the good performance of the German labor market during the Great Recession. To address these questions, we develop a macroeconomic model with heterogeneous households that emphasizes the trade-off between insurance and incentive, and use a calibrated version of the model economy to simulate the macroeconomic effects of the Hartz reforms.

[1]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) and resulted in a spike in the unemployment rate in 2005. More than 80 percent of these added unemployed workers lacked the equivalent of a high-school degree.

Figure 2. Quarterly Unemployment Rate, Germany, France, and Spain 2000:Q1–2012:Q4



Source: OECD: quarterly harmonized unemployment rate for Germany, France, and Spain.

The model used in this paper combines the tractable incomplete-market model with human capital developed in Krebs (2003) with a model of search unemployment along the lines of Ljungqvist and Sargent (1998). There is a large number of risk-averse, long-lived households who can invest in risk-free physical and risky human capital. Unemployed households decide on the intensity of job search and receive unemployment benefits that are not conditioned on (unobserved) search effort. We distinguish between short-term and long-term unemployment and assume that job search of the long-term unemployed is less effective than the job search of the short-term unemployed. We close the model assuming an aggregate production function with constant returns to scale that takes physical and human capital as input factors.[2] Finally, the unemployment insurance system is financed with a linear tax on labor.

Our quantitative analysis shows that the Hartz IV reform resulted in a substantial reduction in the noncyclical unemployment rate. In our baseline calibration, the reform reduces the steady-state unemployment rate by 1.4 percentage points from a value of 9 (the average for the period 2000–04) to a new steady-state value of 7.6 percent. As expected, the main force driving the reduction in unemployment is an increase in search effort that leads to higher job finding rates for both short-term and long-term unemployed, where the effect for the long-term unemployed is more pronounced.[3] In short, the Hartz IV reform achieved its main

[2]We use a closed-economy model with an aggregate resource constraint (market clearing) that determines wages and the interest rate endogenously. We think that it is desirable to include an analysis of possible real wage effects of the Hartz reform, something that would be missing if we had used a standard small open economy framework. Clearly, the Germany's export sector is large (about half of GDP), and an extension of the current analysis that allows for current account effects of the Hartz reform is an important topic for future research.

[3]Data on the job finding rates for short-term and long-term unemployed before and after the reform support this prediction of the theory. See Section I for more details.

goal, namely to reduce the noncyclical component of unemployment by permanently increasing the incentive to search for new jobs.

We also find that the Hartz IV reform leads to an increase in long-run growth and a decline in real wages. Wages decrease because the reduction in unemployment benefits increases labor supply.[4] There are two reasons why economic growth goes up. First, the increase in employment increases output. Second, the return to human capital investment increases, which induces more investment in human capital stimulating growth. Human capital returns go up because the labor tax can be reduced because of the reduction in unemployment, and this effect dominates the initial decline in pretax wages. In our baseline calibration, annual long-run growth increases by about 0.1 percent.

Our quantitative welfare analysis shows that the Hartz IV reform creates winners and losers as the gains and losses of the reform are very unevenly distributed across the population. In Germany, the unemployment insurance system is mainly financed through social security taxes levied on labor income ("called social contributions"), and we therefore assume that reductions in unemployment benefits and/or unemployment lead to corresponding reductions in social security taxes. We find that employed households win because the gain from the reduction in social security tax outweighs the welfare loss because of the decrease in unemployment insurance. The resulting welfare gain for employed households is equivalent to an increase of around 0.4 percent of lifetime consumption. In contrast, the situation is reversed for the long-term unemployed, who experience a cut in their unemployment benefits that is quite large. In our baseline calibration, the welfare loss of the long-term unemployed is around 1 percent of lifetime consumption. Finally, the short-term unemployed also lose, but their welfare loss is significantly smaller than the welfare loss of the long-term unemployed. These welfare losses experienced by the unemployed could explain why the reform has encountered so much resistance in large parts of the German population.

In addition to the Hartz IV reform, the German government implemented the Hartz I–III reforms in 2003 and 2004, which were mainly concerned with creating new types of employment opportunities (Hartz I), introducing additional wage subsidies (Hartz II), and restructuring the Federal Employment Agency (Hartz III). The evidence suggests that the combined effect of the Hartz I–III reform package was to speed up the matching process resulting in a significant increase in the job finding rate. Based on the available empirical evidence and our simulation results, we find that the Hartz I–III reforms reduced the noncyclical rate of unemployment in Germany by 1.5 percentage points. Thus, the entire package of labor market reforms, Hartz I–IV, provided a large boost to "labor supply" that reduced the noncyclical component of unemployment substantially and can account for at least half of the decline in the unemployment rate observed in the period 2005–12.

We also use the calibrated model economy to analyze the interaction between the Hartz reforms and macroeconomic shocks. We find that the reaction of the

[4]We use an endogenous growth model in which the labor market reform affects the long-run growth rate of the economy, including the long-run growth rate of real wages. The real wage decline we discuss here is a decline relative to the long-run trend. See Figure 8 for details.

German labor market to the global crisis in 2008/09 would have been less benign if the Hartz reforms had not been enacted. Specifically, our analysis suggests that a German economy with an unreformed labor market would have experienced a cyclical increase in the unemployment rate by almost 2 percentage points during the Great Recession, whereas the actual increase of the German unemployment rate was only 0.8 percentage points. Our analysis emphasizes two reasons for the good performance of the German labor market during the Great Recession. First, the reform enhanced labor market flexibility leading to a higher job finding rates, so that the same hike in job destruction has a smaller unemployment effect. Second, as a result of the Hartz reforms, the German unemployment rate gradually declined to its new steady-state level, and this adjustment process was most likely not completed when the Great Recession began to impact the German labor market. Thus, a secular decline in the unemployment rate dampened the unemployment effect of cyclical factors.

Finally, we take an international perspective and ask what, if anything, can other countries learn from the German experience. Specifically, we ask to what extent a Hartz-type reform of the unemployment insurance system could help other European countries in their fight against unemployment. To this end, we consider two European countries, France and Spain, and calibrate the model economy to the data and institutions of the French and Spanish economy, respectively. In particular, we require the calibrated model economy to match the respective net replacement rates for the short-term unemployed and the long-term unemployed in the two countries. Our analysis suggests that a Hartz-type reform of the unemployment insurance system in France or Spain would have relatively modest effects on the French or Spanish unemployment rate: a steady-state reduction of 0.5 percentage points in the case of France and only 0.3 in the case of Spain. The reason for this finding is simple: the benefits paid to the long-term unemployed are already low in France and very low in Spain, and reducing these unemployment benefits to even lower levels is not likely to have large incentive effects. In contrast, the German unemployment insurance system was very generous to the long-term unemployed before the Hartz IV reform, and in this case efficiency gains from implementing the reform were quite large.[5]

Literature: Our paper is most closely related to the large macro literature on job search and unemployment insurance, where the common theme is the trade-off between insurance and incentive (Hansen and Imrohoroglu, 1992 and Ljungqvist and Sargent, 1998). We contribute to this literature in two ways. First, we introduce a human capital channel and emphasize the important distinction between short-term and long-term unemployed workers. Second, we develop a tractable framework with risk-averse households who make a search and a saving decision, and apply the framework to one of the most significant reforms of the unemployment insurance system in recent history, the Hartz IV reform. We are

[5]Our results do not rule out the possibility that adopting other parts of the Hartz reforms (Hartz I–III) could prove more beneficial to France or Spain.

aware of only two studies analyzing this reform using a structural approach with search unemployment.[6] Krause and Uhlig (2012) find unemployment effects of Hartz IV that are larger than the ones reported here, whereas Launov and Waelde (2013) suggest that Hart IV had relatively small unemployment effects. We provide a detailed comparison of our approach with Krause and Uhlig (2012) and Launov and Waelde (2013) in section "Robustness" below.

Our results on the steady-state effects of Hartz IV are in line with the large body of empirical work on labor market institutions/policy and labor market outcome using cross-country data, which usually find a significant and large effect of unemployment benefits on unemployment (Layard, Nickell, and Jackman, 2005). More recent work that uses country panel data (Bois and others, 2012) also finds large and significant effects of unemployment benefits. The literature on search and matching (Mortensen and Pissarides, 1994) suggests that the Hartz I–III reforms should have reduced the unemployment rate in Germany because of improvements in matching efficiency. Fahr and Sunde (2009) and Klinger and Rothe (2012) analyze this issue empirically, and we base our macroeconomic analysis of Hartz I–III on their findings.

Our discussion of Hartz reforms and the Great Recession in Germany is related to previous work on the interaction between labor market institutions/policies and macroeconomics shocks (Ljungqvist and Sargent, 1998; Blanchard and Wolfers, 2000). There has been an extensive discussion among policy makers about Hartz reforms and the German labor market during the Great Recession, but surprisingly little formal work. Krause and Uhlig (2012) and Schindler (2013) argue, as we do, that the transition of the German economy to its new steady state after the Hartz reforms might not have been completed at the onset of the global recession, and that this contributed to the mild response of the German labor market. Boysen-Hogrefe, Groll, and Merkl (2010) emphasize the role of wage moderation in their analysis of the Great Recession in Germany.[7] Burda and Hunt (2011) suggest that firms were reluctant to hire workers in the expansion preceding the crisis and therefore laid off fewer workers during the crisis. Finally, Bornhorst and Mody (2013), Rinne and Zimmermann (2013), and Schindler (2013) provide general discussions of the experience of the German labor market during the Great Recession.

I. Labor Market Developments in Germany

In this section, we briefly review the German labor market experience since the 1970s and discuss the main elements of the labor market reforms implemented in

[6]Franz and others (2012) analyze the Hartz IV reform using a microsimulation approach where households make a static labor supply decision.

[7]A glance at Figure 4 shows that wage moderation has been taken place in Germany, but it also shows that this process of wage moderation started many years before the Hartz reforms. The wage evolution in Germany depicted in Figure 4 further suggests that in Germany, where union coverage is still relatively high, the bargaining power of unions in wage negotiations has been small for some time. Thus, our modeling assumption of a competitive labor market might be appropriate to a first approximation.

2003–05, the so-called Hartz reforms. A more detailed account of the Hartz reforms can be found in Jacobi and Kluve (2006).

Macroeconomic Performance

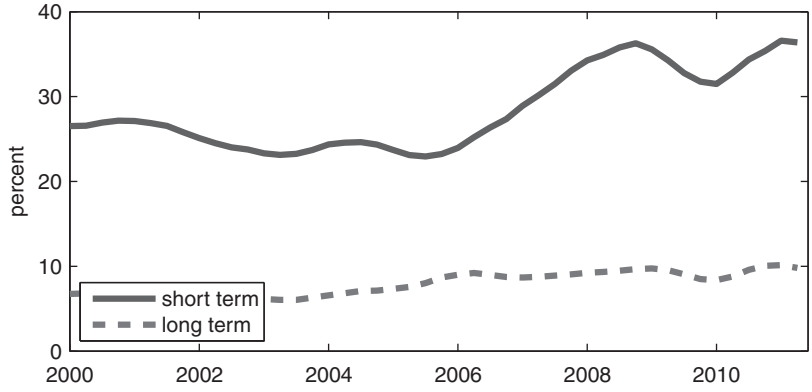
Figure 1 shows the unemployment rate in Germany in the period 1970–2012. The graph suggests that the unemployment rate has a strong cyclical component, but also a trend component that has been rising since the 1970s until the mid-2000s. For example, the average unemployment rate in the 1970s was below 4 percent, and this average had increased to almost 9 percent in the period 1995–2005. Clearly, in the period 1970–2005 Germany had experienced a substantial increase in the noncyclical component of the unemployment rate. 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 5.5 percent at the end of 2012. In comparison, between 2008 and 2012, the unemployment rate in France increased by 3 percentage points and in Spain by almost 17 percentage points (see Figure 2).

