Labor Market Institutions and the Cost of Recessions

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Abstract

This paper studies the effect of two labor market institutions, unemployment insurance (UI) and job search assistance, on the welfare costs of recessions. The paper develops a tractable search model with idiosyncratic and aggregate labor market risk and derives a convenient formula for the welfare costs of recessions. The theoretical analysis shows that an improvement in job search assistance reduces the welfare costs of recessions, but that the effect of a change in unemployment benefits is ambiguous since partial-equilibrium effect and general-equilibrium effect work in opposite directions. The paper also provides a quantitative application to the German labor market reforms of 2003-2005, the so-called Hartz reforms, which reduced unemployement benefits (Hartz IV) and improved job search assistance (Hartz III). The quantitative analysis suggests that these two reforms led to a substantial reduction in the welfare costs of recessions in Germany, with the bulk of the reduction due to the improvement in job search assistance (Hartz III).

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1. Introduction

The Great Recession ended an era of macroeconomic stability and renewed interest in business cycle research. A recent empirical literature has assessed the cost of recessions in the US and other advanced economies. A general finding of this literature is that the average output loss associated with recessions is large, and that these output losses vary substantially across countries. There is also anecdotal evidence that for some countries, most notably Germany, the costs of recessions have changed substantially over time. In general, differences in the cost of recessions can be explained by differences in the nature of shocks, differences in the government response to shocks (macroeconomic stabilization policy), or differences in the institutional structure of the economy including the long-run policy choices of the government. In this paper, we pursue the third explanation. Specifically, we analyze the effect of two labor market institutions, unemployment insurance (UI) determining search incentives and job search assistance (JSA) affecting search efficiency, on welfare costs of recessions.

Our analysis is based on a tractable model of job search. There is a large number of long-lived, risk-averse workers with log-preferences who are either employed or unemployed and have the opportunity to save in a risk-free asset in zero net supply. There is an exogenous cost of financial intermediation that introduces a spread between the borrowing rate and the lending rate. Unemployed workers receive unemployment benefits and choose the level of search intensity, which is unobservable to the government and determines the probability of a job offer. Unemployed workers also receive public job search assistance affecting the efficiency of job search. The government finances spending on unemployment insurance and job search assistance through a linear social security (labor income) tax, and these policy choices by the government are independent of business cycle conditions. In this sense, this paper deals with the choice of labor market institutions (cycle-independent government policy) as opposed to macroeconomic stabilization policy (cycle-dependent government policy). Unemployment is associated with skill losses making unemployment costly beyond the direct loss of wages/output due to non-work, and these long-term earnings losses increase during recessions. Job loss occurs for exogenous reasons and the (exogenous) job loss rate depends

on business cycles conditions – during a recession the job destruction rate increases. The aggregate production function is linear in effective labor (hours times human capital) and labor markets are competitive so that the wage per efficiency unit of labor is equal to its marginal product.

We use the model outlined above to make two substantive contributions to the literature. First, we provide a theoretical analysis of the effect of unemployment insurance and job search assistance on the welfare cost of recessions. We define the cost of recessions as the welfare gain of moving from an economy with recessions to an economy without recessions.[1] We find that an increase in job search assistance reduces the cost of recessions if general equilibrium effects are small, which is the case when the initial level of job search assistance is low. In contrast, a reduction in unemployment benefits only reduces the costs of recessions if general equilibrium effects are large, which is the case when initial unemployment benefits are large.

The economic intuition behind our theoretical results is as follows. Recessions are costly because the job loss rate increases and more employed workers become unemployed. An improvement in job search assistance increases job finding rates, which increases welfare of the unemployed and therefore reduces the costs of recessions – the partial equilibrium effect. The improvement in job search assistance, however, has to be paid for with higher taxes, which reduces the welfare of the employed and therefore increases the cost of recessions – the general equilibrium effect.[2] If the partial equilibrium effect dominates the general equilibrium effect, then an improvement in job search assistance reduces the welfare costs of recessions. In the case of a reduction in unemployment benefits, the individual roles of par-

[1]This cost of recessions is related to the welfare cost of business cycles as introduced by Lucas (1987, 2003), but not the same. See XX for a more detailed discussion of these two concepts.

[2]Some authors call any search model a partial equilibrium model and use the term general equilibrium to describe the matching function approach to the labor market with endogenous vacancies (job creation) and endogenous job destruction. See, foe example, Shimer, Rogerson and Wright for a good discussion of this point. In this paper, general equilibrium refers to a model with aggregate resources constraint, which is equivalent to the government budget constraint in our simple model (Walras' law).

tial equilibrium effect and general equilibrium effect are reversed. Specifically, a reduction in unemployment benefits also increases job finding rates, but in partial equilibrium it reduces the welfare of the unemployed and therefore increases the costs of recessions. However, the reduction in unemployment benefits allows the government to reduce taxes, which increases the welfare of employed workers and therefore reduces the cost of recessions. If the second, general equilibrium, effect dominates the partial equilibrium effect, then a reduction in unemployment benefits reduces the costs of recessions.

Our second substantive contribution is to provide a quantitative analysis of our theoretical arguments. Specifically, we study the German labor market reform of 2003-2005, the so-called Hartz reforms, which turned "the sick man of Europe" into a "labor market miracle". Two essential ingredients of these reforms were i) a complete overhaul of the Public Employment Agency (Hartz III) dramatically improving job search assistance and job placement services and ii) a substantial reduction in the unemployment benefits for the long-term unemployed (Hartz IV) increasing search incentives. There is strong empirical evidence that, in line with the theoretical prediction, these two reforms led to a substantial increase in the non-cyclical component of the job finding rate of unemployed workers – the main economic mechanism emphasized in our theoretical analysis. The empirical evidence in conjunction with the scale of the German labor market reforms of 2003-2005 make them an ideal candidate for a quantitative assessment of the theory.[3]

Our main quantitative findings can be summarized as follows. First, the welfare costs of recessions in Germany are substantial: around X percent of lifetime consumption in our baseline calibration. About x percent of this cost is due to the temporary output loss during a typical recession, y percent is due to the uneven distribution of losses across the population

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

(combined with risk aversion), and z percent is due to the loss in potential output, which is driven by the reduction in the human capital stock that occurs during recessions (skill loss of unemployment). Second, the two reforms (Hartz III and Hartz IV) reduced the welfare costs of recessions in Germany substantially, where the bulk of the reduction is due to the Hartz III reform. Specifically, Hartz III reduced the welfare costs of recessions by x percent and Hartz IV by y percent.

In addition to the substantive contributions, this paper also makes a methodological contribution by developing a tractable model of job search. Specifically, we show that in equilibrium workers do not trade the risk-free asset if the cost of financial intermediation is large enough (but finite), and we also derive an explicit formula for the minimum cost of financial intermediation necessary to support the no-trade equilibrium. The proof of this equilibrium characterization result is non-standard since the first-order conditions associated with the worker maximization problem are in general not sufficient due to the non-concavity of the objective function, a problem that is well-known in the literature on multi-period moral hazard problems with (unobserved) asset trade. However, we show that in our model set-up first-order condition are indeed sufficient, and we use this property of our model to prove that no-trade is an equilibrium with sufficiently high cost of financial intermediation. Our proof heavily relies on three key assumptions: i) homothetic preferences, ii) non-asset income that is proportional to human capital of workers, and iii) human capital that evolves subject to shocks that are proportional to human capital (proportional skill depreciation during unemployment).

At this stage, two general comments are in order. First, in this paper we focus on the effect of labor market institutions on the welfare cost of recessions, but we do not study optimal labor market institutions in the sense of analyzing the labor market institution that maximizes social welfare.[4] We have two reasons for taking this approach. First, the cost of recessions is an important economic variable by itself that strongly influences pol-

[4]Section XXX contains a short discussion of the optimal level of unemployment insurance within the class of linear government policies considered in this paper. Fahri and Werning ( ) .

icy making, and it is therefore important to understand how labor market reform affects the cost of recessions. Second, the cost of recessions can be interpreted as the potential gains from macroeconomic stabilization policy. Adopting this interpretation, our analysis points towards an interesting interaction between structural reform of the labor market and macroeconomic stabilization policy. Specifically, our analysis suggests that countries that have successfully reformed their labor markets need, ceteris paribus, less stabilization policy (i.e. fiscal stimulus packages) than non-reforming countries with more rigid labor markets.[5]

Our second comment regards the model structure we employ. The model we develop in this paper is tractable and focuses on one basic channel, namely how labor market reforms that increase the job finding rate have the potential to reduce the cost of recessions. This approach has the advantage that we can conduct a theoretical analysis of the link between labor market institutions and the cost of recessions. An additional advantage is that we can provide independent empirical evidence in support of the basic mechanism in the case of the German labor markets reforms of 2003-2005. Clearly, there are many additional channels through which labor market institutions affect the cost of recessions,[6] and incorporating these additional channels into the analysis is an important topic for future research.

Literature Our paper is related to several strands of the literature. First, it is closely related to the large literature on the welfare cost of business cycles following the seminal contribution of Lucas (1987). This literature has extensively studied to what extent the introduction of uninsurable idiosyncratic risk increases the welfare cost of business cycles. For example, Atkeson and Phelan (1994), Imrohoroglu (1989), and Krusell and Smith (1999) analyze cyclical fluctuations in unemployment rates and unemployment duration and Gomes,

[5]Section XXX contains a short discussion of the optimal level of unemployment insurance within the class of linear government policies considered in this paper. In the literature review and in Section XXX we discuss in detail the link of our work to the cost of business cycle literature.

[6]In standard search and matching models along the lines of Mortenson and Pissarides (1994) and Den Haan, Ramey, and Watson (2000), the labor market reforms considered here would increase the steady state job finding rate *and* reduce the volatility of the job destruction rate (see Costain and Reiter, 2008, and Kuhn and Jung, 2012) thereby proving an additional channel through which labor market reform reduces the cost of business cycles.

Greenwood, Rebelo (2001) introduce endogenous search effort. Krebs (2003) and Storesletten, Telmer, and Yaron (2001) study cyclical variations in labor income risk more generally and Beaudry and Pages (2001) and Krebs (2007) focus on the long-term earnings losses associated with job displacement. The literature has also analyzed models in which aggregate fluctuations affect the level of output or the growth rate of output (Barlevy, 2004, den Haan and Sedlacek, 2013) and the effect of more general preference assumptions (Alvarez and Jermann, 2004, and Tallarini, 2000). Our paper contributes to this vast literature by taking the next step of analyzing how labor market reforms affect the welfare cost of business cycles.