Figure 1 suggests that the Hartz IV reform implemented in 2005 reduced the unemployment rate. However, the unemployment rate is highly cyclical, and GDP growth was 2.5 percent in 2006 and 3 percent in 2007, far above the average growth rate of 1.1 percent in the period 1992–2012. Further, Hartz IV is only one component of an entire reform package, and it is not clear how to separate the effects of Hartz IV from Hartz I–III if labor market adjustment to reform is not immediate, a hypothesis that is confirmed by the current analysis. Figure 1 also cannot speak to the welfare consequences of labor market reform. For these reasons, in this paper we take a structural approach and use a calibrated model economy to simulate the unemployment and welfare effects of the Hartz reforms.

In this paper, we emphasize that Hartz IV reduced the unemployment rate because it increased search effort and therefore job finding rates. There is evidence supporting this idea. The job finding rates for both the short-term unemployed and long-term unemployed has been very stable before the Hartz IV reform and then began to increase steadily until the year 2007, at which stage they remained relatively stable at a significantly higher level—see Figure 3 and Bundesagentur fuer Arbeit (2011).[8] For the long-term unemployed, the quarterly job finding rate increased from 6.3 percent at the beginning of 2004 to 9.3 percent at the beginning of 2006, and then stayed at this higher level for the subsequent years. Similarly, the job-finding rate for the short-term unemployed increased substantially, but most of the rise occured in the period 2006–08. The quantitative results derived from the calibrated model economy are in line with these observations. However, the quantitative results reported in Section V also suggest that the increase in the job

[8]The fact that the German job finding rate has only a negligible cyclical component has also been documented in Jung and Kuhn (2012), a finding that stands in contrast to the findings for the United States (Shimer, 2005).

Figure 3. Quarterly Job Finding Rates by Duration of Unemployment, Germany 2000:Q1–2011:Q4



Source: Bundesagentur fuer Arbeit (2011).

finding rate due to Hartz IV is less than the increase observed in the data, in particular for the short-term unemployed.[9] Thus, our results are consistent with the idea that Hartz I–III also contributed to the increase in job finding rates by improving matching efficiency. We return to this issue in the section "Long-Run Macroeconomic Effects of Hartz I-III Reforms" below, where we use the empirical results obtained in Fahr and Sunde (2009) and Klinger and Rothe (2012) in conjunction with our calibrated macro model to simulate the unemployment effects of Hartz I–III.

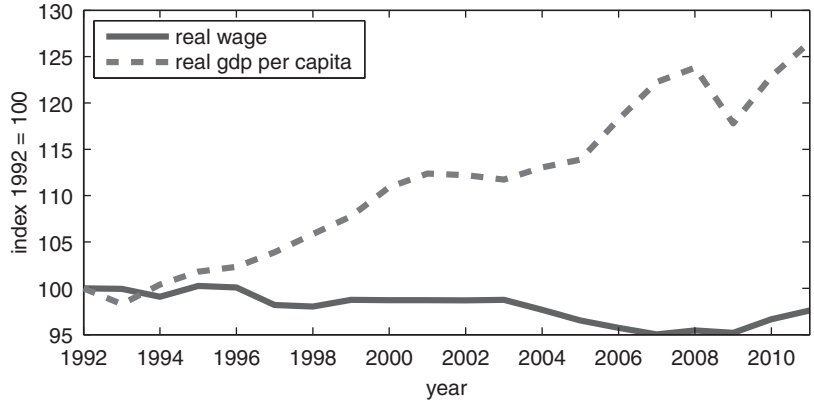
Figure 4 shows the evolution of per capita output and real wages in the postunification period 1992–2011. We see that per capita output grew modestly at an average annual rate of 1 percent. In this period, Germany went through three recessions, 1993, 2003–04, and 2008–09, and had two periods of strong economic expansion, 2004–07 and starting in 2010, and one prolonged period of weak but positive GDP growth in 1994–2001. Real wages stagnated between 1992 and 2003, and then fell about 4 percent in the period 2004–09.

Labor Market Reforms: Hartz I–IV

The dismal labor market performance 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 implemented in 2003–05 a number of labor market reforms, the so-called Hartz reforms named after the chairman of the

[9]The OECD reports the fraction of long-term unemployed (the incidence of long-term unemployment). In accordance with the model prediction, in the data this variable decreased after the reform. However, the data on the incidence of long-term unemployed are not well suited to "test" the basic mechanism for two reasons. First, this variable is heavily influenced by movements into and out of the labor force, which can be very different for short-term and long-term unemployed workers. Second, the variable has a strong cyclical component.

Figure 4. Real Wage and Real GDP per Capita (1992 = 100), Germany 1992–2011



Sources: Statistisches Bundesamt: annual real wage index (series: Reallohnindex) and annual real GDP per capita (series: Bruttoinlandsprodukt) normalized to 1992.

commission that worked out the reform package.[10] The far-reaching reform package had three ambitious goals: (i) improve the services of the employment agencies (increase the matching efficiency); (ii) activate the unemployed (provide better incentives to search for jobs); and (iii) foster new employment opportunities with low tax wedges and deregulate the labor market (increase labor demand). Overall, the Hartz reforms constitute one of the most ambitious attempts in recent history of restructuring the labor market of an advanced economy.[11]

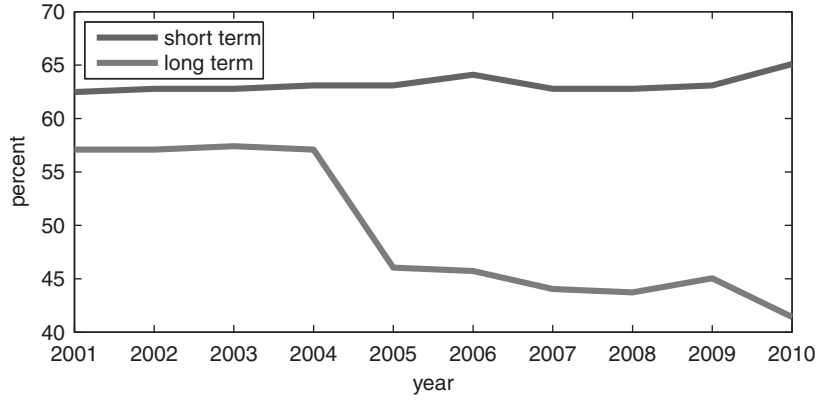
Hartz I and Hartz II took effect from January 1, 2003. Their main objective was to reduce labor costs through wage subsidies and to create new employment opportunities. For example, these laws eliminated the social security tax for jobs paying up to 400 euro per month (Mini-job) and reduced social security contributions for jobs paying up to 800 euro per month (Midi-jobs) and for firms hiring older workers. They also deregulated the labor market. In particular, restrictions on temporary work agencies and fixed-term contracts were weakened and dismissal regulations were simplified and additional exceptions were introduced.

On January 1, 2004, Hartz III was enacted with the goal to increase the efficiency of the job placement service for the unemployed. To this end, the Federal Employment Agency was restructured and a heavy emphasis was placed on quality control. Moreover, the German government adopted a more market-based approach by allowing the Federal Employment Agency to outsource services to private firms and by offering unemployed workers the option to choose private

[10]To gather public support for the reforms, the government took advantage of a scandal involving the Federal Employment Agency, which had grossly mis-reported the success of job placement.

[11]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 or the implementation was much more gradual.

Figure 5. Average Net Replacement Rate, Germany 2001–10



Sources: OECD. (1) net replacement rates: OECD Tax-Benefit Models, (2) population weights: OECD Family Database.

employment agencies. Finally, Hartz III improved the process of matching particular measures of active labor market policy to the needs of unemployed individuals.

The best-known part of the reform package, Hartz IV, was implemented on January 1, 2005. It constituted a radical overhaul of the German unemployment benefit system. Before the reform, the system was characterized by very long period of Unemployment Benefit entitlement and an essentially unlimited, means-tested Unemployment Assistance and/or Social Assistance after the eligibility for Unemployment Benefits had expired. The Hartz IV reform merged Unemployment Assistance and Social Assistance into Unemployment Benefit II and reduced the benefits payments for most households previously receiving Unemployment Assistance/Social Assistance (that is, for most of the long-term unemployed).[12]

The Hartz IV reform reduced entitlement duration and benefit levels for most households, but the extent of the reduction varies substantially across household groups. One way to aggregate this heterogeneity is to follow the OECD and to report the median net replacement rate for short-term unemployed households, defined as unemployment less than one year, and long-term unemployed households, defined as unemployment more than one year. Figure 5 shows the average net replacement rate for single households based on the OECD data (see Section IV for details). Clearly, Hartz IV had almost no effect on the net replacement rate of the short-term unemployed, but a very large effect on the net replacement rate of the long-term unemployed.

[12]In addition, 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 Figure 5).

II. Model

This section develops the model and defines our concept of equilibrium. The framework combines the incomplete-market model with human capital developed in Krebs (2003) with a search model along the lines of Ljungqvist and Sargent (1998).

Households

Time is discrete and open ended. There is a unit mass of infinitely lived households. In each period t, an individual households receives an idiosyncratic shock, s_t, which has two components $s_t = (s_{1t}, s_{2t})$. The first component, s_{1t}, denotes the current employment status, and households are either employed or unemployed, and the unemployed can be either good job seekers or bad job seekers. We identify the good job seekers with the short-term unemployed and the bad job seekers with the long-term unemployed. Thus, we have $s_{1t} \in \{e, su, lu\}$, where e stands for employed, su for short-term unemployed (unemployed and good job seeker), and lu for long-term unemployed (unemployed and bad job seeker). Unemployed households search for new jobs with search intensity (effort) l, and they find a new job in the subsequent period with probability $\pi(e|su,l)$ if they are short-term unemployed and $\pi(e|lu,l)$ if they are long-term unemployed. We assume $\pi(e|su,l) \geq \pi(e|lu,l)$ for all effort levels l, that is, short-term unemployed have a higher re-employment probability than long-term unemployed. At the beginning of any unemployment spell, the household is short-term unemployed, and then becomes long-term unemployed with constant (effort-independent) probability $\pi(lu|su)$. Employed households become unemployed with constant probability $\pi(e|su)$. The second component of the idiosyncratic shock, s_{2t}, represents wage risk, which is modeled as i.i.d. shocks to the individual stock of human capital (see below). The idiosyncratic shock s is observed by the government, but individual search effort, l, is unobservable (moral hazard). Note that our specification implies that the process $\{s_t\}$ is a Markov process with stationary transition probabilities $\pi(s_{t+1}|s_t,l_t)$.

Households are risk-averse and have identical preferences that allow for a time-additive expected utility representation. We also assume that utility is separable in consumption and search effort, and that the current utility is given by $u(c_t,l_t, s_{1t}) = \ln c_t - d(l_t,s_{1t})$, where d is the disutility from search, a strictly increasing and strictly convex function that we normalize so that $d(l_t, s_{1t}) = 0$ if $s_{1t} = e$. Expected life-time utility associated with a consumption-effort plan, $\{c_t, l_t\}$, for a household with initial shock s_0 is given by:

$$U(\{c_t, l_t | s_0\}) = E\left[\sum_{t=0}^{\infty} \beta^t (\ln c_t - d(l_t, s_{1t})) | s_0\right], \tag{1}$$

where β is the pure discount factor. Note that the expectations in Equation (1) is taken with respect to joint distribution that depends through the transition probabilities $\pi(e|su,l)$ and $\pi(e|lu,l)$ on the effort choice $\{l_t\}$. Thus, we should write $E_{\{l_t\}}[.]$, but for notational ease we suppress the dependence of expectations on effort choice.

At time $t=0$, the initial state of an individual household is (k_0,h_0,s_0), where k_0 denotes the initial stock of physical capital and h_0 the initial stock of human capital. Households can invest in physical capital (save) and human capital. Employed households receive capital and labor income, $r_{kt}k_t$ and $r_{ht}h_t$, where r_{kt} and r_{ht} denote the rental rate of physical and human capital, respectively. For an employed household, the risk-free return to physical capital investment is $r_{kt}-\delta_k$ and the risky return to human capital investment is $r_{ht}-\delta_h+\eta(s_{2t})$. Here δ_k and δ_h denote the (average) depreciation rate of physical capital and human capital, respectively, and η is a shock to individual human capital that represents wage risk. Unemployed households receive unemployment benefits that are proportional to their human capital, $B_t=b(s_{1t})h_t$, an assumption that keeps the model tractable. Note that unemployment benefits, b, depend on the type of the unemployed household (good or bad job seeker), but do not depend on unobserved search effort l_t. To rule out large portfolio shifts of the unemployed, we further assume that the unemployed earn a return on physical capital investment that equals the return to human capital investment, that is, income of an unemployed household is $b(s_{1t})(k_t+h_t)$.

Households' sequential budget constraint reads

$$c_t+k_{t+1}+h_{t+1} = \begin{cases} (1+r_{kt}-\delta_k)k_t+(1+(1-\tau)r_{ht}-\delta_h+\eta(s_{2t}))h_t & \text{if } s_{1t}=e \\ (1+b(s_{1t}))(k_t+h_t) & \text{if } s_{1t}=su,lu \end{cases}, \quad (2)$$

where τ is the tax rate on labor income. The tax revenues from the labor income tax are used to finance unemployment benefit payments (see below). For given government policy, $\{b_t,\tau_t\}$, households choose a plan $\{c_t,l_t,k_t,h_t\}$ that maximizes Equation (1) subject to the constraint (2).

Introduce the following new household-level variables:

$$w_t = k_t+h_t, \quad (3)$$

$$\theta_t = k_t/w_t,$$

$$r(\theta_t,s_t) = \begin{cases} \theta_t(1+r_{kt}-\delta_k)+(1-\theta_t)(1+(1-\tau)r_{ht}-\delta_h+\eta(s_{2t})) & \text{if } s_{1t}=e \\ b(s_{1t}) & \text{if } s_{1t}=su,lu \end{cases}.$$

Here w is the value of total wealth, financial and human, θ the share of total wealth invested in physical capital, and r is the total return on investment (in human and physical capital). Note that w_t is total wealth before assets have paid off and depreciation has taken place and $(1+r)w$ is total wealth after asset payoff and depreciation has occurred. Note also that the relevant state variable for an individual household now becomes (θ_t,w_t,s_t). Using the new definitions, the household budget constraint can be written as

$$w_{t+1} = (1+r(\theta_t,s_t))w_t-c_t. \quad (4)$$

The household problem is now to choose a plan $\{c_t, w_t, \theta_t, l_t\}$ that maximizes lifetime utility subject to the budget constraint. The budget constraint (equation (4)) in conjunction with the assumption of homothetic preferences (log-utility) is the key to the tractability of the model: individual households solve a Merton-type consumption-saving and portfolio problem, where in our setting there is an added effort choice. The solution to this class of problems is quite simple (see Proposition 1).

Firms

There is one all-purpose good that can be consumed or invested in physical capital or human capital. Production takes place under the aggregate production function $Y_t = F(K_t, H_t^e)$, where Y_t is aggregate output in period t, K_t the aggregate physical capital stock employed by firms, and H_t^e the aggregate stock of human capital employed by firms (the human capital stock of employed households). We assume that F is a standard neoclassical production function. In particular, it exhibits constant returns to scale.

There is a large number of identical firms that have access to the production function F and hire physical capital and human capital (labor) in competitive markets at rental rates r_k and r_h, respectively. In each period, firms hire physical capital and human capital so as to maximize profit

$$F(K_t, H_t^e) - r_{kt}K_t - r_{ht}H_t^e. \tag{5}$$

Government

The government pays out unemployment benefits and mainly finances the transfer payments with a linear tax on labor income. It also imposes a linear tax on capital income of unemployed households. We assume that the government runs a balanced budget in every period so that the government budget constraint reads:

$$\tau E[r_{ht}h_t \mid s_{1t} = e] + E[(r_{kt} - b(s_{2t}))k_t \mid s_{1t} \neq e] = E[b(s_{2t})h_t \mid s_{1t} \neq e]. \tag{6}$$

Equilibrium

Denote the aggregate stock of physical capital owned by households as $E[k_t] = E[\theta_t w_t]$. Similarly, denote the aggregate stock of human capital of employed households as $E[h_t | s_{1t} = e] = E[(1-\theta_t)w_t | s_{1t} = e]$. In equilibrium, choices of firms and households have to be consistent, that is, the capital market and the labor market have to clear:

$$K_t = E[\theta_t w_t] \tag{7}$$

$$H_t^e = E[(1-\theta_t)w_t \mid s_{1t} = e]$$

Note that the aggregate resource constraint reads

$$C_t + K_{t+1} + H_{t+1} = (1-\delta_k)K_t + (1-\delta_h)H_t + F(K_t, H_t^e) \tag{8}$$

A standard argument shows that the government budget constraint (equation (6)), the household budget constraint (equation (4)), and the market-clearing condition (equation (7)) imply the resource constraint (equation (8)) under the assumption of competitive rental markets and constant returns to scale in production. In other words, in our model Walras law states that capital market clearing and labor market clearing (equation (7)) implies goods market clearing (equation (8)).

A (sequential) competitive equilibrium is defined in the standard manner:

Definition For given government policy $\{b_t,\tau_t\}$, a competitive equilibrium is a sequence of rentals rates, $\{r_{kt},r_{ht}\}$, a family of individual household plans, $\{c_t,w_t,\theta_t, l_t\}$, and a sequence of firm choices, $\{K_t, H_t^e\}$, so that

(i) for given rental rates (r_{kt},r_{ht}) the production choice (K_t, H_t^e) maximizes profit (equation (5)) in each period t;
(ii) for given sequence of rental rates $\{r_{kt},r_{ht}\}$ the individual plan $\{c_t,w_t,\theta_t,l_t\}$ maximizes expected lifetime utility (equation (1)) subject to the budget constraint (equation (4));
(iii) market-clearing condition (equation (7)), respectively (equation (8)), holds in each period t;
(iv) the government budget constraint (equation (6)) holds.

A stationary competitive equilibrium (steady-state equilibrium) is a competitive equilibrium in which aggregate ratio variables, such as the capital-to-labor ratio and the unemployment rate, are constant, but aggregate variables such as output and capital grow at a constant rate. The property of unbounded growth is an implication of the constant-returns-to-scale assumption and the further assumption that the two input factors, physical capital and human capital, can be accumulated without limits. See the discussion in Krebs (2003) for a more detailed discussion of the equilibrium behavior of this class of endogenous growth models with idiosyncratic risk.

Note that equilibrium unemployment rates for the short-term and long-term unemployed, $U(su)$ and $U(lu)$, are defined through initial values and the transition probabilities in the standard way. The law of motion for the two unemployment rates is given by Equation (16).

III. Theoretical Results

In this section, we present the main theoretical results. Proposition 1 shows that the household problem has a simple solution. Proposition 2 provides a convenient characterization of equilibria that is used in the quantitative section to compute equilibria. Proofs of the two propositions are relegated to the Appendix. To ease the exposition, we only discuss a stationary equilibrium, but we note that in this paper we also solve for the dynamic adjustment path toward the new long-run equilibrium after the reform.

Household Problem

The recursive formulation of the household maximization problem reads

$$V(w,\theta,s) = \max_{c,\theta',w',l}\left\{\ln c - d(l,s) + \beta\sum_{s'} V(w,\theta',s')\pi(s' \mid s,l)\right\} \tag{9}$$

$$\text{s.t.} \quad w' = (1+r(\theta,s))w - c,$$

where the effort choice, l, is only relevant if $s_1 = su,lu$. In the Appendix, we show that the Bellman equation (9) has a simple solution. More precisely, the optimal portfolio choice, θ, is independent of wealth, w, and consumption and next-period wealth are linear functions of current wealth:

$$c = (1-\beta)\,(1+r(\theta,s))w, \tag{10}$$

$$w' = \beta(1+r(\theta,s))w.$$

Moreover, the value function has the functional form

$$V(w,\theta,s) = \tilde{V}(s) + \frac{1}{1-\beta}[\ln\,(1+r(\theta,s)) + \ln\, w] \tag{11}$$

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

$$\begin{aligned}\tilde{V}(s) =& \max_{\theta',l}\left\{B - d(l,s) + \frac{\beta}{1-\beta}\sum_{s'}\ln(1+r(\theta',s'))\pi(s' \mid s,l)\right.\\ &\left. + \beta\sum_{s'}\tilde{V}(s')\pi(s' \mid s,l)\right\},\end{aligned} \tag{12}$$

where the constant B is defined as $B = \ln(1-\beta) + (\beta/1-\beta)\ln\beta$.

Proposition 1. *The solution to the household maximization problem is given by Equations* (10), (11)*, and* (12).

Proposition 1 is useful 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 (12). Second, it states that consumption choices are linear in wealth, and that portfolio and effort choices are independent of wealth. This property allows us to solve for the general equilibrium without knowledge of the endogenous wealth distribution (Proposition 2).

Equilibrium

Define the aggregate capital-to-labor ratio $\tilde{K} = K_t/H_t^e$ and the intensive-form production function $f(\tilde{K}) = F(\tilde{K},1)$. Under constant-returns-to-scale and perfect competition, profit maximization of firms implies that the rental rates become a

function of the aggregate capital-to-labor ratio:

$$r_k = r_k(\tilde{K}) = f'(\tilde{K}), \tag{13}$$

$$r_h = r_h(\tilde{K}) = f(\tilde{K}) - \tilde{K}f'(\tilde{K}).$$

In the Appendix, we show that the relevant aggregate state variable is (Ω,U), where Ω is a vector with components $\Omega(s_1) = E[(1+r)w|s_1]/E[(1+r)w]$, $s_1 \in \{e,su,lu\}$, denoting the share of aggregate total wealth held by households of type s_1, and $U = (U(su),U(lu))$ is the two-dimensional vector consisting of the unemployment rate of the short-term unemployed, $U(su)$, and the unemployment rate of the long-term unemployed, $U(lu)$. The solution to the intensive-form Bellman equation (12) in conjunction with the pricing conditions (equation (13)) define optimal portfolio and effort functions $\theta' = \theta'(s, \Omega, U)$ and $l = l(s, \Omega, U)$. The market-clearing condition (equation (7)) is equivalent to the intensive-form market-clearing condition

$$\tilde{K}' = \frac{\sum_{s_1} \theta'(s_1, \Omega, U)\Omega(s_1)}{(1 - U'(su) - U'(lu)) \sum_{s_1} (1 - \theta'(s_1, \Omega, U))\Omega(s)}, \tag{14}$$

where a prime indicates a next-period variable. In the Appendix we also show that the law of motion for Ω is

$$\Omega'(s_1') = \frac{\sum_{s_1} (1 + r(\theta'(s_1, \Omega, U), s_1'))\pi(s_1' \mid s_1, l(s_1, \Omega, U))\Omega(s_1)}{\sum_{s_1, s_{1'}} (1 + r(\theta'(s_1, \Omega, U), s_1'))\pi(s_1' \mid s_1, l(s_1, \Omega, U))\Omega(s_1)}. \tag{15}$$

Finally, the unemployment rates for the short-term and long-term unemployed, $U(su)$ and $U(lu)$, follow the law of motion

$$\begin{aligned} U'(su) =& \pi(su \mid e)(1 - U(su) - U(lu)) + \pi(su \mid lu)U(lu) \\ &+ (1 - \pi(e \mid su, l(su, \Omega, U)) - \pi(lu \mid su))U(su), \end{aligned}$$

$$\begin{aligned} U'(lu) =& \pi(lu \mid su)U(su) + (1 - \pi(su \mid lu) \\ &- \pi(e \mid lu, l(lu, \Omega, U))U(lu). \end{aligned} \tag{16}$$

In summary, we have the following result:

Proposition 2. *Any solution to Equations* (12)–(16) *with* $\Omega' = \Omega$ *and* $(U'(su),U'(lu)) = (U(su),U(lu))$ *is a stationary competitive equilibrium.*

IV. Calibrating the Model

As discussed in Section I, in the period 2003–2005 the German government implemented a number of wide-ranging labor market reforms, the so-called Hartz reforms. In this section, we calibrate the model to match a number of facts of the

German economy before the reform package. In particular, the model economy matches some of the key features of the German unemployment insurance system before the reform. In addition, we require the model economy to be consistent with the empirical evidence on labor market risk and the unemployment benefit elasticity of individual job finding rates (search intensity). Finally, we impose the restriction that the values of a number of macro variables (unemployment rate, flows in and out of unemployment) in the stationary equilibrium of the calibrated model economy should match the corresponding long-run values for the German economy before the reform.