Our paper is also related to the literature on labor market institutions and unemployment. This literature has studied extensively the effect of various labor market institutions on non-cyclical unemployment, but much less work has been done on the interaction between labor market institutions and macro shocks. Blanchard and Wolfers (2002) provide a comprehensive empirical study of the issue and Ljungqvist and Sargent (1998) use a search model to argue that the rise of unemployment rate in many European countries observed in the 1980s and 1990s can be explained by the interaction of a generous social insurance (welfare) system with a rise in market turbulence. More recently, Bentolila et al. (2012) and Jung and Kuhn (2012) use search and matching models to study to what extend labor market institutions can explain the differences in worker flow volatilities between France and Spain, respectively Germany and the US. Finally, there is recent work using New Keynesian models with search and matching frictions in the labor market to discuss how labor market institutions affect output volatility and the design of monetary policy. These contributions have provided important insights into a number of issues. However, their focus has not been on welfare analysis, and an analysis of the interaction between labor market reform and the welfare cost of business cycles has so far been lacking.[7]

There is also a large literature that analyzes the optimal path of unemployment insurance payments when search effort is unobservable (Hopenhayn and Nicolini, 1997, Pavoni,

[7]See, for example, Christiano, Trabandt, and W (2011) and their criticism of the literature.

2007, and Shimer and Werning, 2007). Work in this literature does not impose any prior restrictions on the class of unemployment insurance systems beyond incentive-compatibility and resource feasibility. In contrast, in the current paper we confine attention to a class of unemployment insurance systems that resemble actual unemployment systems and ask how parametric changes within this class affect the welfare costs of business cycles. Extending our approach to the study of more general unemployment insurance systems is an important topic for future research.

Finally, our paper is related to the economic literature on the German labor market reform of 2003-2005. There is a large empirical literature on this issue, which is surveyed in Sections 5 and the Appendix. Structural studies of the Hartz reforms based on macroeconomic search (and matching) models are surprisingly rare. Three notable exceptions are Launov and Waelde (2013), Krause and Uhlig (2012), and Krebs and Scheffel (2013), which are discussed in more detail in sections 5 and 6. Of these three contributions the paper by Krebs and Scheffel (2013) is most closely related to the current paper in the sense that they provide a welfare analysis of the Hartz reforms. However, Krebs and Scheffel (2013) do not consider cyclical variations in labor market variables and therefore cannot analyze the welfare cost of business cycles.

2. Model

This section develops the model and provides a convenient characterization of equilibrium. The model combines the tractable incomplete-market model of Krebs (2007), which in turn is based on Constantinides and Duffie (1996), with a job search model along the lines of Hansen and Imrohoroglu (1992) and Ljungqvist and Sargent (1998).

2.1 Workers

Time is discrete and open ended. There is a unit mass of infinitely-lived workers. The employment status of a worker in period t is denoted by s_t and can take on three values, $s_t \in \{e, su, lu\}$, where e stands for employed, su for short-term unemployed, and lu for long-term unemployed. Unemployed workers search for jobs and the job finding rate of

a worker of unemployment status $s = su, lu$ depends on individual search effort, l_s, and efficiency parameter, x_s, that depends on the level and quality of government spending on job search assistance, and the vector of unemployment rates $U = (U_{su}, U_{lu})$. We denote the job finding rate of an unemployed worker by $\pi_{e|s}(l_s, x_s, U)$ with $s = su$ (short-term unemployed) and $s = lu$ (long-term unemployed). We assume that for given U the job finding rate $\pi_{e|s}(l_s, x_s, U)$ is an increasing and concave function in (l_s, x_s). For example, in for our quantitative analysis we use the function $\pi_{e|s}(l, U) = x_s\, l_s\, U^{\eta-1}$ with $0 < \eta, 1$. At the beginning of any unemployment spell, the household is short-term unemployed, and then becomes long-term unemployed with probability $\pi_{lu|su}$. Employed households become unemployed with probability $\pi_{su|e}(S)$, which we call the job destruction rate. This job destruction rate is independent of effort (no moral hazard problem during employment), but depends on business cycle condition S. We assume that the aggregate state S follows a Markov process with stationary transition probabilities, which we denote by $\pi(S'|S)$. For simplicity, we assume that there are two aggregate states $S = R, N$, where $S = R$ denotes recession and $S = N$ normal times.

Employed workers receive labor income $(1-\tau)wh_t$, where w is the wage per unit of human capital and τ is a linear tax on labor income (social security tax). Unemployed workers receive unemployment benefits $b(s_t)h_t$ with $s_t = su, lu$. For tractability reasons, we assume that unemployment benefit payments depend on the current human level of human capital. At the beginning of life, worker have no financial wealth but they can save at the risk free rate $r_{f,t}$ and borrow at the rate $r_{f,t} + \alpha$, where α is an exogenous cost of financial intermediation. Thus, workers' budget constraint reads

$$
\begin{aligned}
a_{t+1} &= \begin{cases} (1+r_{f,t})a_t + (1-\tau)wh_t - c_t & if\ a_{t+1} \geq 0\ and\ s_t = e \\ (1+r_{f,t})a_t + b(s_t)h_t - c_t & if\ a_{t+1} \geq 0\ and\ s_t = su, lu \\ (1+r_{f,t}+\alpha)a_t + (1-\tau)wh_t - c_t & if\ a_{t+1} < 0\ and\ s_t = e \\ (1+r_{f,t}+\alpha)a_t + b(s_t)h_t - c_t & if\ a_{t+1} < 0\ and\ s_t = su, lu \end{cases} \\
h_{t+1} &= (1+\epsilon(s_{t+1}, S_{t+1}))h_t \qquad (1)
\end{aligned}
$$

where a_t denotes financial asset holdings at the beginning of period t. The function ϵ defining the law of motion of worker human capital, h, may depend on the individual state, s, and the

aggregate state S. The first dependence is used to introduce skill losses during unemployment and the second one to capture the idea that these losses increase during recessions. Note that the exogenous process of human capital (skills) in conjunction with the wage rate define the labor income process. Note also that each c_t is a function mapping histories of individual shocks, s^t, and aggregate shocks, S^t, into consumption choices $c_t(s^t, S^t)$. A similar comment applies to a_{t+1} and h_{t+1}.

In this paper we consider two types of labor market institutions. The first labor market institution is the unemployment insurance system defined by the benefit levels $b = (b_{su}, b_{lu})$. The second labor market institution is the Public Employment Agency that provides job search assistance and job placement services improving job finding rates summarized by the efficiency parameters $x = (x_{su}, x_{lu})$. The resource cost of providing job search assistance is paid by the government and enters into the government budget constraint, which we define below. Note that neither b nor x depend on business cycle conditions S. This assumption is made since in this paper the focus is on labor market institutions – labor market policies that do not respond to business cycle conditions.

Workers are risk-averse and have identical preferences that allow for a time-additive expected utility representation. The one-period utility function depends on consumption, search effort, and the employment status. We confine attention to utility functions that are logarithmic over consumption: $u(c, l, s) = \ln c - d(l, s)$, where d is an increasing and strictly convex function in l. Expected life-time utility associated with a consumption-effort plan, $\{c_t, l_t\}$ for a worker with initial employment status s_0 is given by

$$U(\{c_t, l_t\}) \;=\; E_{\{l_t\}}\left[\sum_{t=0}^{\infty} \beta^t \left(\ln c_t - d(l_t, s_t)\right) | s_0\right] \tag{2}$$

where β is the pure discount factor of workers. Note that we use the notation $E_{\{l_t\}}[.]$ to indicate that the expectations in (2) is taken with respect to a joint distribution over idiosyncratic and aggregate shocks that depends on the effort plan $\{l_t\}$ through its effect on transition probabilities, π.

Workers choose a plan $\{c_t, l_t, a_t\}$ so as to maximize (2) subject to (1), where a plan is

a sequences of (arbitrary) functions of the history of individual employment states and aggregate productivity shocks: $c_t = c_t(s^t, S^t)$, $l_t = l_t(s^t, S^t)$, and $a_{t+1} = a_t(s^t, S^t)$. Aggregate variables are denotes by upper case letters and are obtained from individual plans by taking the expectations over individual histories and initial types conditional on the history of aggregate shocks: $C_t \doteq E_t[c_t] = \int_{h_0} \sum_{s^t} c_t(s^t, h_0)\pi_t(s^t)d\pi_0(h_0)$. This notation linking individual plans to aggregate variables is used throughout the paper.

2.2 Firms

There is a continuum of firms producing a single consumption good using labor as the only input factor. A firm is defined by its productivity parameter that takes on two values, $Z > 0$ or 0. One firm is matched with one worker and that a worker-firm match produces Zh or 0. We assume that a firm with productivity 0 will have productivity 0 forever and will shut down. Thus, the job destruction rates $\pi_{u|e}(S')$ introduced in section 2.1 are equal to the probability that firm-level productivity moves from Z in period t to 0 in period $t+1$. The transitions rates $\pi_{u|e}(S')$ are exogenous. We assume that the matching of workers with firms is random so that aggregate output is equal to $Y_t = ZH_{t,e}$, where $H_{t,e} = E[h_t|s_t = e]$ is the aggregate human capital stock of the employed workers.[8] The labor market is competitive in the sense that the real wage per unit of human capital, w, is equal to the marginal product of labor: $w = Z$.

2.3 Equilibrium

We assume that the risk-free asset available to households is in zero net supply. Thus, market clearing in the (domestic) asset market reads:

$$A_t \quad = \quad 0 \tag{3}$$

Denote by A_t^- the total debt of workers and A_t+ the total asset holdings of workers. Note that $A_t^- = A_t^=$ because of (3). We define output net of the cost of financial intermediation as $\tilde{Y}_t = Y_t - A_t^-$.

[8] See also textbook of Acemoglu for a similar model...

We next turn to the government budget constraint. Clearly, and government choice of labor market institutions (b, x, τ) induces a stochastic process of government spending, $\{G_t\}$, and government revenues, $\{T_t\}$, where government spending in period t and tax revenues in period t are given by T_t, as

$$\begin{aligned} G_t &\doteq [b_{su} + \lambda_{su}(x_{su})]\, H_{t,su} + [b_{lu} + \lambda_{lu}(x_{lu})]\, H_{t,lu} \\ T_t &\doteq \tau w H_{t,e} \end{aligned} \tag{4}$$

The first term in the definition of G is government spending on short-term unemployed workers (unemployment benefits plus jobs search assistance) and the second term is spending on long-term unemployed workers. The functions λ_s measure the resource cost of providing job search assistance of quality x_s. We assume that λ_s is an increasing and convex function for $s = su, lu$.