Our calibration strategy requires us to find the long-run values of a number of macro variables before the reform. We use two methods to find these long-run values. The first method computes from the data the average value in the period 2000–04. The second method is to apply the HP-filter to the data in the period until 2005, and then to take the value of the long-run trend in the year 2002. Both methods yield almost identical results and we therefore report only the results using the first method. However, it is conceivable that alternative methods could produce very different target values. We therefore return to the issue of finding long-run values from the data in our robustness analysis in the section "Robustness," where we report how our main results change if we choose target values that differ substantially from the ones chosen here.

Search

The basic model period is one quarter. We use the standard 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 *su* to *lu* equal to 0.25.

For the job search technology, we follow Hopenhayn and Nicolini (1997), Lentz (2009), and Shimer and Werning (2008) and assume an exponential specification:

$$\pi(e \mid su, l) = 1 - e^{-\lambda(su)l},$$

$$\pi(e \mid lu, l) = 1 - e^{-\lambda(lu)l}. \tag{17}$$

We choose the values of $\lambda(su)$ and $\lambda(lu)$ so that the corresponding job finding probabilities match the observed average transition rates in the period 2000–04 for the short-term unemployed and long-term unemployed, respectively. The values for the quarterly transition probabilities are $\pi(e|lu) = 0.06$ and $\pi(e|su) = 0.24$ according to the data provided by the Federal Employment Agency (Bundesagentur fuer Arbeit), which yields $\lambda(su) = 0.724$ and $\lambda(lu) = 0.229$.

We assume that disutility of search is

$$d(l) = d_0 l^{\gamma} - d_1 \tag{18}$$

for both the short-term and long-term unemployed. For the employed households, we normalize this term to zero so that $d_1 > 0$ can be interpreted as

the disutility from work. It is well-known that with specification (equation (17)) and (equation (18)), the parameters $\lambda(su)$, $\lambda(lu)$ and d_0 are not separately identified. We therefore choose a numerically convenient normalization of $d_0 = 1$. We choose γ in conjunction with d_1 to match given values for the elasticity of the job finding rate with respect to benefits payments for both short-term unemployed and long-term unemployed. The targets for these two search elasticities are chosen as follows.

For the United States, there are a number of empirical micro studies estimating the search elasticity directly. The best known study is Meyer (1990) who estimates an elasticity of −0.9, which is also used by Landais, Michaillat, and Saez (2010) for calibration purpose. Subsequent work using U.S. data has found similar results for some groups of workers and lower values for other group of workers (for example, Meyer and Mok, 2007). There is much less work on this issue for Germany, but Hunt (1995) finds estimates for Germany that are similar to the U.S. results. Consistent with this finding are the results reported in Hofmann (2012) and Mueller and Steiner (2008), who find that imposing benefit sanctions on long-term unemployed for noncompliance has significant effects on the unemployment-to-employment transition in Germany. Addison, Centeno, and Portugal (2008) use a structural search model and the European Community Household Panel to estimate the elasticity for several European countries, and they find values ranging from −1.14 to −1.66 for Germany. In this paper, we follow Meyer (1990), Hunt (1995), and Landais, Michaillat, and Saez (2010) and choose as target value an average elasticity of −0.9 for the unemployed.

We are not aware of any study that estimates this elasticity separately for the short-term and long-term unemployed. However, work by Chetty (2008) shows that the effect of unemployment benefits on unemployment duration is much stronger for low-wealth individuals, an effect he calls the liquidity effect based on the assumption that low-wealth individuals are liquidity constrained. In the data and in our model the long-term unemployed are the low-wealth individuals. Indeed, in Germany unemployment insurance for the long-term unemployed (Unemployment Benefits II) is means-tested with very low levels of permissable asset holdings. Using the estimates reported in Chetty (2008) and identifying the long-term unemployed with the low-wealth individuals, we conclude that the search elasticity of the long-term unemployed is at least twice as large as the search elasticity of the short-term unemployed. We therefore choose γ and d_1 so that the implied elasticities for the short-term unemployed and the long-term unemployed match (i) an average value of −0.9 and (ii) a value for the long-term unemployed that is twice as large as for the short-term unemployed, that is, we choose −0.6 for the short-term unemployed and−1.2 for the long-term unemployed. The corresponding values for the utility parameters are $d_1 = 0.294$ and $\gamma = 2.774$.

We choose the job separation rate, $\pi(e|su)$, so that the implied unemployment rate is equal to the average unemployment rate in the period 2000–04, namely 9 percent. This yields a job separation rate of $\pi(e|su) = 0.0148$, which is in line with Jung and Kuhn (2012). Finally, we choose $\pi(su|lu)$ 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 2000–04, a value we match if $\pi(su|lu) = 0.190$.

Wage Risk

We assume that human capital shocks, and therefore wage risk, are normally distributed: $\eta \sim N(0, \sigma^2)$. One can show (Krebs, 2003) that this assumption in conjunction with the i.i.d assumption implies that the log of labor income of individual households follows approximately a random walk with innovation term $\varepsilon \sim N(0,(1-\theta)^2\sigma^2)$. For the United States, the random walk component of individual labor income has been estimated by a number of empirical studies using data drawn from the PSID, and estimates of $(1-\theta)\sigma$ for the United States 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, Krebs and Yao (2013) and Fuchs-Schuendeln, Krueger, and Sommer (2010) find similar values, and we therefore choose the value of the parameter σ to yield $(1-\theta)\sigma = 0.075$ in equilibrium.

Production

We follow Krebs (2003) and use quarterly depreciation rates of $\delta_k = \delta_h = 0.015$. We assume a Cobb-Douglas production function, $F(K, H^e) = AK^{\alpha}(H^e)^{1-\alpha}$, and set the capital share of output to $\alpha = 0.36$. We choose the technology parameter A and the discount factor so that the model matches the output growth rate and saving rate in Germany before the reform, namely 1 percent economic growth and a saving rate of 20 percent. This yields $A = 0.0656$ and $\beta = 0.9847$.

Unemployment Benefits

We choose the unemployment benefit parameters $b(su)$ and $b(lu)$ to match the net replacement rate for the short-term and long-term unemployed before the reform (the period 2000–04),[13] and use OECD data on net replacement rates. The OECD reports the net replacement rate for short-term and long-term unemployed, where long-term unemployment is defined as unemployment duration longer than one year. The Hartz IV reform clearly had different effects on different subgroups of the short-term and long-term unemployed. However, neither the model nor the OECD data are detailed enough to capture all aspects of this heterogeneity. We therefore focus on net replacement rates of single households with median earnings before the job loss. The OECD reports the net replacement rate for two subgroups of this group of households, namely single households without children and single households with two children. We calibrate the parameters $b(su)$ and $b(lu)$ so that the model matches the weighted average net replacement rate for these two groups, where the weight for the first group is set equal to the population weight of all households without children and the weight of the second group is set equal to the

[13] In the model, the net replacement rate is not b, but $b/((1-\tau)r_h)$, and we choose b so that the implied value of $b/((1-\tau)r_h)$ matches the corresponding net replacement rate.

Table 1. Calibration

Parameter	Meaning	Value
$\pi(su\|e)$	transition probability $e \rightarrow su$	0.0148
$\pi(lu\|su)$	transition probability $su \rightarrow lu$	0.25
$\pi(su\|lu)$	transition probability $lu \rightarrow su$	0.19
$\lambda(su)$	search efficiency of short-term unemployed	0.724
$\lambda(lu)$	search efficiency of long-term unemployed	0.229
d_0	disutility parameter (normalization constant)	1
d_1	disutility parameter	0.293
γ	curvature of disutility function	2.774
β	discount factor	0.985
σ	standard deviation of wage shocks	0.075
δ_k	depreciation rate of physical capital	0.015
δ_h	depreciation rate of human capital	0.015
α	capital's share in output	0.36
A	total factor productivity	0.0656
$b(su)$	net replacement rate for short-term unemployed	0.628
$b(lu)$	net replacement rate for long-term unemployed	0.572

population weight of all households with children. For the period 2000–04, this yields a net replacement rate of 0.63 for the short-term unemployed and 0.57 for the long-term unemployed.[14]

Table 1 summarizes the parameter values of the calibrated model economy.

V. Quantitative Results

In this section, we use the calibrated model economy to simulate the consequences of labor market reform in Germany. In the section "Long-Run Macroeconomics Effects of Hartz IV Reform," we begin with a discussion of the steady-state effects of the Hartz IV reform, implemented in 2005, on unemployment, output, and wages. Section "Welfare Effects of Hartz IV Reform" turns to a welfare analysis of the Hartz IV reform and the section "Long-Run Macroeconomic Effects of Hartz I-III Reforms" provides a brief analysis of the macroeconomic effects of the earlier parts of the Hartz reforms, namely Hartz I–III. In the section "Hartz Reforms and the Great Recession in Germany," we argue that despite its long-run objectives, the Hartz reforms also had important implications for the cyclical behavior of the German labor market. Section "International Comparison" takes an international perspective and the section "Robustness" concludes with a robustness analysis.

[14]The results are similar, at least in terms of the effect of Hartz IV on net replacement rates, if we take couples instead of singles as long as we weigh the group without children and the group with two children the same way. The OECD does not report net replacement rates for households with one child. Hartz IV had a larger effect on the net replacement rate of households with one child than it had on the net replacement rate of households with two children, and our weighing scheme therefore understates the effect of Hartz IV on net replacement rates.

Long-Run Macroeconomics Effects of Hartz IV Reform

We begin with an analysis of the long-run effects of the Hartz IV reform on some of the main macroeconomic variables. This reform consisted of a complete overhaul of the German unemployment insurance system and resulted in a number of far-reaching changes. However, its impact on the net replacement rate of the short-term unemployed, regardless of household type, was limited. It is therefore not surprising that the average net replacement rate for the short-term unemployed was not affected by the reform (see Figure 5). In contrast, the net replacement rate for the long-term unemployed dropped sharply after the reform for all households without children. For our average measure, we find that the Hartz IV reform reduced the net replacement rate from 0.57 in the period 2000–04 to 0.46 after the reform in 2005 (see Figure 5). Based on this evidence, we simulate the effects of Hartz IV assuming that it reduced the net replacement rate for the long-term unemployed from 0.57 to 0.46 and that it left the net replacement rate for the short-term unemployed unchanged.

Table 2 presents the long-run effects of the Hartz IV reform on some of the main macroeconomic variables, where the long-run effects are computed by comparing the stationary equilibrium (steady-state) values before the reform with the stationary equilibrium (steady-state) values after the reform (second column). The first row of Table 2 shows that the reform leads to a substantial reduction in the unemployment rate—from 9 percent before the reform to 7.60 percent after the reform. Thus, our analysis suggests that a significant part of the decrease in the unemployment rate observed in the period 2005–08 (see Figure 1) can be attributed to the Hartz IV reform and amounts to a reduction in the noncyclical component of the unemployment rate.

The second and third rows of Table 2 show the steady-state values of the job finding rate for the short-term and the long-term unemployed before and after the reform. As expected, these job finding rates increase as household exert more search effort in response to the reduction in unemployment benefits. We also note that, in percentage terms, the increase in the job finding rate for the long-term unemployed exceeds the increase for the short-term unemployed, a result that seems intuitive given that the long-term unemployed are more directly affected by the reform than the short-term unemployed. The increase in job finding rates for the

Table 2. Macroeconomic Effects of Hartz IV Reform

	Prereform	Postreform
Unemployment rate	9%	7.760%
Unemployment rate (*su*)	4.5%	3.92%
Unemployment rate (*lu*)	4.5%	3.67%
Job finding rate (*su*)	24%	27.7%
Job finding rate (*lu*)	6%	7.7%
Growth	1%	1.08%

Note: *su* denotes short-term unemployed and *lu* denotes long-term unemployed. Job finding rates are quarterly rates and the growth rate is annual.

short-term and long-term unemployed is the main force behind the decrease in the unemployment rate reported in the first row of Table 2. In short, the Hartz IV reform achieved its main goal, namely to reduce the structural unemployment rate by increasing the incentive of the unemployed to search for new jobs.

As we mentioned before, the data on job finding rates are in line with the model prediction. However, a comparison of Figure 5 and Table 2 also shows that Hartz IV by itself cannot explain the entire increase in job finding rates observed in the data, in particular for the short-term unemployed. In other words, our analysis suggests that Hartz IV had large positive effects on job finding rates, but Hartz IV cannot account for all of the observed increase in job finding rates. Clearly, improvements in matching efficiency because of Hartz III are a natural candidate for explaining the nonnegligible residual. We return to this issue in the section "Long-Run Macroeconomic Effects of Hartz I-III Reforms" below.

Figure 6 shows the transitional dynamics of the unemployment rate after the reform. We see that it takes about eight quarters for the unemployment rate to get half way to the new stationary equilibrium value. This persistence is mainly generated by the fact that the the unemployment rate and the fraction of long-term unemployed are state variables, and both variables take time to adjust to the new long-run equilibrium. The share of long-term unemployment in unemployment decreases from a long-run value of 50 percent before the reform to a new long-run value of 48 percent after the reform. Figure 7 shows the dynamic evolution of the unemployment rates of the short-term unemployed and long-term unemployed separately. We see that the dynamic adjustment process is very similar for both variables.

We also find that the reform leads to an increase in long-run growth and an initial decline in real wages. Wages decrease initially because the reduction in unemployment benefits increases labor supply. There are two reasons why

Figure 6. Unemployment Rate

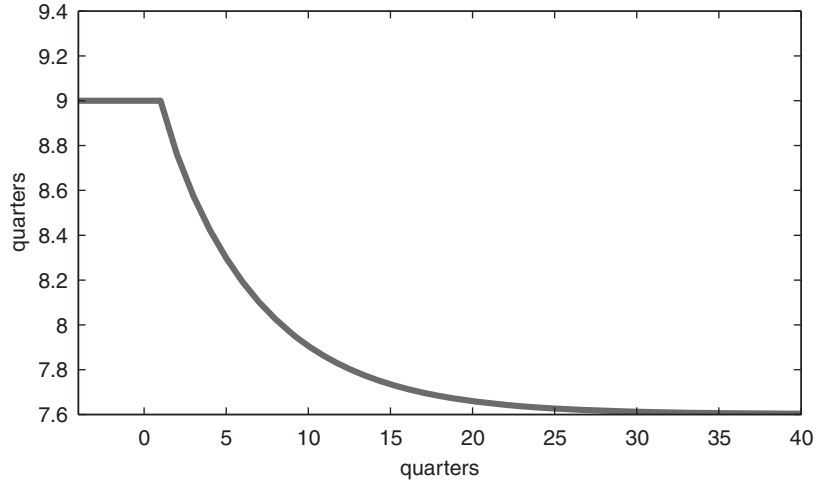
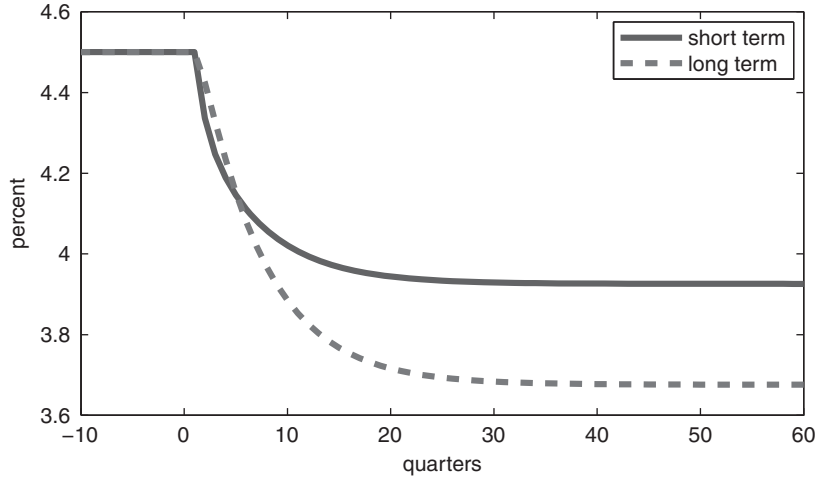


Figure 7. Unemployment Rate by Duration of Unemployment Spell



economic growth goes up. First, the increase in employment increases output. Second, the return to human capital investment increases, which induces more investment in human capital stimulating growth. Human capital returns go up because the labor tax can be reduced due to the reduction in unemployment, and this effect dominates the initial decline in pretax wages. Table 2 shows that the increase in the annual long-run growth rate of the economy is about 0.1 percent. Figures 8 and 9 show the time paths of output growth and real wage growth.

Welfare Effects of Hartz IV Reform

We now turn to a welfare discussion of the Hartz IV reform. This reform had two opposing effects on welfare of individual households (expected lifetime utility) and social welfare. On the one hand, there is a negative effect as the reform reduces insurance against unemployment risk. The long-term unemployed are most directly affected by this reduction in benefits, but also the short-term unemployed and even the employed take into account that there is a chance that some time in the future they might become long-term unemployed. On the other hand, the reform increases employment and therefore production. In our analysis, all employed households benefit directly from this output effect through the reduction in the labor income tax after the reform.

We conduct the welfare analysis as follows. We compute welfare (expected lifetime utility) for each group of households (employed, short-term unemployed, long-term unemployed) in the stationary equilibrium before the reform. We also compute welfare for each group of households after the reform taking into account the adjustment path of the economy toward the new stationary equilibrium (transitional dynamics). We do the same for social welfare, which we define as the population-weighted average of the welfare of the three groups of households.

Figure 8. Annualized Growth Rate of Aggregate Output

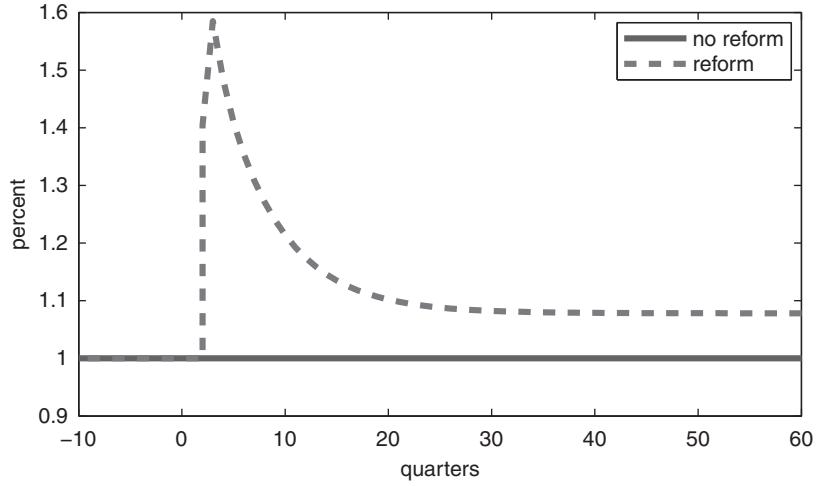
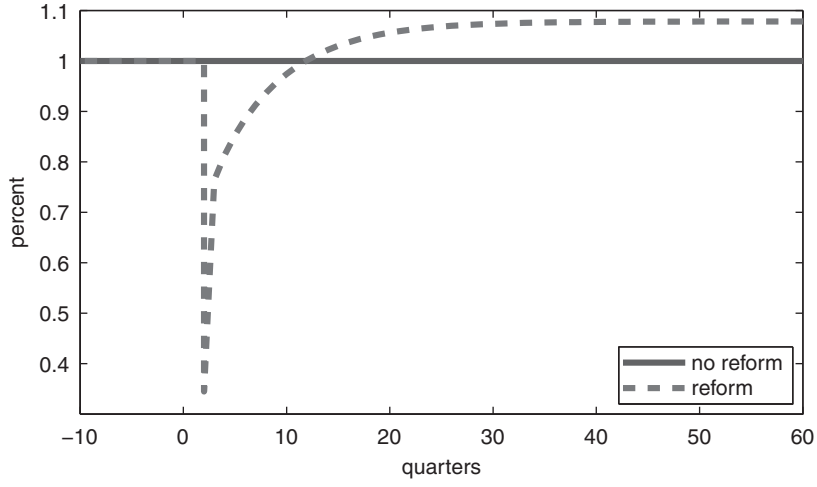


Figure 9. Annualized Growth Rate of Average Wage



Finally, we translate the computed welfare changes into equivalent consumption units by computing the corresponding change in certainty consumption that would make households indifferent between no-reform and reform (Lucas, 2003). More precisely, if we let $\{c_t, l_t | s_0\}$ stand for the consumption-effort plan of a household of type s_0 before the reform and $\{\hat{c}_t, \hat{l}_t \mid s_0\}$ stand for the consumption-effort plan after the reform, then the welfare gain of the reform for households of type s_0,

Table 3. Welfare Effects of Hartz IV Reform

	Net Effect (%)	Insurance Effect (%)
Employed	+0.439	−1.795
Short-term unemployed	−0.132	−2.354
Long-term unemployed	−0.739	−2.948
Social welfare	+0.361	−1.873

Note: Welfare effects are computed in equivalent units of lifetime consumption.

denoted $\Delta(s_0)$, is defined as the solution to

$$U(\{(1+\Delta(s_0))c_t, l_t \mid s_0\}) = U\big(\{\hat{c}_t, \hat{l}_t \mid s_0\}\big), \tag{19}$$

where the utility function over consumption-effort plans is defined in Equation (1).

Table 3 reports the welfare results. The first row shows that employed households are the winners of the reform: their welfare increases by 0.44 percent of lifetime consumption. For the employed households, the gain from the tax reduction outweighs the welfare loss because of the reduction in unemployment insurance. At the opposite end are the long-term unemployed: their welfare decreases by 0.74 percent of lifetime consumption. For the long-term unemployed, the direct loss of unemployment benefits is much larger than the gain from the reduction in consumption taxes. Finally, the short-term unemployed are somewhere in between, but they also lose.

To understand better the two effects on welfare, we also show in Table 3 the welfare loss that is because of the insurance loss. More precisely, we compute the change in welfare for each group of households assuming that the mean consumption growth rate is unchanged. The table shows that the adverse effect of the loss of insurance on welfare is substantial for all three groups.