We assume that the government chooses policies (b, x, τ) that satisfy the balanced budget constraint on average:

$$\lim_{t\to\infty} E\left[\frac{G_t - T_t}{\tilde{Y}_t} | U_0, H_0, S_0\right] = 0 \tag{5}$$

where $\tilde{Y}_t = Y_t - A_t^-$ is total output net of cost of financial intermediation (see above) and the expectation in (5) indicates that we average over histories of aggregate states S^t: $E[G_t] = \sum_{S^t} G_t(S^t)\pi_t(S^t)$ and $E[T_t] = \sum_{S^t} T_t(S^t)\pi_t(S^t)$ conditional on the initial aggregate state (U_0, H_0, S_0). In equation (5) we use the deficit-to-output ratio in order to avoid technical issues that arise when taking the limit for sequences of random variables that grow in expectations. Note that equation (5) assumes that the government can borrow and lend in international capital markets, and that it uses this ability to smooth aggregate consumption/output over time and across aggregate shocks S (recall that domestic households are in the aggregate neither borrowing nor lending).[9]

Our assumption that government policies have to satisfy the government budget con-

[9] An alternative assumption is that there is one additional domestic household (a capitalist) who is more patient than workers, an assumption often made in the literature. See, for example, XXX for a review of New-Keynesian models that make heavy use of this construct.

straint (5), instead of a period-by-period balanced budget constraint, allows us to consider labor market policies that do no respond to the business cycle (labor market institutions). However, the induced fiscal policy, defined by the process $\{G_t, T_t\}$ and the corresponding process of government debt $\{D_t\}$, may not satisfy the no-Ponzi-scheme condition and may not imply a bounded debt-to-output ratio. $\{G_t, T_t\}$ defines a government debt process $\{D_t\}$. See, for example, Bohn (1995) for a general discussion of this issue. We note, however, that the no-Ponzi scheme condition is always satisfied if international investors lending to the domestic government have either i) high consumption growth or ii) high level of risk aversion or iii) their intertemporal marginal rate of substitution is correlated with domestic government debt. Further, in our robustness analysis we show that for any fiscal policy $\{G_t, T_t\}$ induced by a labor market institution (b, x, τ) there is a fiscal policy $\{G'_t, T'_t\}$ that generates the same equilibrium allocation, but implies a bounded debt-to-GDP ratio (and also satisfies the no-Ponzi scheme condition). In this new equilibrium welfare is different from welfare in the old equilibrium, but we show that these welfare differences are negloigible in our quantitative application.

Given the concepts introduced so far, our definition of sequential equilibrium and feasibility of government policy are standard:

Definition For given government policy $(b, x, \tau,)$, a sequential equilibrium is a wage rate w, a sequence of interest rates, $\{r_t\}$, and a worker plan, $\{c_t, a_t, l_t\}$, so that

i) for given wage rate w and sequence of interest rates $\{r_{f,t}\}$, the individual plan $\{c_t, a_t, l_t\}$ maximizes expected lifetime utility (2) subject to (1).

ii) Market clearing condition (3) holds in each period t.

A budget feasible government policy is a policy (b, x, τ) satisfying the government budget constraint (5).

The household budget constraint (1) in conjunction with the asset market clearing condition (6) and the government budget constraint (9) imply the aggregate resource constraint

(goods market clearing condition)

$$\lim_{t\to\infty}\sum_{s} E\left[\frac{C_{t,s}}{\tilde{Y}_t}|U_0,H_0,S_0\right]+\lim_{t\to\infty}\sum_{s=su,lu} E\left[\frac{\Lambda_{t,s}}{\tilde{Y}_t}|U_0,H_0,S_0\right] \;=\; 1 \tag{6}$$

where $C_{t,s}$ is aggregate consumption of workers of type $s = su, lu, e$ and $\Lambda_{t,s} = E[\lambda_s(x_{t,s})]$ is aggregate spending on job search assistance for unemployed of type $s = su, lu$. Note that the aggregate resource constraint (6) only holds in expectation, where the expectation is taken over all histories S^t. This has to be the case since the government budget constraint (5) only holds in expectations.

2.4 Equlibrium Characterization

We show below that (U, S) is the relevant aggregate state variable for formulating the worker's problem in a recursive manner. Foreshadowing this result, we can write the worker's maximization problem as

$$\begin{aligned} V_s(a,h,U,S) \quad &= \quad \max_{c,l,a'}\left\{\ln c - d_s(l)+\beta\sum_{s',S'} V_{s'}(a',h',S',U')\pi_{s'|s}(l,U,S')\pi(S'|S)\right\} \\ &s.t. \quad (a',c)\;\in\;\Gamma_s(a,h,U) \\ &\qquad h' \;=\; (1+\epsilon_{s'}(S'))h \\ &\qquad U' \;=\; \Phi(U,S,S') \end{aligned} \tag{7}$$

where Γ is the correspondence defined by the individual budget set (1) and Φ is the (endogenous) equilibrium law of motion for the unemployment rate U. Note that the effort choice l is only relevant for the transition probability $\pi_{s'|s}(l, U, S')$ if $s = su, lu$ and that the aggregate state S only affects this transition probability if $s = e$.

In the Appendix we show that under certain conditions there is an equilibrium in which workers choose asset holdings $a_t = 0$ and consumption $c_t = \phi(s_t)h_t$ for all histories (for all states), where we define $\phi(e) = (1 - \tau)w$ and $\phi(s) = b(s)$ for $s = su, lu$. In other words, there is no trade in financial assets and consumption equals income (after-tax earnings or unemployment benefits). The value function of workers in equilibrium at $a_t = 0$ is given by

$$V_s(0,h,U,S) \;=\; v_s(U,S)+\frac{1}{1-\beta}ln\,h \tag{8}$$

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

$$\begin{aligned} v_s(U,S) &= \max_l \Bigg\{ \ln \phi_s - d_s(l) + \frac{\beta}{1-\beta} \sum_{s',S'} \ln(1+\epsilon_{s'}(S'))\pi_{s'|s}(l,U,S') \\ &\quad +\beta \sum_{s',S'} v_{s'}(U',S')\pi_{s'|s}(l,U,S') \Bigg\} \\ &\quad U' = \Phi(U,S,S') \end{aligned} \tag{9}$$

with the endogenous law of motion of the unemployment rate, Φ, given by

$$U'_{s'} = \sum_{s=su,lu} \pi_{s'|s}(l_s(S,U),U)\, U_s \; + \; \pi_{su|e}(S')(1-U_{su}-U_{lu}) \tag{10}$$

The solution to equations (9) and (10) defines the equilibrium effort choice of workers. We further have $a_t = 0$ and $c_t = \phi(s_t)h_t$ with $h_{t+1} = (1+\epsilon(s_{t+1},S_{t+1}))h_t$ in equilibrium, which implies that the solution to (9) and (10) also defines the equilibrium plan $\{c_t, a_t, l_t\}$ of workers.

Equations (9) and (10) determine the equilibrium effort choice of workers and the equilibrium evolution of the unemployment rate for given government policy (b, x, τ). Government policies have to be feasible, that is they have to satisfy the budget constraint (5). For the recursive equilibria considered here, equation (9) can be rewritten in a more convenient way. To do this, define the human capital share of workers of type s in period t by $\Omega_{t,s} = H_{t,s}/H_t$. In the Appendix, we show that the equilibrium law of motion for Ω is[10]

$$\Omega'_{s'} = \frac{\sum_s (1+\epsilon_{s'}(S'))\pi_{s'|s}(l(U,S),U,S')\Omega_s}{\sum_s (1+\epsilon_{s'}(S'))\pi_{s'|s}(l(U,S),U,S')\Omega_s} \tag{11}$$

The equilibrium law of motion (11) in conjunction with the stationary Markov process over aggregate shocks S define a Markov process with stationary transition function, for which a stationary distribution exists under very weak assumptions. Let Ω^* stand for the mean of Ω computed using this stationary distribution: $\Omega^* = \int_{U,\Omega} \Omega d\pi^*(U,\Omega)$. Under additional

[10]Human capital evolves according to $H'_{s'} = \sum_s (1+\epsilon(s',S'))\pi_{s'|s}(l_s(S,U),U,S')H_s$.

assumptions, we have $\lim_{t\to\infty} E[\Omega_t|U_0, \Omega_0, S_0] = \Omega^*$ (see Stokey and Lucas, 1989), and the government budget constraint (9) is therefore satisfied if and only if the following budget constraint holds:

$$[b_{su} + x_{su}]\,\Omega^*_{su} + [b_{lu} + x_{lu}]\,\Omega^*_{lu} \;=\; \tau w \Omega^*_e \tag{12}$$

Proposition 1. Suppose that the cost of financial intermediation α is greater or equal to α_{min} given in (A2). Then the solution to (9)-(12) defines a recursive equilibrium with budget feasible government policy (b, x, τ).

Proof: Appendix.

Proposition 1 simplifies the theoretical and quantitative analysis for two reasons. First, it reduces the problem of solving the Bellman equation (7) to the much simpler problem of solving the intensive-form Bellman equation (9). Note that in (7) the individual worker makes a consumption-saving choice and an effort choice, whereas in (9) the worker only makes an effort choice. Second, it shows that workers do not trade the risk-free asset in equilibrium so that the infinite-dimensional wealth distribution is not a relevant state variable. Indeed, proposition 1 shows that the relevant endogenous state variable is $(U, \Omega$, a four-dimensional object in our case (recall that $\Omega = (\Omega_{su}, \Omega_{lu}, \Omega_e)$ and $U = (U_{su}, U_{lu})$ and that the individual components of Ω are normalized to one). Note that Ω does not enter into the household decision problem (9) and in this sense the problem is further simplified. Specifically, in our quantitative application we first solve the household maximization problem (9) and (10) for given tax rate τ, and then vary τ until the government budget constraint (12) is satisfied.

3. Theoretical Analysis

We now turn to the analysis of the interaction between labor market institutions and the welfare cost of recessions. In section 3.1 we define the welfare cost of recessions and section 3.2 discusses the relationship to the welfare cost of business cycle. In Section 3.3 we derive a useful formula for the cost of recessions and state our theoretical results about the effect of labor market institutions on the welfare cost of recessions.

3.1 Welfare Cost of Recessions

We define the welfare cost of recessions as the gain in social welfare that accrues when recessions are eliminated. More precisely, we consider a thought experiment in which we move from an economy with recessions, in which job destruction rates $\pi_{su,e}(S')$ depend on business cycle conditions S', to an economy without recessions and a job destruction rate $\hat{\pi}_{su|e}$ that is independent of S'. The job destruction rate in the new economy without recessions is equal to the job destruction rate that prevailed in normal times $\hat{\pi}_{su|e} = \pi_{su|e}(N)$. Similarly, we assume that the skill loss due to unemployment in the new economy, $\hat{\epsilon}_{s'}$, is equal to the skill loss in the normal times, $\epsilon_{s'}(N)$. Thus, in the thought experiment we assume that we remove recessions without affecting the labor market in normal (or boom) times. Finally, we assume that job finding rates remain the same so that:

$$\begin{aligned} \hat{\pi}_{su|e} &= \pi_{su|e}(N) \\ \hat{\epsilon}_{s'} &= \epsilon_{s'}(N) \\ \hat{\pi}_{e|s}(l,U) &= \pi_{e|s}(l,U) \quad s = su, lu \end{aligned} \tag{13}$$

Equation (13) shows how the elimination of recessions affects the job destruction rate and proposition 1 provides an algorithm to compute equilibria before and after the elimination of recessions. Let Δ stand for the welfare cost of recessions, that is, the difference, expressed in lifetime consumption units, between social welfare in the economy without recessions and social welfare in the economy with recessions. Welfare of individual workers is computed using the equilibrium value functions $v_s(U,S)+\ln h$, respectively $\hat{v}(U)+\ln h$, but to compute differences in social welfare, we need to specify the social welfare function/weights and the initial state of the two economies. With respect to the latter, we assume that the initial distribution over human capital, h, and the initial unemployment rate U are the same in both economies. Thus, we compare two economies with the same initial state and take into account the transition path. With respect to the former, we confine attention to social preference that assign equal weight to each individual worker. With these assumptions, the welfare cost of recessions Δ, expressed in percentage of consumption in each state and period

(lifetime consumption),[11] is given by the following expression in our economy:

$$\begin{aligned}\ln(1+\Delta(U,S)) &= (1-\beta)\left[\hat{v}_{su}(U,S)-v_{su}(U,S)\right]U_{su}+(1-\beta)\left[\hat{v}_{lu}(U,S)-v_{lu}(U,S)\right]U_{lu}\\ &\quad+(1-\beta)\left[\hat{v}_{e}(U,S)-v_{e}(U,S)\right](1-U) \qquad (14)\end{aligned}$$

Equation (14) shows that the welfare cost of recessions is independent of the initial distribution of human capital, a result that is a direct consequence of our assumption of homothetic preferences and skill shocks (depreciation rates during unemployment) that are proportional to the stock of human capital. It depends, however, on the state (U,S) that prevails when recessions are eliminated (the initial state).

3.2 Relation to Cost of Business Cycles

In this section, we briefly discuss the relationship between the welfare cost of recessions as defined by (13) and (14) and the welfare cost of business cycles as defined by Lucas (1987, 2003) for representative household economies and extended to economies with uninsurable idiosyncratic risk by, among others, Krebs (2003, 2007), Krusell and Smith (1999), and Krusell et al. (2009). Lucas (1987, 2003) considers a thought experiment in which we move from an economy with business cycles (an economy with S-dependent job destruction rate) to an economy without business cycles (an economy with constant job destruction rate). Krebs (2003, 2007), Krusell and Smith (1999), and Krusell et al. (2009) extend this idea to economies with uninsurable idiosyncratic risk by assuming that the elimination of business cycles amounts to an averaging procedure over S-dependent fundamentals (job destruction rates) conditional on the individual state. More formally, the S-dependent job destruction rates $\pi_{su,e}(S)$ are replaced by a constant job destruction rate $\hat{\pi}_{su|e}$ and the S-dependent skill growth rates, $\epsilon_{s'}(S')$, are replaced by S-independent skill growth rates, $\hat{\epsilon}_{s'}$: according to

$$\begin{aligned}\hat{\pi}_{s'|e} &= \sum_{S}\pi_{s'|e}(S)\alpha(S|e) \qquad (15)\\ \hat{\epsilon}_{s'} &= \sum_{S'}\epsilon_{s'}(S')\alpha(S')\end{aligned}$$

[11] More precisely, workers in the economy with recessions receive a consumption subsidy Δ so that their consumption in equilibrium is $c_t=(1+\Delta)\phi(s_t)h_t$ in every period.

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

Krebs (2003, 2007) and Krusell and Smith (1999), and Krusell et al. (2009) use a weighting distribution $\alpha(S') = \pi(S'|e)$, where $\pi(S'|e) = \pi(e, S')/\pi(e)$ is the probability that the aggregate state S' occurs (conditional on $s' = e$) in the economy with business cycles. Put differently, business cycles are eliminated in a symmetric way so that the S'-dependent job destruction rates are replaced by a constant job destruction rate with the same mean. In contrast, the welfare cost of recessions as defined in (13) and (14) are obtained if we choose $\alpha(R) = 0$ and $\alpha(N) = 1$. In other words, business cycles are eliminated in an asymmetric fashion so that the S'-dependent job destruction rates are replaced by a constant job destruction rate with a lower mean.

In this paper, the focus is on the welfare costs of recessions. However, in the quantitative section we also compute the welfare costs of business cycles for the case $\alpha(S') = \pi(S'|e)$. Further, proposition 2 is valid for any weighting α for which $\alpha(N) > \pi(N|e)$, that is, any weighting scheme that puts slightly more weight on normal times than the fully symmetric weighting scheme. If one interprets the welfare cost of business cycles as the potential gains from stabilization policy, then there are at least three reasons why asymmetric effects could occur. First, Auerbach and Gorodnichenko (2012) provide empirical evidence that fiscal multipliers are substantially larger in recessions than in booms. If output and job destruction rates are positively correlated, then this finding implies that stabilization policy has an asymmetric effect on the labor market and can change the average job destruction rate. In line with this empirical finding, Gali, Gertler, and Lopez-Salido (2007) show that in a simple New-Keynesian model efficiency losses due to mis-pricing during a recession are not offset by the efficiency gains in a boom. Second, Beaudry and Pages (2001) provide a theoretical argument that implicit contracts lead to an asymmetric response of the labor market, though they focus on the earnings losses of displaced workers. Third, papers by Further, Hairault, Lagot, and Osotimehim (2010) and Jung and Kuester (2011) have shown that in standard search and matching models a mean-preserving reduction in the volatility of aggregate productivity shocks reduces the mean of the unemployment rate.

3.3 Simplified Version of the Model

We next discuss a simplified version of the model that provides the basis for our theoretical analysis of the link between labor market institutions and the cost of recessions. Suppose that the job finding rate does not depend on the unemployment rate: $\pi_{e|s}(l)$ is independent of U for $s = su, lu$. In this case, U is not a relevant state variable – equilibrium effort choice and intensive-form value function only depend on s and S. Assume further that the aggregate productivity process is i.i.d, $\pi(S'|S) = \pi(S')$, and that the human capital growth rate, ϵ, is independent of the aggregate state. Finally, assume for notational simplicity that there is only one unemployment state, $s = u, e$. In this case, equation (9) simplifies to

$$\begin{aligned} v_u &= \max_l \left\{ \ln b - d(l) + \frac{\beta}{1-\beta} \sum_{s'=u,e} \left[\ln(1+\epsilon_{s'}) + \beta v_{s'}\right] \pi_{s'|u}(l;x) \right\} \\ v_e &= \left\{ \ln(1-\tau)w + \frac{\beta}{1-\beta} \sum_{s'=u,e} \left[\ln(1+\epsilon_{s'}) + \beta v_{s'}\right] \sum_{S'} \pi_{s'|e}(S')\pi(S') \right\} \end{aligned} \tag{16}$$

Thus, the equilibrium effort choice, l, and the value function coefficients, v_s, are independent of U and S and only depend on the average job destruction rate, $\sum_{S'} \pi_{u|e}(S')\pi(S')$. Further, the Ω^* used in the government budget constraint can be computed as the solution to the following equation

$$\begin{aligned} \Omega_u^* &= N^{-1}(1+\epsilon_u) \left[(1-\pi_{e|u}(l))\Omega_u^* + \sum_{S'} \pi_{u|e}(S')\pi(S')\Omega_e^* \right] \\ \Omega_e^* &= N^{-1}(1+\epsilon_e) \left[(1-\sum_{S'} \pi_{u|e}(S')\pi(S'))\Omega_e^* + \pi_{e|u}(l)\Omega_u^* \right] \\ N &= (1+\epsilon_u) \left[(1-\pi_{e|u}(l))\Omega_u^* + \sum_{S'} \pi_{u|e}(S')\pi(S')\Omega_e^* \right] \\ &\quad + (1+\epsilon_e) \left[(1-\sum_{S'} \pi_{u|e}(S')\pi(S'))\Omega_e^* + \pi_{e|u}(l)\Omega_u^* \right] \end{aligned} \tag{17}$$

Equations (16) and (17) together with the government budget constraint

$$[b+x]\,\Omega_u^* = \tau w \Omega_e^* \tag{18}$$

determine the equilibrium. Note that these equations only depend on the average job destruction rate $\sum_{S'} \pi_{u|e}(S')\pi(S')$. Thus, the equilibrium conditions for the economy with

cycle-dependent job destruction rates $\pi_{u|e}(S')$ are isomorphic to the equilibrium conditions of an economy with cycle-independent job destruction rates $\sum_{S'} \pi_{u|e}(S')\pi(S')$.