Table 3 also shows that the reform increased social welfare. Put differently, if we distributed more of the output gains to the unemployed and less to the employed, then the reform would benefit all households. However, in reality most of the output gain goes to employed households, mainly through a reduction in their contributions to the unemployment insurance system.[15]

Long-Run Macroeconomic Effects of Hartz I–III Reforms

As described in Section I, the German government implemented the first two waves of the Hartz reforms, Hartz I–III, in 2003 and 2004. These reforms were mainly concerned with creating new types of employment opportunities (Hartz I), introducing additional wage subsidies (Hartz II), and restructuring the Federal Employment Agency (Hartz III). Empirical work in Fahr and Sunde (2009) and

[15]We also computed the benefits rate that maximizes social welfare and found that this rate is lower than the postreform benefit rate, but the welfare gains of this further benefit reduction are very small.

Klinger and Rothe (2012), based on the matching function approach to the labor market and worker flow data, suggests that the combined effect of these reforms was to increase the speed and efficiency of the matching process substantially. Although their exact results vary somewhat depending on the specification of the matching function, the results with respect to the net effect on the job finding rate are fairly robust to the various parameterizations and suggest a substantial improvement in matching efficiency.

The results in Fahr and Sunde (2009) show that Hartz I and Hartz II, simultaneously implemented in January 2003, increased the job finding rate of the unemployed by between 5 and 15 percent, where the variation refers to different occupations. Hartz III, implemented in January 2004, led to an additional increase of the job finding rate of similar magnitude. Klinger and Rothe (2012) find that Hartz I–III combined increased the job finding rate by about 15 percent, with a slightly stronger effect for the long-term unemployed. There are two reasons why these results most likely underestimate the true effect of Hartz I–III. First, Fahr and Sunde (2009) 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 estimation strategy used in Fahr and Sunde (2009) requires that there is no occupational mobility in Germany. Similarly, the estimation strategy used in Klinger and Rothe (2012) requires that there is no geographic mobility in Germany. Clearly, there is some mobility in Germany, even if occupational mobility and geographic are relatively low in Germany. Guided by the empirical findings and these additional considerations, we assume in our model simulation that Hartz I–III increased the job finding rate, for both short-term unemployed and the long-term unemployed, by 20 percent of their respective steady-state values before the reform.

Table 4 presents the impact of the Hartz I–III reforms on the steady-state values of some of the main macroeconomic variables, where steady-state values are computed as in Table 2. The first row of Table 2 shows that these reforms lead to a substantial reduction in the unemployment rate—from 9 percent before the reform to 7.52 percent after the reform. This change in the steady-state unemployment rate is of similar size as the reduction we have computed for the Hartz IV reform. Thus, Hartz I–III and Hartz IV played equally important roles in reducing noncyclical unemployment in Germany. Table 4 also shows that the combined effect of the Hartz reforms, Hartz I–III plus Hartz IV, was to reduce the steady-state unemployment rate from 9 percent to 6.44 percent.[16] Thus, about half of the decrease in the unemployment rate observed in the period 2005–12 (see Figure 1) can be attributed to the Hartz reforms and amounts to a permanent reduction.

Hartz Reforms and the Great Recession in Germany

In this section, we analyze to what extent the Hartz reforms changed the reaction of the German labor market to adverse macroeconomic shocks, that is, we investigate

[16]This effect is somewhat smaller than sum of the two individual effects because of nonlinearities.

Table 4. Macroeconomic Effects of Hartz I–III and Hartz I–IV

	Prereform	Post-Hartz I–III	Post-Hartz I–IV
Unemployment	9%	7.52%	6.44%
Unemployment rate (*su*)	4.5%	3.84%	3.392%
Unemployment rate (*lu*)	4.5%	3.67%	3.027%
Job finding rate (*su*)	24%	28.8%	32.6%
Job finding rate (*lu*)	6%	7.2%	9.12%
Growth	1%	1.08%	1.14%

Note: *su* denotes short-term unemployed and *lu* denotes long-term unemployed. Job finding rates are quarterly rates and the growth rate is annual.

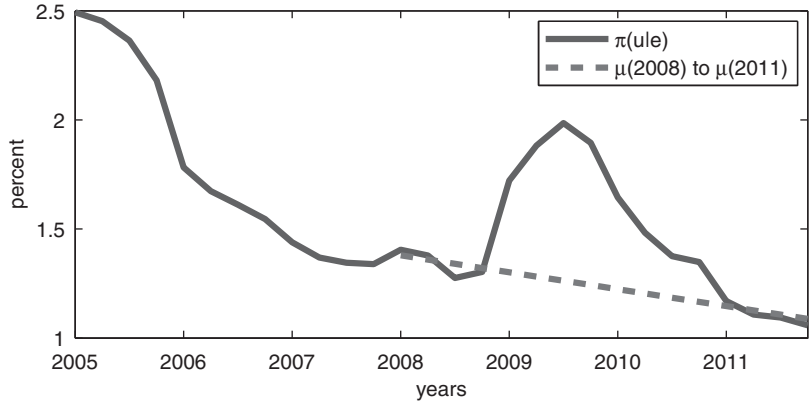
the interaction between labor market policy and macroeconomic shocks. In particular, we ask if the Hartz reforms contributed to the good performance of the German labor market during the Great Recession. In our model, the job destruction rate is exogenous and we therefore assume that the adverse macroeconomic shock that hit the German economy during the Great Recession led to an exogenous increase in the job destruction rate.[17] We choose the size and duration of the shock to the job destruction rate as follows.

Figure 10 depicts the quarterly flow rate from employment to unemployment in the period 2005–12 constructed from OECD data on unemployment and unemployment duration using the method of Elsby, Hobijn, and Sahin (2008). Figure 10 shows a clear downward trend of the job destruction rate since 2005 and a significant increase in the job destruction rate relative to trend during the Great Recession. We set the shock duration equal to the time the empirical job destruction rates spent above trend during the Great Recession, and set the shock size equal to the average deviation of the empirical job destruction rate from its trend during the Great Recession. A glance at Figure 9 suggests that the German job destruction rate has been on a secular downward trend since 2006 that continued until 2011 or even 2012, and we construct the trend line from the data as follows. We assume that the secular trend is linear between 2008:Q1 and 2011:Q4. We further assume that the average value of the observed job destruction rate in 2008, respectively 2011, coincides with the average value of the trend job destruction rate in 2008, respectively 2011. The resulting trend line is shown in Figure 10. Given this trend line, we find that the job destruction rate spent eight quarters above trend during the Great Recession and that the average deviation from trend was 34.8 percent.[18]

[17]Of course, this approach is somewhat crude, but seems appropriate given that the Hartz reforms mainly affected job finding rates and our interest is in analyzing how the Hartz reforms changed the dynamic response of the German labor market to macroeconomic shocks. Clearly, our approach is necessarily silent about the fundamental factors underlying the cyclical rise in job destruction.

[18]Contrary to popular belief, this shows that the German job destruction rate increased during the Great Recession (relative to trend), though the increase was probably less pronounced than what one

Figure 10. Quarterly Job Separation Rate, Germany 2005:Q1–2011:Q4



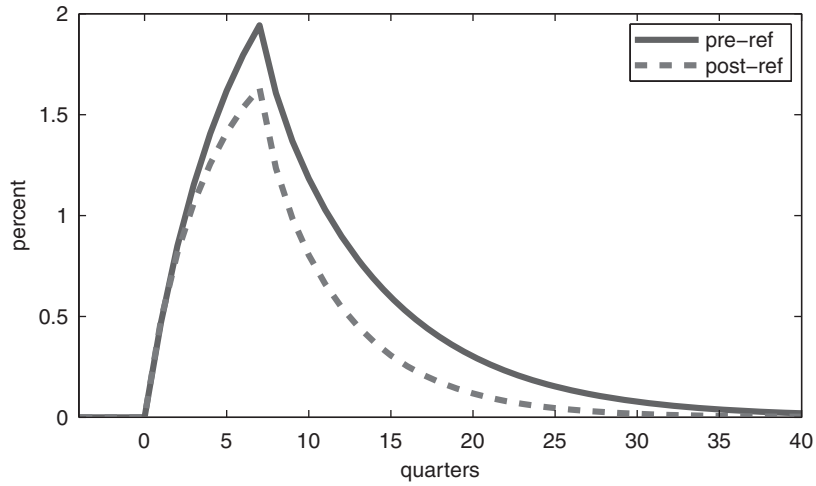
Sources: OECD: Unemployment by Duration 1992–2011; Job Separation Rates computed according to Elsby, Hobijn, and Sahin (2008).

Figure 11 shows the dynamic response of the unemployment rate to an adverse macroeconomic shock that increases the job destruction rate by 34.8 percent for eight quarters. We consider two cases, an economy without Hartz reforms and an economy in which Hartz reforms were implemented. In both cases we assume that before the arrival of the adverse macroeconomic shock the economy is in its respective steady state. Figure 10 shows that in both economies the unemployment rate rises for eight quarters in response to the shock, and then declines slowly to its steady-state level. However, for the unreformed economy, the increase in the unemployment rate peaks at 1.94 percentage points, whereas for the economy with Hartz reforms the maximum increase is only 1.63 percentage points—a difference of 0.31 percentage points. Further, this difference in the cyclical rise of the unemployment rate persists for a long time. Thus, we conclude that the Hartz reforms, by increasing labor market flexibility on the job finding margin, have improved the cyclical performance of the German labor market.

The above analysis suggests that the Hartz reforms dampened the unemployment hike during the Great Recession, but it still implies that the unemployment rate should have increased by 1.6 percentage points. However, the actual increase in the German unemployment rate was 0.8 percentage points. The difference can be explained if we incorporate into the analysis that the transition of the German economy to its new steady state after the Hartz reforms was not completed at the onset of the global recession. In our previous analysis, we find that the transitional dynamics is completed after 2–3 years after the shock hits the economy, which seems to indicate that this argument is not supported by our model. However, our modeling approach does not take into account that the matching efficiency gains

would expect given that GDP contracted by 5 percent in 2009. Jung and Kuhn (2012) and Gartner, Merkl, and Rothe (2012) compute the cyclical component of the job destruction rate (flow rate from employment to unemployment) using IAB data for the time period before the Hartz IV reform, and find that the job destruction rate in Germany is in general highly volatile.

Figure 11. Deviation of Unemployment Rate in Response to Shock to Job Destruction Rate



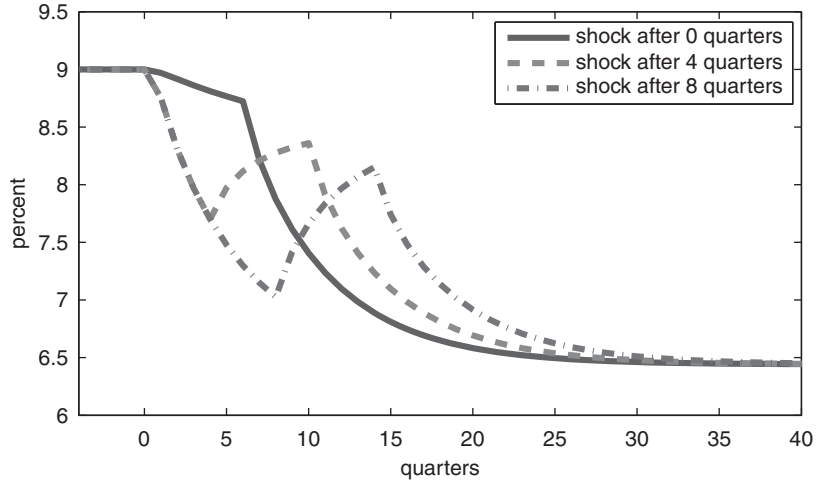
from Hartz I–III might take time to materialize and that the positive incentive effect of Hartz IV also needs some time to reach the entire population of unemployed workers. This idea also finds support in the data: Figure 3 shows that the increase in the empirical job finding rates after the Hartz reforms was more gradual than suggested by our model.