3.4 Labor Market Institutions

Equations (16) - (18) determine the equilibrium values of $(v_e, v_u, l, \tau, \Omega^* e, \Omega_u^*)$ for given labor market institutions (b, x). Together with the welfare formula (14), which now reads

$$\ln(1+\Delta) \;=\; (1-\beta)\left[\hat{v}_u\right) - v_u\right] U + (1-\beta)\left[\hat{v}_e - v_e\right](1-U) \tag{19}$$

this determines the welfare costs of recessions. Changes in labor market institutions (b, x) induce changes in the equilibrium values of $(v_e, v_u, l, \tau, \Omega^* e, \Omega_u^*)$. In this way we define functions $v_e = v_e(b, x)$ and $v_u = v_u(b, x)$, and therefore also a function $\Delta = \Delta(b, x)$. The function $\Delta(b, x)$ encodes the information about the effects of labor market institutions on the welfare costs of recessions. In particular, we are interested in the sign of the derivatives $\frac{\partial \Delta}{\partial b}$ and $\frac{\partial \Delta}{\partial x}$. These derivatives can be decomposed into two part, a partial-equilibrium effect and a general-equilibrium effect. More precisely, define the function $\tilde{\Delta} = \tilde{\Delta}(b, x, \tau)$ by the solution to the workers problem (16) for given labor market institutions (b, x, τ) and define the function $\tau = \tau(b, x)$ by the solution to the government budget constraint (17) and (18). We then have

$$\begin{aligned} \frac{\partial \Delta}{\partial b} &= \frac{\partial \tilde{\Delta}}{\partial b} + \frac{\partial \tilde{\Delta}}{\partial \tau}\frac{\partial \tau}{\partial b} \\ \frac{\partial \Delta}{\partial x} &= \frac{\partial \tilde{\Delta}}{\partial x} + \frac{\partial \tilde{\Delta}}{\partial \tau}\frac{\partial \tau}{\partial x} \end{aligned} \tag{20}$$

Proposition 2. Suppose there is only one unemployment state, $s = u, e$. Suppose further that the job finding rate is independent of the unemployment rate, the skill depreciation rate is independent of the aggregate shock, and that aggregate shock process follow i.i.d. process. Finally, assume that the condition $\frac{2\beta\pi_{e|u}}{1-\beta+\beta(\pi_{e|u}+\pi_{u|e})} > 1$ is satisfied. Then the following holds.

i) An increase in unemployment benefits increases the welfare costs of recessions in partial equilibrium

$$\frac{\partial \tilde{\Delta}}{\partial b} \;>\; 0$$

ii) An increase in job search assistance reduces the welfare costs of recessions in partial equilibrium

$$\frac{\partial \tilde{\Delta}}{\partial x} < 0$$

If the initial level of job search assistance is low, (if $\lambda_s'(x_s)$ is low), then it also reduces the welfare costs of recessions in general equilibrium

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

4. Calibration

In this section, we specify a baseline model and calibrate the model economy in order to match a number of facts of the German labor market before the Hartz reforms. Our calibration approach broadly follows Krebs and Scheffel (2013). In particular, the model economy matches some of the key features of the German unemployment insurance system before the reform and the unemployment benefit elasticity of individual job finding rates (search intensity). We also require the model economy to match 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. Finally, we calibrate the parameters of the stochastic job destruction process to match the behavior of job separation rates (flow rates from employment into unemployment) during a typical recession in Germany and discuss the cyclical properties of the implied job finding rates.

Our calibration strategy requires us to find the long-run values of a number of macro variables before the reform. We compute these long-run values by taking the mean of the respective variables in the period 2000-2004. We use a relatively short time period because the German unemployment rate has shown a steady upward trend until the beginning of the 2000s – see figure 1.[12]

[12]We also used an alternative method by applying the HP-filter to the data in the period until 2005, and then to take the value of the long-run trend in year 2002. Both methods yield almost identical results and we therefore report only the results using the first method.

4.1 Model Specification

The basic model period is one quarter. We continue to assume a two-state aggregate shock process $S \in \{R, N\}$, where R stands for recession (high job destruction rate) and N for normal times (normal rate of job destruction). We further assume $\epsilon_{s',S'} = \epsilon_{s'}$ and denote skill depreciation of the short-term unemployed and long-term unemployed by $\epsilon_{su} = \delta_{h,su}$ and $\epsilon_{lu} = \delta_{h,lu}$, respectively. For the baseline calibration, we assume $\delta_{h,su} = \delta_{h,lu}$. We use the standard OECD convention and define long-term unemployment as any unemployment spell that lasts longer than 12 months. Thus, we choose the probability $\pi_{lu|su}$ of transiting from su to lu equal to 0.25.

4.2 Search and Job Finding Rates

For the job search technology we assume a linear function:

$$\begin{aligned} \pi_{e|su}(l, U) &= x_{su}\, l\, U^{\eta-1} \\ \pi_{e|lu}(l, U) &= x_{lu}\, l\, U^{\eta-1}\ , \end{aligned} \tag{21}$$

where $U = U_{su} + U_{lu}$. This functional form for the job finding rate is in line with the matching function approach to the labor market assuming constant vacancy rates and an elasticity of job matching with respect to the unemployment rate that is equal to η. See Petrongolo and Pissarides (2001), who survey the relevant theoretical literature and discuss the empirical studies estimating η.[13] For Germany, Burda and Wyplosz (1994) find a value of $\eta = 0.68$ and we use this value for our baseline calibration.

We choose the values of x_{su} and x_{lu} so that the corresponding job finding probabilities match the observed average transition rates in the period 2000-2004 for the short-term unemployed and long-term unemployed, respectively. The values for the quarterly transition probabilities are $\pi_{e|lu} = .06$ and $\pi_{e|su} = .24$ according to the data provided by the Federal Employment Agency (Bundesagentur fuer Arbeit), which yields $x_{su} = 0.1275$ and $x_{lu} =$

[13] Petrongolo and Pissarides (2001) suggest that $U \times L$ instead of U should enter the matching function, where L is the average search effort chosen by unemployed workers.

0.0715.

We assume that dis-utility of search is

$$d_s(l) \;=\; d_0\, l^{\gamma} - d_{1,s} \tag{22}$$

For the employed workers, we set the disutility of work, $d_1(e)$, equal to the value assumed in the standard real business cycle model with log utility (Prescott and Hansen, 1995). It is well-known that with the above specification the parameters x_{su}, x_{lu} and d_0 are not separately identified. We therefore choose a numerically convenient normalization of $d_0 = 1$. We choose $d_{1,su}$ and $d_{1,lu}$ so that the value of the disultility term d in equilibrium is the same for employed workers, short-term unemployed workers, and long-term unemployed workers. We choose the curvature parameter γ to match a given value of the elasticity of the job finding rate with respect to benefits payments for the short-term unemployed, where we choose as target the micro elasticity holding constant the labor market state U. This target elasticity is chosen as follows.

For the US, there are a number of empirical micro studies estimating the search elasticity directly. The best known studies are Moffitt (1985) and Meyer (1990) who estimate an elasticity of around -0.9. Krueger and Meyer (2002) survey the literature and suggest an elasticity of -1. There is much less work on this issue for Germany, but Hunt (1995) finds estimates for Germany that are similar to the US 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 non-compliance 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 (ECHP) to estimate the elasticity for several European countries, and they find values ranging from -1.14 to -1.66 for Germany. Almost all empirical studies deal with unemployed workers who are short-term unemployed according to our definition (less than one year of unemployment). In our baseline calibration, we choose a target elasticity of -0.9 for the short-term unemployed, a value also chosen in Krebs and Scheffel (2013).

Our calibration implies an elasticity of unemployment duration with respect to unemployment benefits for the long-term unemployed of $-XXXX$, which is somewhat higher than the corresponding elasticity for the short-term 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. The estimates reported in Chetty (2008) suggest that the elasticity of the long-term unemployed (low-wealth unemployed) is substantially larger than the search elasticity of the short-term unemployed.

One general concern with our calibration approach is that macro elasticities could be different from micro elasticities. For example, Landais, Michaillat, and Saez (2010) have argued that labor demand externalities generate a macro elasticity that is smaller than the corresponding micro elasticity. Several papers have tried to estimate this labor-demand externality, but the empirical literature has not reached a consensus. For example, Blundell et al. (2004) find no spillover effect in the UK, but Crepon et al. (2013) estimate a reduction of 37 percent for young French job seekers. The macro elasticity can also be larger than the micro elasticity if there are wage externalities (Landais et al., 2010) or if job destruction is endogenous.[14] Indeed, Hagedorn, Karahan, Manovskii, and Mitman (2013) provide empirical evidence that the macro elasticity is substantially larger than the micro elasticity due to effect of unemployment benefits on job creation. In Section XXXXXX we discuss the robustness of our quantitative results to alternative assumptions about the target elasticity.

We also allow for transitions from long-term unemployment to short-term unemployment.

[14]Landais et la. (2010) also argue that the elasticity wedge is counter-cyclical, and Crepon et al. (2013) provide evidence supporting this view. Below we discuss the cyclical properties of the elasticity implied by our calibrated model economy.

We choose the transition probability $\pi_{su|lu}$ to match a given fraction of long-term unemployed in the unemployment pool. According to the OECD statistics, the share of long-term unemployment was 50 percent for the period 2000-2004, a value we match if $\pi_{su|lu} = 0.190$.

4.3 Job Separation

We choose an average job separation rate, $\pi_{su|e} = \sum_S \pi_{su|e}(S)\pi(S|e)$, so that the implied steady state unemployment rate is equal the average unemployment rate in the period 2000-2004, namely 10 percent. This yields a steady state job separation rate of $\pi_{e|su} = 0.0159$, which is in line with Jung and Kuhn (2013).

4.4 Skill Loss During Unemployment

There is substantial empirical evidence that job loss leads to subsequent lower wages and earnings, and that these wage losses increase with the duration of unemployment. For the US, Addisson and Portugal (1989) use data drawn from the Displaced Worker Survey and find that an increase in the unemployment duration by 10% reduces wages between 0.8% and 1.4%. Using the same data, Neal (1995) finds that an additional week of unemployment reduces the wages by 0.37%, implying a monthly rate of wage loss of 1.5%. Further, using a structural approach Keane and Wolpin (1997) estimate high rates of skill depreciation during unemployment. For Germany, Schmieder, Wachter, and Bender (2013) use a large administrative data set to implement a regression discontinuity (RD) design and find that each month out of work reduces reemployment wages by 0.8 percent, pointing to substantial costs of long unemployment spells. The work by Schmieder, Wachter, and Bender (2013) is directly applicable to our setting since they allow for job search and wage offers that change with unemployment duration. Their finding of substantial skill depreciation during unemployment is consistent with recent empirical results pointing to a negative effect of unemployment benefits on re-employment wages (Card, Chetty, and Weber, 2007). Guided by the findings of the empirical literature, we set the skill depreciation parameter, $\delta_{h,su} =$

$\delta_{h,lu}$, to a quarterly depreciation rate of 2.5%.[15]

4.5 Unemployment Benefits

The calibration of the unemployment benefit parameters follows Krebs and Scheffel (2013). Specifically, we choose the unemployment benefit parameters $b_{su} = w$ so that consumption of the short-term unemployed only changes because of the loss of human capital (perfect consumption smoothing of transitory income shocks). We choose the unemployment benefit parameter b_{lu} to match the difference in the net replacement rate of the short-term unemployed and long-term unemployed (the change that occurs when moving from short-term unemployment to long-term unemployment).[16] 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 sub-groups 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 parameter 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 population weight of all households with children. For the period 2000-2004, this yields a net replacement rate of 0.63 for the short-term unemployed and 0.57 for the long-term unemployed – see figure 2.[17]

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[15]Note that these empirical studies estimate wage effects that already take into account the possibility that unemployment benefit duration affects match quality, an effect emphasized by Acemoglu and Shimer (1999).

[16]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.

[17]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

4.6 Cyclical Variation

We choose the parameters of the stochastic job destruction process to match the the frequency, persistence, and severity of recessions in Germany. More precisely, we choose $\pi(R|R)$ to match the expected duration of a typical recession, $\pi(N|N)$ to match the frequency of recessions, and $\pi_{su|e}(R)$ to match the average increase of the job destruction rate during recessions. We use data from 1980-2012 drawn from two different sources. For the time period 1980-2005, in which there have been in total four recessions (see figure 2), we use the estimates of quarterly job separation rates from Jung and Kuhn (2013). For the period 2005-2012, in which there has been only one recession (the Great Recession 2008/2009), we use data reported in Krebs and Scheffel (2013). We find that the average duration of the five recessios has been XXX quarters, the average increase of the job separation rate has been XXX percent, and the fraction of time spent in a recession was XXX. This yileds parameter values XXXXX.

We do not target the cyclical properties of the job finding rate, but find that the model is roughly in line wit the data. Specifcally, in the model the job finding rate declines during recessions by XXX percent due to the increase in the unemployment rate leading to a congestion effect. In comparison, in the data the job finding rate declines by XXX percent. This suggests that our model captures the main mechanism behind the cyclical variation in job finding probabilities in Germany.

In the calibrated model economy, earnings losses associated with job loss increase by XXX percent during recessions – this is a consequence of skill loss during unemployment combined with the fact that unemployment duration increases during recessions. This finding is also in line with the empirical evidence. Specifically, there is substantial evidence for the US economy that earnings losses due to job displacement increase substantially during recessions.

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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.

See, for example, Jacobson, Sullivan, and (1993) and most recently Davis and Wachter (2011). For Germany, Burda and Mertens (2001) also find that earnings losses associated with job displacement are cyclical, but the estimates are less precise than estimates for the US economy.

5. Quantitative Results

In this section we present the quantitative results. Section 5.1 provide a brief discussion of the German labor market reform of 2003-2005, the so-called Hartz reforms, and how the two parts of interest, Hartz III and Hartz IV, have changed the model parameters. Section 5.3 analyzes the effects of the two reforms on unemployment and welfare. Section 5.4 provides an analysis of the effects of these two reforms on the welfare cost of recessions. Section 5.5 concludes with a robustness analysis.

5.1 German Labor Market Reform 2003-2005

At the beginning of the 2000s, 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 enacted in 2003-2005 a number of far-reaching labor market reforms, the so-called Hartz reforms. These reforms consisted of four laws that were implemented in three steps in January 2003 (Hartz I+II), January 2004 (Hartz III), and January 2005 (Hartz IV). The main objective of the Hartz reforms was simple yet ambitious: improve the process of moving workers from unemployment to employment.[18] In other words, these reforms mainly aimed at increasing the non-cyclical component of the job finding rate of unemployed workers. To achieve their objective, the reforms used a multi-layered strategy that had three core elements: i) increase the matching efficiency by improving job placement services, ii) increase labor supply by activating the

[18]The core elements of the reform were based on recommendations made by an expert commission that was headed by Peter Hartz, the Chief Human Resources Officer of Volkswagen at that time. In the preamble of the commission's report (Hartz et al 2002) this objective in combination with the idea of "challenge and promote" ("Fordern und Foerdern") are singled out as the most important principles guiding any reform effort.

unemployed, and iii) increase labor demand by deregulating the market for temporary work and providing employment subsidies. At the risk of over-simplification, we can say that Hartz III was mainly about the first point, Hartz IV was concerned with the second point, and Hartz I and II were mainly dealing with the last point. In this paper, we confine attention to Hartz III and Hartz IV, to which we turn next.[19]

5.1.1 Effect of Hartz III (Improvement in Job Search Assistance)

January 1, 2004, Hartz III was enacted with the goal to improve the efficiency of the job placement services for the unemployed. To this end, the Public Employment Agency was restructured and transformed from a strongly centralized and bureaucratic institution with little quality control into a decentralized, customer-oriented organization with a high degree of responsibility and accountability of local employment offices (called job centers after the reform). Further, in the wake of the reform many services were streamlined and heavy emphasis was placed on job search assistance to improve the process of matching unemployed workers with vacant jobs. In addition, the reform broke the de facto monopoly of the Public Employment Agency, which introduced competition in the market for job placement services. In particular, a voucher system was introduced providing individual job seekers with the opportunity to choose private placement agencies.[20]

In the Appendix we review the evidence regarding the effect of Hartz III on the efficiency of job search. The available evidence suggests that the restructuring of the Public Employment Agency (Hartz III) increased the quality of job search assistance leading to an increase in the efficiency parameter of the aggregate matching function by at least 5 percent and perhaps up to 10 percent. The evidence also suggests that the introduction of vouchers for placement

[19]Jacobi and Kluve (2007) provide a detailed account of the Hartz reforms and Wunsch (2005) provides a comprehensive survey of German labor market policy before the reform. See also Krebs and Scheffel (2013).

[20]The voucher system was already introduced in 2002 as part of the Job-AQTIV amendment, but Hartz III and Hartz IV subsequently allowed for a more wide-spread application of vouchers. The Job-AQTIV amendment in 2002 and Hartz I in 2003 also introduced the possibility that the Public Employment Agency outsources placement services to private providers (temporary work agencies).

services improved the job finding rate of affected workers by about $10 - 30$ percent. On average, 20 percent of unemployed workers receive a voucher (Pfeiffer and Winterhager, 2006), which translates into an increase in the unconditional job finding rate by $2 - 6$ percent for all unemployed workers. Thus, the available evidence suggests that Hartz III in conjunction with the introduction of the voucher system improved the quality of job search assistance substantially and led to an increase in search efficiency by at least $7 - 16$ percent.

Based on the available evidence, we assume that the Hartz III reform increased job search efficiency by 7 percent, that is, in our quantitative analysis we simulate the effect of the Hartz III reform as an increase in the efficiency parameters x_{su} and x_{lu} by 7 percent. Clearly, this choice lies at the lower end of the empirical estimates and is therefore a conservative choice. The evidence also shows that this increase in job search efficiency did not increase the resource costs of providing job search assistance. Thus, we assume that in our analysis below that the Hartz III reform increases x_{su} and x_{lu} by 7 without a change in $\phi_s(x_s)$ in the government budget constraint.

5.1.2 Effect of Hartz IV (Reduction in Unemployment Benefits)

The Hartz IV legislation was enacted in January 1, 2005, and constituted a radical overhaul of the German unemployment insurance system.The main objective of Hartz IV was to activate unemployed job seekers. Before the reform, the unemployment system was characterized by a very long period of Unemployment Benefit entitlement followed by a relatively generous and essentially unlimited, means-tested Social Welfare Program (consisting of a combination of Unemployment Assistance and/or Social Assistance). The Hartz IV reform resulted in a simple two-tier unemployment insurance system in which most unemployed workers with unemployment spells less than one year (short-term unemployed) receive unemployment benefits that are proportional to earnings at the last job (called Unemployment Benefit I) and most unemployed workers with an unemployment spell of more than one year (long-term unemployed) receive means-tested payments that heavily depend on household composition

(called Unemployment Benefit II).[21]

The Hartz IV reform reduced unemployment payments for many households, but the extent of the reduction varies substantially across household groups and length of unemployment spell. One way to aggregate this heterogeneity is to use the OECD data on net replacement rates for different household groups and to compute an average net replacement rate as described in section XXX. In figure XXXX we plot the resulting net replacement rate over the period XXXX-YYYY. 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. Specifically, Hartz IV reduced the net replacement rate from 0.57 in the period 2000-2004 to 0.46 after the reform in 2005. Based on this evidence, we follow Krebs and Scheffel (2013) and 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.[22]

FIGURE 2 HERE

5.1.3 Job-Finding Rates Before and After the Reform

According to our model, both the improvement in job search assistance (Hartz III) and the reduction in unemployment benefits (Hartz IV) are expected to increase the non-cyclical component of the job finding rate. Aggregate time series data provide strong support for this

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

[22]We note that a net replacement rate of 57 percent, the value for the long-term unemployed in Germany before the reform, is exceptionally high. In comparison, using the same methodology, we find a value of 27 percent in Spain and 38 percent in France for the long-term unemployed. Indeed, even after the reform, the net replacement rate for the long-term unemployed in Germany (46 percent) is still higher than in Spain (27 percent) and France (38 percent). In contrast, net replacement rates for short-term unemployed a very similar for all three countries: 68 percent for France, 66 percent for Spain, and 63 percent for Germany.

basic implication of the theory. Specifcally, in the data the job finding rates for both groups have been relatively stable before implementation of these two reform packages and then began to rise steadily until the years 2007, at which stage they remained relatively stable at a significantly higher level – see figure XXX.[23] For the long-term unemployed the average job finding rate in the period 2000-2003 is 6.3 percent and the average job finding rate in the period 2007-2012 is 9.3 percent. For the short-term unemployed the corresponding numbers are 24 and 37 percent, respectively.

The model prediction with regard to job finding rates is not only qualitatively in accordance with the data, but also the quantittaive implication of teh calibrated model economy lines up well with the data. Specifically, according to our baseline calibration, Hartz III and Hartz IV taken together lead to an increase in the job finding rate of the short-term unemployed from 24 percent to 31.0 percent and of the long-term unemployed from 6 percent to 8.6 percent, which is very close to what we observe in the data.