In order to assess the implications of the "gradual adjustment channel," we consider three different scenarios. In the first scenario, the adverse shock hits the economy eight quarters after the implementation of the labor market reform, in the second scenario four quarters after the shock arrival, and in the third scenario reform and shock happen simultaneously. In all three scenarios, we continue to assume that the shock lasts for eight quarters and increases the job destruction rate by 34.8 percentage points. The results of these experiments are depicted in Figure 12 and are quite striking. In the first scenario, the unemployment rate increases by 1.4 percentage points, in the second scenario the unemployment rate rises by 0.7 percentage points, and in the third scenario the unemployment rate never increases. Thus, the second scenario is broadly in line with the observed increase of the unemployment rate of 0.8 percentage points during the Great Recession. Given that without the Hartz reforms the cyclical increase in the unemployment rate would have been 1.9 percentage points (Figure 11), we conclude that reforms reduced the cyclical increase of the unemployment rate in Germany during the Great Recession by 1.1 percentage points.

International Comparison

In this section, we ask if a reform of the unemployment insurance system along the lines of Hartz IV could help other European countries to reduce their long-run unemployment rate substantially. To this end, we choose two countries, France and

Figure 12. Unemployment Rate Dynamics with Shock to Job Destruction Rate During Transition



Spain, whose recent labor market experience has been quite different from the German experience. Because of space limitations we focus on the long-run effects of hypothetical labor market reform in France and Spain.

For the application to France, respectively Spain, we recalibrate the model economy along three dimensions. First, we choose the unemployment benefits of the short-term unemployed and the unemployment benefits of the long-term unemployed so that the model is consistent with the OECD data on net replacement rates for France, respectively Spain, in the period 2000–04. For the short-term unemployed, this yields a value of 68.4 percent for France and a value of 66.5 percent for Spain, very similar to the value of 62.8 percent in the case of Germany. For the long-term unemployed, however, we find an average net replacement rate of 38.1 percent in France and 26.9 percent in Spain, significantly lower than the net replacement rate of 57.2 percent in Germany before the Hartz IV reform. We also choose the job destruction rate and the transition rate $\pi(su|lu)$ to match the unemployment rate and the share of long-term unemployed in France, respectively Spain, in the period 2000–04.

In Germany, the Hartz IV reform reduced the net replacement rate of the long-term unemployed by 19.5 percent of the prereform value of 57.2 percent. Correspondingly, we assume that a hypothetical labor market reform in France or Spain along the lines of Hartz IV would reduce the net replacement rate of the long-term unemployed by 19.5 percent of their respective prereform levels. The results of this experiment are shown in Table 5 and can be summarized as follows. A Hartz-type reform of the unemployment insurance system in France or Spain would have relatively modest effects on the French or Spanish unemployment rate: a steady-state reduction of 0.5 percentage points in the case of France and only 0.3 in the case of Spain. The reason for this finding is simple: the benefits paid to the

Table 5. Unemployment Effect of Hartz IV Reform in Different Countries

	Prereform (%)	Postreform (%)
Germany	9.00	7.76
France	8.66	8.16
Spain	11.06	10.73

long-term unemployed are already low in France and very low in Spain, and reducing these unemployment benefits to even lower levels is not likely to have large incentive effects. In contrast, the German unemployment insurance system was very generous to the long-term unemployed before the Hartz IV reform, and in this case efficiency gains from implementing the reform were quite large.

Robustness

We conducted an extensive robustness analysis changing the calibration targets one by one. We now report the results of our analysis focusing on the main parameters of interest. We only report steady-state results.

Net Replacement Rate

In our baseline analysis the Hartz IV reform reduces the net replacement rate for the long-term unemployed on average from 0.57 to 0.46—a substantial reduction. If, in contrast, the reduction in the net replacement rate is only half to 0.53, then the effect of the reform on the long-run unemployment rate is much smaller: 0.7 percentage points instead of 1.4 percentage points. On the other hand, if we assume that the Hartz IV reform reduced the net replacement rate for the long-term unemployed to 0.42, then the effect is significantly larger: 1.7 percentage points instead of 1.4. These results show that, not surprisingly, the unemployment effect of Hartz IV crucially depends on the extent to which the reform reduced the net replacement rate of the long-term unemployed.

The last finding provides a possible answer to the question why our analysis yields results that differ from the results reported in Krause and Uhlig (2012), who report a larger effect of Hartz IV than we find, and Launov and Waelde (2013), who report a smaller effect. Specifically, the Hartz IV reform affected different groups of long-term unemployed very differently—see our discussion in the section "Unemployment Benefits". Our approach to this heterogeneity conundrum has been to use a simple macro model with little ex-ante heterogeneity of the long-term unemployed, and to use an average net replacement rate computed from the OECD data to find an adequate description of the German unemployment insurance system before and after the reform. In contrast, Krause and Uhlig (2012) and Launov and Waelde (2013) base their analyses on models with high levels of heterogeneity, and then simulate the effects of a stylized version of the Hartz IV reform. Neither paper reports the implied change in the average net replacement rate. However, a careful reading of the two papers

suggests that Krause and Uhlig (2012) put a large weight on those groups of long-term unemployed that were heavily affected by Hartz IV, whereas Launov and Waelde (2013) emphasize much more the groups of long-term unemployed that were barely affected.

Search Elasticity

Another key parameter is the micro-level search elasticity with respect to unemployment benefits. In our baseline calibration, we assume an average elasticity for short-term unemployed and long-term unemployed of −0.9. If we reduce this elasticity to −0.8, then the unemployment reduction because of Hartz IV is 1.28 percentage points, and for an average elasticity of −0.5 the unemployment effect of Hartz IV goes down to 0.87 percentage points. Clearly, an elasticity of −0.5 is a lower bound for the German economy before the Hartz reforms. If, in contrast, we choose an elasticity of −1.2, as suggested by the empirical results of Addison, Centeno, and Portugal (2008), then the Hartz IV reform reduces the steady-state unemployment rate by 1.75 percentage points—a very large effect, indeed.[19]

Unemployment Target

One key target for the calibration of the model is the steady-state unemployment rate. In our baseline model, we chose 9 percent. If we choose instead an unemployment rate of 10.5 percent, which is the target chosen by Krause and Uhlig (2012), then the Hartz IV reform reduces the long-run unemployment rate by 1.64 percentage points. In contrast, if we choose as target a prereform steady-state unemployment rate of 8 percent, the impact of the Hartz IV reform is a 1.25 percent reduction of the long-run unemployment rate. Thus, we conclude that our main results are robust to a wide range of target unemployment rates.

Another key target for the calibration is the incidence of long-term unemployment in steady state. In our baseline calibration, we chose 50 percent. If we choose instead a prereform value of 40 percent, we find that the Hartz IV reform reduces the steady-state unemployment rate by 1.25 percentage points.

VI. Conclusion

In this paper, we used an incomplete-market model with search unemployment to evaluate the macroeconomic effects of the Hartz reforms, with an emphasis on Hartz IV. We calibrated the model economy to German data before the reform and then used the calibrated model economy to simulate the effects of the Hartz reforms. In our baseline calibration, we found that Hartz I-III reduced the structural unemployment rate by 1.5 percentage points and Hartz IV by 1.4 percentage

[19]Different assumptions about the implied search elasticities are another possible explanation for the different findings in the macro literature on Hartz IV. However, neither Krause and Uhlig (2012) nor Launov and Waelde (2013) report the respective micro-level search elasticity that their calibrated macro models imply, and it is therefore difficult to analyze the issue further.

points. Hartz IV created winners and losers: the welfare of employed households increases, but the welfare of both short-term and long-term unemployed households decreases even with moderate risk aversion (log utility). Finally, we discussed how the Hartz reforms shaped the response of the German labor market to the recent global crisis.

The model used in this paper abstracted from a number of important channels through which unemployment benefits may affect output, and incorporating these channels into the analysis is an important task for future research. For example, unemployment benefits adversely affect worker productivity and output if skills are lost during unemployment spells. On the other hand, unemployment benefits can increase productivity and output if they increase matching efficiency (Acemoglu and Shimer, 2000). Finally, the current analysis does not take into account aggregate demand channels, which could be an important issue for understanding the dynamic adjustment of unemployment and output toward their long-run equilibrium values.

The tractability of the framework makes it an ideal vehicle for the analysis of the interaction between labor market institutions/policies and macroeconomics shocks. In this paper, we have kept the analysis brief and focused on the experience of the German economy during the Great Recession. The results of a more general analysis of this issue could provide a structural interpretation of the findings in Blanchard and Wolfers (2000), and shed light on the empirical results that the short-run output-unemployment elasticity (Okun's law) varies across countries (Ball, Leigh, and Loungani, 2013).

Finally, in this paper, we made the ad-hoc assumption that unemployment benefits are proportional to human capital (labor income) and therefore ruled out by assumption the use of more sophisticated (nonlinear) policies. There is large literature on optimal unemployment insurance (Hopenhayn and Nicolini, 1997; Shimer and Werning, 2008) that allows government policy to be a general function of observable variables. In this line of research, government policy is only constrained by the unobservability of search effort (moral hazard). The application of this approach to the current framework is an important topic for future research.

APPENDIX I

Proof of Proposition 1

The household maximization problem we consider in this paper has the feature that probabilities depend on choices, in contrast to the class of problems analyzed in Stokey and Lucas (1989). However, the standard argument for the principle of optimality still applies. Similarly, another standard argument shows that the Bellman equation (9) has a unique solution in an appropriately defined function space (contraction mapping theorem). Guess-and-verify then shows that the value function (equation (11)) with coefficients determined by Equation (12) solves Equation (9) with optimal policy function defined in Equation (10).

There is a technical issue regarding the construction of the appropriate function space as the economic problem is naturally an unbounded problem. 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 $|| V || \doteq sup_x \mid V(x) \mid / W(x)$, 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.[20] 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 $x \in X$. This completes the proof of Proposition 1.[21]

Proof of Proposition 2

From Proposition 1 we know that individual households maximize utility subject to the budget constraint. Thus, it remains to be shown that the intensive-form market-clearing condition (equation (14)) is equivalent to the market-clearing conditions (equation (7)) and that Equations (15) and (16) are the equilibrium law of motions for Ω and U.

First, note that the solution to the household problem only depends on the first component s_1, but not on the i.i.d. component s_2. Recall that $\Omega_t(s_{1t}) = (E[(1+r_t)w_t \mid s_{1t}]\pi(s_{1t}))/E[(1+r_t)w_t]$ and let $\tilde{w}_t = (1+r_t)w_t$ be total wealth in period t after production and depreciation has taken place. The aggregate stock of physical capital held by households in period t+1 is

$$\begin{aligned} E[k_t] &= E[\theta_{t+1} w_{t+1}] \\ &= \beta E[\theta_{t+1}(1+r_t)w_t] \\ &= \beta \sum_{s_{1t}} E[\theta_{t+1}\tilde{w}_t \mid s_{1t}]\pi(s_{1t}) \\ &= \beta \sum_{s_{1t}} \theta(s_{1t}) E[\tilde{w}_t \mid s_{1t}]\pi(s_{1t}) \\ &= \beta E[\tilde{w}_t] \sum_{s_{1t}} \theta(s_{1t})\Omega_t(s_{1t}). \end{aligned} \tag{A.1}$$

The second line in Equation (A.1) uses the equilibrium law of motion for the individual state variable w, the third line is simply the law of iterated expectations, the fourth line follows from the fact that the portfolio choices only depend on s_1, and the last line is a direct implication of the definition of Ω. A similar expression holds for the aggregate stock of human capital held by all households, $E[h_t] = E[(1-\theta_t)w_t]$, and the aggregate stock of human capital held by employed households, $E[h_t | s_{1t} = e] = E[(1-\theta_t)w_t | s_{1t} = e]$. Dividing the expression for $E[k_t]$ by the expression for $E[(1-\theta_t)w_t | s_{1t} = e]$ proves the equivalence between Equations (7) and (14).