5.2 Welfare Cost of Recessions

In the previous section we discussed how the German labor market reforms reduced unemployment benefits of the long-term unemployed, b_{lu}, and the quality of job search assistance, x. We now turn to an analysis of this change in labor market institutions on the welfare costs of recessions, where we compute the welfare costs of recessions according to ( ). We continue to assume that the labor income tax, τ, adjusts to ensure that the government budget constraint ( ) is satisfied.[24]

The first column in table 1 shows the welfare costs of recessions in partial equilibrium before the Hartz reforms, after the Hartz III reform, after the Hartz IV reform, and after

[23]The analysis of Jung and Kuhn (2013) confirms that the German job finding rate is relatively stable over the business cycle, in contrast to the findings for the US economy (Shimer, 2005).

[24]For the case of the German labor market reform of 2003-2005 this is a realistic assumption given that before the reform the unemployment insurance system had big financing issues and after the reform the unemployment insurance tax was indeed reduced.

the Hartz III and Hartz IV reforms combined.

The second column in table 1 shows the welfare costs of recessions in general equilibrium before the Hartz reforms, after the Hartz III reform, after the Hartz IV reform, and after the Hartz III and Hartz IV reforms combined.

The third and fourth columns in table show the welfare cost of business cycles in partial equilibrium and in general equilibrium before the Hartz reforms, after the Hartz III reform, after the Hartz IV reform, and after the Hartz III and Hartz IV reforms combined.

Welfare cost of recessions for unemployed and welfare cost of recessions for employed ...

Welfare cost of recessions when we average over initial states ...

5.3 Unemployment and Output Dynamics

The Hartz III and Hartz IV reforms increased job finding rates and therefore made the German labor market more resilient to adverse macroeconomic shocks. To see this effect more clearly, in figure XXXX we plot the response of the unemployment rate to an adverse macroeconomic shock before and after the reform, where the adverse macroeconomic shock is a temporary increase in the job destruction rate. We choose the size and persistence of the increase in the job destruction rate equal to the values that characterize the German labor market during the Great Recession. As shown in Krebs and Scheffel (2013), during the Great Recession the job destruction rate in Germany increased for 8 Quarters by an average of 34 percent relative to trend. Figure 6 shows that in both cases, before and after the reform, 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 2.3 percentage points, whereas for the reformed economy the maximum increase is 1.8 percentage points.[25] Further, in the reformed economy the

[25]Our analysis suggest that the German unemployment rate should have increased by 1.6 percentage points during the Great Recession, but the actual increase was only 0.8 percentage points. Krebs and Scheffel (2013) show how this discrepancy can be explained through transitional dynamics after the implementation of the

convergence to the steady state is much faster than in the unreformed economy so that the above-trend increase in the unemployment rate during the Great Recession is on average 30 percent smaller in the reformed economy than in the unreformed economy. Thus, we conclude that the Hartz reforms, by increasing labor market flexibility along the job finding margin, have improved the cyclical performance of the German labor market significantly.

We also plot the output response to the adverse macro shock. Here we need to emphasize the effect on potential output.

5.4 Steady State Effects of Hartz Reforms

In this section we discuss the steady-state effects of the Hartz III and Hartz IV reforms. To this end, we consider the steady state version of the model and compute the unemployment and welfare effects of an increase in matching efficiency (Hartz III) and a reduction of unemployment benefits for the long-term unemployed (Hartz IV).

5.4.1 Unemployment

Table 1 shows the steady-state unemployment effects of Hartz III and Hartz IV. Starting from the initial steady state unemployment rate of 10 percent, Hartz III reduces the steady state unemployment rate by 1.51 percentage points and Hartz IV reduces the steady state unemployment rate by 1.15 percentage points. Taken together, the two reforms (Hartz III plus Hartz IV) reduce the steady state unemployment rate by 2.42 percentage points from 10 percent to 7.58 percent.[26] Thus, our analysis suggests that a significant part of the decrease in the unemployment rate observed in the period 2005-2008 (see figure 1) can be attributed to the Hartz III and Hartz IV reforms and amounts to a reduction in the non-cyclical component of the unemployment rate.

FIGURE XXXX HERE

Hartz reforms.

[26]Note that the total effect of Hartz III and Hartz IV on the unemployment rate is not the sum of the two individual effects because of non-linearities.

Our results regarding the steady state unemployment effects of Hartz IV are in line with the results reported in Krebs and Scheffel (2013), who find that Hartz IV reduced the steady state unemployment rate by 1.4 percentage points. In contrast, Launov and Waelde (2013) report significantly smaller effects, whereas Krause and Uhlig (2012) find that Hartz IV reduced the steady state unemployment rate by 2.8 percentage points. All three studies are based on different models, but Launov and Waelde (2013) provide a detailed analysis of this issue and show that the difference in results is mainly driven by different assumptions about the degree to which Hartz IV affected net replacement rates. Specifically, Launov and Waelde (2013) assume that Hartz IV had on average almost no effect on net replacement rates, Krause and Uhlig (2012) simulate the Hartz IV reform assuming that all low skill workers lost dramatically, and we base our simulation on the average net replacement rate as shown in figure 2.

5.4.2 Welfare (SHOULD PROBABLY BE DROPPED)

Finally, we turn to a welfare comparison. Clearly, an improvement in matching efficiency (Hartz III) increases welfare of all workers regardless of type and also increases social welfare. In contrast, a reduction in unemployment benefits (Hartz IV) has two opposing effects on 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 loss of insurance, but also the short-term unemployed and even the employed take into account that there is a chance that they might become long-term unemployed in the future. On the other hand, the reduction in unemployment benefits increases employment and therefore output. In our baseline model, employed workers gain most directly from the output expansion through the reduction in the social security tax.

Table 1 shows the welfare effects of German labor market reform. For our welfare analysis, we assume that short-term unemployed and long-term unemployed are assigned the same weights $\mu(su) = \mu(lu) = \mu$. Given that we impose the normalization $U\mu + (1-U)\mu(e) = 1$ it follows that employed workers have the weight $\mu(e) = \frac{1-U\mu}{1-U}$. Further, the requirement that

social welfare weights are non-negative in conjunction with a steady state unemployment rate of 10 percent before the reform imply that μ varies between 0 (no weight on the unemployed) and 10 (all weight assigned to the unemployed). For simplicity, table 1 show the welfare results for three values of the welfare weights: $\mu = 0, 1, 10$.

As expected, Hartz III increases welfare of all workers and therefore increases social welfare. Further, the increase in social welfare is substantial for all types of social welfare weights (all values of μ). Specifically, Hartz III increases social welfare by 2.93 percent of lifetime consumption if the social planner puts zero weight on the unemployed ($\mu = 0$), it increases social welfare by 3.38 percent of lifetime consumption if equal social welfare weights are used ($\mu = 1$), and it increases social welfare by 7.21 percent of lifetime consumption if the social planner only cares about the unemployed ($\mu = 10$). Hartz IV also increases social welfare substantially independently of the welfare weights, but the welfare gain is only about half of the welfare gain of Hartz III. Overall, Hartz III and IV taken together lead to large increases in social welfare varying between 4.10 percent and 9.56 percent of lifetime consumption depending on the welfare weights used. Note that in all cases the welfare gains is increasing in μ – the more weight the social planner puts on the unemployed the larger the welfare gain of labor market reform.

6. Robustness Analysis

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Appendix

Appendix A: Proof of Proposition 1

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

$$1 + r_f(Z) = \frac{1}{\beta} \left(\sum_{s',Z'} \frac{\phi_e}{\phi_{s'}(1+\epsilon_{s'})} \pi_{s'|e}(Z')\pi(Z'|Z) \right)^{-1} \qquad (A1)$$

and the miniumum transaction cost

$$\begin{aligned} \alpha_{min} &= \max_{Z,U} \left\{ \frac{1}{\beta} \left(\sum_{s'} \frac{\phi_{su}}{\phi_{s'}(1+\epsilon_{s'})} \pi_{s'|su}(l_{su}(Z,U),U) \right)^{-1} \right. \qquad (A2) \\ &- \left. \frac{1}{\beta} \left(\sum_{s',Z'} \frac{\phi_e}{\phi_{s'}(1+\epsilon_{s'})} \pi_{s'|e}(Z')\pi(Z'|Z) \right)^{-1} \right\} \end{aligned}$$

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

To ease the notation, we confine attention to the case of a constant interest rate $r_t = r$ and job finding rates that are independent of the aggregate state (U, Z). Consider an extended household maximization problem with endogenous choice of human capital. Specifically, suppose that the household can transform one unit of the good into $\nu(s)$ units of human

capital and denote the (resource) cost of human capital investment by i. Thus, the extended household maximization problem is the problem of choosing $\{c_t, a_t, h_t, i_t, l_t\}$ so as to maximize (2) subject to the sequential budget constraint

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

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

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

Define the following new variables:

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

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

budget constraint (A1) can be written as

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

The extended household maximization problem is to choose a plan $\{c_t, w_t, \theta_{at}, \theta_{ht}, l_t\}$ that maximizes (1) subject to (A4).

The Bellman equation associated with the extended household maximization problem reads

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

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

There is a technical issue regarding the construction of the appropriate function space since 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 $||V|| \doteq sup_x |V(x)|/W(x)$, where $x = (w, \theta, s)$ and the weighting function W is given by $W(x) = |L(x)| + |U(x)|$ with U an upper bound and L a lower bound, and endow this function space with the corresponding metric. Thus, B_W is the set of all functions, V, with $L(x) \leq V(x) \leq U(x)$ for all $x \in \mathbf{X}$. A straightforward but tedious argument shows that confining attention to this function space is without loss of generality. More precisely, one can show that there exist functions L and H so that for all candidate solutions, V, we have $L(x) \leq V(x) \leq H(x)$ for all $x \in \mathbf{X}$.[27]

[27] Alvarez and Stokey (1998) provide a different, but related argument to prove the existence and uniqueness

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

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

Moreover, the value function has the functional form

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

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

$$\tilde{V}(s) \ = \ \max_{\theta'_a, \theta'_h, l} \left\{ B - \nu(s) - d(l,s) + \frac{\beta}{1-\beta} \sum_{s'} ln\,(1 + r(\theta'_a, \theta'_h, s, s'))\pi(s'|s,l) \ + \ \beta \sum_{s'} \tilde{V}(s')\pi(s'|s,l) \right\} \ ,$$

$$\theta'_a + \theta'_h \ = \ 1 \ , \ \ \theta'_h \ \geq \ 0 \qquad (A8)$$

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

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

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

where the first inequality has to hold with equality if $\theta'_a > 0$ and the second inequality has to hold with equality if $\theta'_a < 0$. Note that the numerator is the excess return of human capital investment over the return to financial investment and that $(1+r)^{-1}$ is the marginal utility

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of a Bellman equation for a class of unbounded problems similar to the one considered here (without moral hazard).

of consumption. Thus, equation (A9) says that expected marginal utility weighted returns are equalized across assets, a well-known optimality condition in portfolio choice theory.

Suppose the human capital productivity parameter ν is chosen as

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

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

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

Clearly, if the interest rate, r_f, is set according to (A1) and the financial intermediation cost is at least as large as α_{min} given in (A2), then (A11) is satisfied (and holds with equality if the cost is equal to φ_{min}). Straightforward algebra shows that in this case the value function (A7) reduces to (12) and equation (A8) becomes (13). Further, in this case the optimal plan given by (A6) is simply $c_t = \phi(s_t)h_t$ and $h_{t+1} = (1+\epsilon(s_{t+1}))h_t$. This completes the proof of the first part of proposition 1.

It remains to be shown that (15) is the equilibrium law of motion for the state Ω. To see this, note that

$$\begin{aligned} \Omega_{t+1}(s_{t+1}) &= \frac{E[h_{t+1}|s_{t+1}, Z^{t+1}]\pi(s_{t+1}|Z^{t+1})}{E[h_{t+1}|Z^{t+1}]} \qquad (A12) \\ &= \frac{E[(1+\epsilon(s_{t+1}))h_t|s_{t+1}, Z^{t+1}]\pi(s_{t+1}|Z^{t+1})}{E[(1+\epsilon(s_{t+1}))h_t|Z^{t+1}]} \\ &= \frac{\sum_{s_t} E[(1+\epsilon(s_{t+1}))h_t|s_t, s_{t+1}, Z^{t+1}]\pi(s_t|s_{t+1}, Z^{t+1})\pi(s_{t+1}|Z^{t+1})}{\sum_{s_t, Z_t, s_{t+1}} E[(1+\epsilon(s_{t+1}))h_t|s_t, s_{t+1}, Z^{t+1}]\pi(s_t|s_{t+1}, Z^{t+1})\pi(s_{t+1}|Z_{t+1})} \\ &= \frac{\sum_{s_t}(1+\epsilon(s_{t+1}))\pi(s_{t+1}|s_t, Z^{t+1})E[h_t|s_t, Z^t]\pi(s_t|Z^t)}{\sum_{s_t, s_{t+1}}(1+\epsilon(s_{t+1}))\pi(s_{t+1}|s_t, Z^{t+1})E[h_t|s_t, Z^t]\pi(s_t|Z^t)} \\ &= \frac{\sum_{s_t}(1+\epsilon(s_{t+1}))\pi(s_{t+1}, Z_{t+1}|s_t)\Omega_t(s_t)}{\sum_{s_t, s_{t+1}}(1+\epsilon(s_{t+1}))\pi(s_{t+1}, Z_{t+1}|s_t)\Omega_t(s_t)} \end{aligned}$$

This completes the proof of proposition 1.

Proof of Propsition 2

Clearly, the equilibrium conditions (16) - (18) are the equilibrium conditions of an economy without aggregate shocks S' and with job destruction rate $q = \sum_{S'} \pi_{u|e}(S')\pi(S')$. Thus, we can write equilibrium social welfare as a function of labor market institutions, (b, x), and average job destruction rate: $W = W(b, x, q) = v_u(b, x, q)U + v_e(b, x, q)(1 - U)$. Further, we have

$$\frac{\partial \Delta}{\partial b} > 0 \quad if \quad \frac{\partial^2 W}{\partial b \partial q} < 0$$
$$\frac{\partial \Delta}{\partial x} < 0 \quad if \quad \frac{\partial^2 W}{\partial x \partial q} > 0$$

We prove proposition 2 by proving the properties of the second-order derivatives of W. Let $\tilde{W} = \tilde{W}(b, x, \tau) = \tilde{v}_u(b, x, \tau)U + \tilde{v}_e(b, x, \tau)(1 - U)$ be the social welfare function defined by the solution to the worker problem (16). This function captures the partial-equilibrium effect of changes in (b, x, q) on social welfare. Define the function $\tilde{\Delta} = \tilde{\Delta}(x, b)$ accordingly. We have

$$\frac{\partial \tilde{\Delta}}{\partial b} > 0 \quad if \quad \frac{\partial^2 \tilde{W}}{\partial b \partial q} < 0$$
$$\frac{\partial \tilde{\Delta}}{\partial x} < 0 \quad if \quad \frac{\partial^2 \tilde{W}}{\partial x \partial q} > 0$$

We begin with the proof that $\frac{\partial^2 \tilde{W}}{\partial b \partial q} < 0$. This proof here ...

We next turn to the proof that $\frac{\partial^2 \tilde{W}}{\partial x \partial q} > 0$. Using the envelope theorem, it suffices to consider the function $\tilde{W}$ defined by the equation (16) for fixed effort choice (without the max operator). Implicit differentiation of (16) shows that $\frac{\partial \hat{v}_u}{\partial x \partial q} < 0$ if $\frac{2\beta p}{1-\beta+\beta(p+q)} > 1$, where $p = \pi_{e|u}(l, x)$. Implicit differentiation of (16) also shows that $\frac{\partial^2 \Delta \hat{v}}{\partial p \partial q} < 0$, where $\Delta \hat{v} = \hat{v}_e - \hat{v}_u$ is the value function difference. Thus, we also have $\frac{\partial \hat{v}_e}{\partial p \partial q} < 0$, which then implies $\frac{\partial^2 \hat{W}}{\partial p \partial q} < 0$. We also have $\frac{\partial p}{\partial x} > 0$ by assumption. This proves $\frac{\partial^2 \tilde{W}}{\partial x \partial q} > 0$.

Appendix C: Empirical Evidence on Hartz III and Hartz IV

In 2003-2005, the German government enacted a number of far-reaching labor market reforms, the so-called Hartz reforms. [28] These reforms consisted of four laws that were implemented in three steps in January 2003 (Hartz I+II), January 2004 (Hartz III), and January

[28] Note that until 1997 the legal basis of German labour market policy was the Employment Promotion Act

2005 (Hartz IV). In this section, we review the empirical studies analyzing the effect of Hartz III and Hartz IV on job finding rates.

January 1, 2004, Hartz III was enacted. This reform restructured the Public Employment Agency with the goal to improve the efficiency of the job placement services for the unemployed. The best known empirical studies about the effects of Hartz III on matching efficiency are Fahr and Sunde (2009) and Klinger and Rothe (2012), who use labor market flow data to estimate matching functions for the German labor market before and after the Hartz III reform. Fahr and Sunde (2009) find that Hartz III increased the efficiency parameter of the estimated matching function by 11.6 percent for manufacturing occupations and around 5 percent for non-manufacturing occupations according to their most preferred specification (column 4 of table 5). Klinger and Rothe (2012), who do not distinguish between manufacturing and non-manufacturing, find an increase in matching efficiency around 5 percent (see their table 2). These numbers are likely to under-state the true effect on matching efficiency for two reasons. First, Fahr and Sunde (2009) and Klinger and Rothe (2012) are likely to under-estimate the true effect of Hartz III on matching efficiency since they only consider data until January 2006, and any effect of the Hartz reforms that materialized after this date is not captured by their estimation. Second, the introduction of vouchers in (2002) injected an element of competition in the market for placement services thereby improving the efficiency of the Public Employment Agency, an effect that is not captured by the empirical work on vouchers or the empirical work on Hartz III.

Empirical work using micro data support the view that the introduction of vouchers for job placement services had positive effects on matching efficiency. Winterhager, Heinze, and Spermann (2006) use a very rich administrative data set provided by the Federal Employment Agency to analyze the efficiency improvements generated by the market-based approach to job placement introduced with the Hartz reforms. Specifically, they apply propensity score

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

matching to estimate the effect of the job placement voucher scheme comparing voucher recipients to a matched control group of non-recipients. They define treatment in the evaluation design as receipt of a first voucher during the unemployment spell in May and June 2003, and outcome as employment within 12 months after voucher issue. The main finding of Winterhager, Heinze, and Spermann (2006) is that 12 months after the receipt of a voucher, 27.09 percent of the recipients are in regular employment, whereas only 20.60 percent of the matched control group are employed. Thus, the average treatment effect on the treated amounts to an increase in the job finding rate by around 30 percent - a very large effect indeed. Their results are in line with the finding of Pfeiffer and Winterhager (2006), who find strong evidence for positive effects of vouchers for job placement services on re-employment probabilities.

There is additional evidence suggesting that matching efficiency in Germany has been low before the reform and that the potential for substantial efficiency gains was large. First, Kuhn and Jung (2013) find that the cyclical properties of the German job separation and job finding rates can only be explained by the standard matching function approach if matching efficiency in the German labor market is much lower than in the US. Second, substantial gains in matching efficiency are plausible given that in Germany i) job search assistance before the reform was basically non-existent (private providers could not compete because of heavy regulation and the public provider had no incentive to provide good services) and ii) well-executed job search assistance has been shown to have substantial effects on re-employment rates of unemployed job seekers (see Card, Kluve, and Weber, 2010, for a survey).[29] In addition, Hertwick and Sigrist (2012) provide evidence that the German Beverage curve shifted inwards around the mid 2000s and estimate that the Hartz reforms taken together (Hartz I-IV) increased matching efficiency by 20 percent. Finally, Launov and Wealde (2013) use a calibrated search and matching model of the German labor market to argue that the

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

estimated efficiency gains due to Hartz III have reduced steady state unemployment by almost 2 percentage points.

There is no micro-econometric work evaluating the effect of the benefit reductions associated with Hartz IV on job-finding rates of the unemployed, mainly because the Hartz IV reform entailed a significant change in the official measurement of unemployment.[30] However, the available evidence based on structural models of the German labor market (Krause and Uhlig, 2012, Krebs and Scheffel, 2013) suggests substantial effects of Hartz IV on job finding rates and equilibrium unemployment. Further, empirical work estimating the effect of changes in unemployment generosity on re-employment probabilities for Germany using data before the Hartz IV reform suggests substantial effects (Hunt, 1995), in line with the findings for the US (Krueger and Meyer, 2002). This literature is reviewed in more detail Section 4 on calibration.

[30]This added more than half a million workers to the pool of unemployed between January 2005 and March 2005 (see Bundesagentur fuer Arbeit, 2005) and explains the spike in the unemployment rate in 2005. more than 80 percent of these added unemployed workers lacked the equivalent of a high school degree.