[20] Thus, B_W is the set of all functions, V, with $L(x) \leq V(x) \leq U(x)$ for all $x \in X$.

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

Define $r(s_{1t}, s_{1,t+1})$ as the investment return after the expectation over s_{2t} and $s_{2,t+1}$ has been taken. The law of motion for Ω can be found as

$$\begin{aligned}
\Omega_{t+1}(s_{1,t+1}) &= \frac{E[\tilde{w}_{t+1} \mid s_{1,t+1}]\pi(s_{1,t+1})}{E[\tilde{w}_{t+1}]} \\
&= \frac{E[(1+r_{t+1})\tilde{w}_t \mid s_{1,t+1}]\pi(s_{1,t+1})}{E[(1+r_{t+1})\tilde{w}_t]} \\
&= \frac{\sum_{s_{1t}} E[(1+r_{t+1})\tilde{w}_t \mid s_{1t}, s_{1,t+1}]\pi(s_{1t} \mid s_{1,t+1})\pi(s_{1,t+1})}{\sum_{s_{1t},s_{1,t+1}} E[(1+r_{t+1})\tilde{w}_t \mid s_{1t}, s_{1,t+1}]\pi(s_{1t}, s_{1,t+1})} \\
&= \frac{\sum_{s_1} (1+r(s_{1t}, s_{1,t+1}))E[\tilde{w}_t \mid s_{1t}]\pi(s_{1t})\pi(s_{1,t+1} \mid s_{1t})}{\sum_{s_{1t},s_{1,t+1}} (1+r(s_{1t}, s_{1,t+1}))E[\tilde{w}_t \mid s_{1t}]\pi(s_{1t})\pi(s_{1,t+1} \mid s_{1t})} \\
&= \frac{\sum_{s_{1t}} (1+r(s_{1t}, s_{1,t+1}))\pi(s_{1,t+1} \mid s_{1t})\Omega_t(s_{1t})}{\sum_{s_{1t},s_{1,t+1}} (1+r(s_{1t}, s_{1,t+1}))\pi(s_{1,t+1} \mid s_{1t})\Omega_t(s_{1t})},
\end{aligned} \tag{A.2}$$

where the second line uses the equilibrium law of motion for the individual state variable w, the third line is simply the law of iterated expectations, the fourth line follows from the fact that portfolio choices only depend on s_1 in conjunction with the definition of r, and the last line is a direct implication of the definition of Ω. This shows that the law of motion for Ω is Equation (15). The law of motion (equation (16)) for U is obvious. This completes the proof of Proposition 2.

Computation

To compute stationary equilibria, we use Proposition 2, that is, we solve the equations (12)–(16) with $\Omega' = \Omega$ and $U' = U$. The max problem (equation (12)) is solved using the first-order conditions approach for portfolio choice and effort choice. Thus, we find a stationary equilibrium by solving a low-dimensional nonlinear equation system.

For the computation of the transitional dynamics, we iterate over the sequence of aggregate wealth shares and unemployment rates, that is, over sequences of the relevant aggregate state variable. Specifically, if we denote the aggregate state by $X = (\Omega_e, \Omega_{su}, \Omega_{lu}, U_{su}, U_{lu})$, then the solution algorithm proceeds as follows:

Step 1: Compute the prereform and postreform stationary equilibrium allocation and the respective lifetime utilities.

Step 2: Set the number of periods T the economy needs to converge to the new stationary equilibrium. Guess a sequence of aggregate states, $\{X_t\}_{t=0}^{T}$, where the initial aggregate state and the final aggregate state correspond to their pre- and postreform equilibrium values, respectively.

Step 3: Given the sequence of aggregate states and the households' life time utility function in intensive form, we start at period T and solve backwards for a time series of individual households portfolio and effort choices, households' intensive-form lifetime utility, the aggregate capital-to-labor ratio, and the consumption tax rate.

Step 4: Given the time series for households' portfolio choices and effort choices and aggregate capital-to-labor ratio, we use the recursive formula (equation (15)) and (equation (16)) for the aggregate state variable to solve forward for a sequence of aggregate state variables $\{X_t\}_{t=0}^{T}$.

Step 5: If $\max\|\{X_t^B\}_{t=0}^T - \{X_t^F\}_{t=0}^T\| < tol$, the backward and forward solutions converged and we have solved for the transitional dynamics of the endogenous variables; otherwise, update the guess for the evolution of the aggregate state variable $\{X_t^B\}_{t=1}^{T-1} = \{X_t^{FT-1}\}_{t=1}$ and go back to step 3.

Solving for the transitional dynamics, we find that setting $T = 100$ is sufficient and that the algorithm converges within five iterations to a tolerance level $tol = 1e{-}8$.

REFERENCES

Acemoglu, D. and R. Shimer, 2000, "Productivity Gains from Unemployment Insurance," *European Economic Review*, Vol. 44, No. 7, pp. 1145–1224.

Addison, J., M. Centeno and P. Portugal, 2008, "Unemployment Benefits and Reservation Wages: Key Elasticities from a Stripped-Down Job-Search Model," IZA Discussion Paper.

Alvarez, F. and N. Stokey, 1998, "Dynamic Programming with Homogeneous Functions," *Journal of Economic Theory*, Vol. 82, No. 1, pp. 167–189.

Ball, L., D. Leigh and P. Loungani, 2013, "Okun's Law: Fit at 50?," NBER Working Paper No. 18668.

Blanchard, O. and J. Wolfers, 2000, "The Role of Shocks and Institutions in the Rise of European Unemployment: The Aggregate Evidence," *Economic Journal*, Vol. 100, No. 462, pp. 1–33.

Bornhorst, F. and A. Mody, 2013, "Tests of German Resilience," in *Germany in an Interconnected World Economy*, ed. by A. Mody (Washington DC: International Monetary Fund).

Boysen-Hogrefe, J., D. Groll and C. Merkl, 2010, "The German Labour Market Miracle," *National Institutional Economic Review*, Vol. 214, No. 1, pp. R38–R50.

Bois, R., O. Causa, C. Demmon, R. Duval and A. Zdziemicka, 2012, "The Short-term effects of Structural Reform: An Empirical Analysis," OECD Economics Department Working Paper No. 949.

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

———— , 2011, "Der Arbeitsmarkt in Deutschland: Sockel- und Langzeitarbeitslosigkeit," Arbeitsmarktberichterstattung.

Burda, M. and J. Hunt, 2011, "What Explains the German Labor Market Miracle in the Great Recession?" NBER Working Paper No. 17187.

Chetty, R., 2008, "Moral Hazard vs Liquidity and Optimal Unemployment Insurance," *Journal of Political Economy*, Vol. 116, No. 2, pp. 173–234.

Elsby, M., B. Hobijn and A. Sahin, 2008, "Unemployment Dynamics in the OECD," NBER Working Paper No. 15979.

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*, Vol. 10, pp. 284–316.

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*, Vol. 13, No. 1, pp. 103–132.

Franz, W., N. Guertzgen, S. Schubert and M. Claus, 2012, "Assessing the Employment Effects of the German Welfare Reform—An Integrated CGE-Microsimulation Approach," *Applied Economcis*, Vol. 44, No. 19, pp. 2403–2421.

Gartner, H., C. Merkl and T. Rothe, 2012, "Sclerosis and Large Volatilities: Two Sides of the Same Coin," *Economic Letters*, Vol. 117, No. 1, pp. 106–109.

Hansen, G. and A. Imrohoroglu, 1992, "The Role of Unemployment Insurance in an Economy with Liquidity Constraints and Moral Hazard," *Journal of Political Economy*, Vol. 100, No. 1, pp. 118–142.

Hofmann, B., 2012, "Short- and Long-Term Ex Post Effects of Unemployment Insurance Sanctions," *Journal of Economics and Statistics*, Vol. 232, No. 1, pp. 31–60.

Hopenhayn, H. and J. Nicolini, 1997, "Optimal Unemployment Insurance," *Journal of Political Economy*, Vol. 105, No. 2, pp. 412–438.

Hunt, J., 1995, "The Effect of Unemployment Compensation on Unemployment Duration in Germany," *Journal of Labor Economics*, Vol. 13, No. 1, pp. 88–120.

Jacobi, L. and J. Kluve, 2006, "Before and After the Hartz Reforms: The Performance of Active Labor Market Policy in Germany," IZA Working Paper No. 2100.

Jung, P. and M. Kuhn, 2012, "Labor Market Institutions and Worker Flows: Comparing Germany and the US?" MRRA Working Paper No. 32322.

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*, Vol. 59, No. 1, pp. 90–114.

Krause, M. and H. Uhlig, 2012, "Transitions in the German Labor Market: Structure and Crisis," *Journal of Monetary Economics*, Vol. 59, No. 1, pp. 64–79.

Krebs, T., 2003, "Human Capital Risk and Economic Growth," *The Quarterly Journal of Economics*, Vol. 118, No. 2, pp. 709–744.

Krebs, T. and Y. Yao, 2013, "Labor Income Risk in Germany," Working Paper, Unpublished.

Landais, C., P. Michaillat and E. Saez, 2010, "Optimal Unemployment Insurance over the Business Cycle," NBER Working Paper No. 16526.

Launov, A. and K. Waelde, 2013, "Estimating Incentive and Welfare Effects of Non-Stationary Unemployment Benefits," *International Economic Review forthcoming*.

Layard, R., S. Nickell and R. Jackman, 2005, *Unemployment: Macroeconomic Performance and the Labour Market* (Oxford: Oxford University Press, 2nd ed.).

Lentz, R., 2009, "Optimal Unemployment Insurance in an Estimated Job-Search Model with Savings," *Review of Economic Dynamics*, Vol. 12, No. 1, pp. 37–57.

Lucas, R., 2003, "Macroeconomic Priorities," *American Economic Review*, Vol. 93, No. 1, pp. 1–14.

Ljungqvist, L. and T. Sargent, 1998, "The European Unemployment Dilemma," *Journal of Political Economy*, pp. 514–550.

Meyer, B., 1990, "Unemployment Insurance and Unemployment Spells," *Econometrica*, Vol. 58, No. 4, pp. 757–782.

Meyer, B. and W. Mok, 2007, "Quasi-Experimental Evidence on the Effects of Unemployment Insurance from New York State," NBER Working Paper No. 12865.

Mortensen, D. and C. Pissarides, 1994, "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies*, Vol. 61, No. 3, pp. 397–415.

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

Rinne, U. and K. Zimmermann, 2013, "Is Germany the North Star of Labor Market Policy?" IZA Working Paper No. 7260.

Schindler, M., 2013, "What Does the Crisis Tell us About the German Labor Market?," in *Germany in an Interconnected World Economy*, ed. by A. Mody (Washington DC: International Monetary Fund).

Shimer, R. and I. Werning, 2008, "Liquidity and Insurance for Unemployed Workers," *American Economic Review*, Vol. 98, No. 5, pp. 1922–1942.

Shimer, R., 2005, "The Cyclical Behavior of Equilibrium Unemployment, Vacancies, and Wages: Evidence and Theory," *American Economic Review*, Vol. 95, No. 1, pp. 25–49.

Streufert, P., 1990, "Stationary Recursive Utility and Dynamic Programming under the Assumption of Biconvergence," *Review of Economic Studies*, Vol. 57, No. 1, pp. 79–97.

Stokey, N. and R. Lucas, 1989, *Recursive Methods in Economic Dynamics*. (Cambridge, MA: Harvard University Press).