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# Macroeconomic Evaluation of Labor Market Reform in Germany*


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## Abstract

In 2005 the German government implemented the so-called Hartz IV reform, which amounted to a complete overhaul of the German unemployment insurance system and resulted in a significant reduction in unemployment benefits for the long-term unemployed. In this paper, we use an incomplete-market model with search unemployment to evaluate the macro-economic and welfare effects of the Hartz IV reform. We calibrate the model economy to German data before the reform and then use the calibrated model economy to simulate the effects of Hartz IV. In our baseline calibration, we find that the reform has reduced the German long-run unemployment rate by 1.2 percentage points. We also find that the welfare of employed households increases, but the welfare of unemployed households decreases even with moderate degree of risk aversion.



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# 1. Introduction

Over the period 1970-2005, unemployment rates in Germany had been steadily rising making the country a leading example of Eurosclerosis (see figure 1). In response to the dismal labor market performance, in 2003-2005 the German government implemented a number of wide-ranging labor market reforms, the so-called Hartz reforms. At the heart of the reform package was the Hartz IV reform implemented in January 2005, which amounted to a complete overhaul of the German unemployment benefit system and resulted in a significant reduction in the level of unemployment benefits for the long-term unemployed (see figure 2). After a short spike mainly due to a change in measurement procedure,[1] Germany's unemployment rate decreased from about 11 percent in 2005 to 7.5 percent in 2008 and barely moved during the Great Recession. The story about the "sick man of Europe" had turned into a story about the "German labor market miracle".

In this paper, we ask how much of the observed reduction in the unemployment rate in the period 2005-2008 can be attributed to the Hartz IV reform, and therefore reflects a reduction in long-run unemployment. Moreover, we analyze the consequences for economic growth taking into account the adjustment of physical capital and human capital. Finally, we investigate the welfare effects of Hartz IV. In particular, we ask how the expected life-time utility of different groups (employed, short-term unemployed, long-term unemployed) has been affected by the reform. To address these questions, we develop a macroeconomic model with heterogeneous households that emphasizes the trade-off between insurance and incentive, and use a calibrated version of the model economy to simulate the effects of the Hartz IV reform.

[1] The Hartz IV reform entailed a significant change in the official measurement of unemployment, which added more than half a million workers to the pool of unemployed between January 2005 and March 2005 (see Bundesagentur fuer Arbeit, 2005) and resulted in a spike in the unemployment rate in 2005. More than 80 percent of these added unemployed workers lacked the equivalent of a high school degree.

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

Our quantitative analysis shows that the Hartz IV reform has resulted in a substantial reduction in long-run unemployment. In our baseline calibration, the reform reduces the unemployment rate by 1.2 percentage points from a long-run value of 9 (the average for the period 2000-2004) to a new long-run value of 7.8 percent. As expected, the main force driving the reduction in unemployment is an increase in search effort that leads to higher job finding rates for both short-term and long-term unemployed, where the effect for the long-term unemployed is more pronounced.[3] In short, the Hartz IV reform achieved its main goal, namely to reduce the long-run unemployment rate by increasing the incentive to search for new jobs.

We also find that the reform leads to an expansion in output and a decline in real wages.[4]

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

[3]Data on the job finding rates for short-term and long-term unemployed before and after the reform support this prediction of the theory. See section 4.2.1 for more details.

[4]We assume that the labor market is competitive so that the wage (per unit of human capital) is equal

There are two opposing forces that affect output. On the one hand, there is an output expansion driven by the increase in employment. On the other hand, the decline in real wages induces households to invest less in human capital, which is harmful for economic growth. In our baseline calibration, the net effect on output is positive and equal to a permanent increase of somewhat less than one percent.

Our quantitative welfare analysis shows that the Hartz IV reform creates winners and losers, which explains why the reform has encountered so much resistance in large parts of the German population. Assuming that the output gains of the reform are uniformly distributed among all households,[5] we find that employed households win because for them the output gains outweigh the welfare loss due to the reduction in unemployment insurance. The resulting welfare gain for employed households is equivalent to an increase of around 0.3 percent of lifetime consumption. In contrast, the situation is reversed for the long-term unemployed, who experience a cut in their unemployment benefits that is much larger than what they receive due to the output gain. In our baseline calibration, the welfare loss of the long-term unemployed is around one percent of lifetime consumption. Finally, the short-term unemployed also lose, but their welfare loss is significantly smaller than the welfare loss of the long-term unemployed.

Our paper is most closely related to the large macro literature on jobs search and unemployment insurance, where the common theme is the trade-off between insurance and incentive (Hansen and Imrohoroglu, 1992, and Ljungqvist and Sargent, 1998). We contribute to this literature in two ways. First, we introduce a human capital channel and emphasize the

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to its marginal product. In our baseline calibration, the real wage decreases permanently by somewhat less than one percent.

[5]In our analysis we use a consumption tax to finance the unemployment benefit payments, and the reform leads to a reduction of this tax. In our model, the saving rate is the same for all households, and in this sense re-distribution of the output gain is uniform.

important distinction between short-term and long-term unemployed workers. Second, we develop a tractable framework with risk-averse households who make a search and a saving decision, and apply the framework to one of the most significant reforms of the unemployment insurance system in recent history, the Hartz IV reform. We are aware of only two macro studies analyzing this reform using a structural approach. Krause and Uhlig (2011) find unemployment effects of Hartz IV that are larger than the ones reported here, whereas Launov and Waelde (2012) suggest that Hart IV had relatively small unemployment effects.[6]

Our results are in line with the large body of work empirical work on labor market institutions/policy and labor market outcome using cross country data, which usually find a significant and large effect of unemployment benefits on unemployment (Layard, Nickell, and Jackson, 2005).[7] In a similar vein, empirical work that analyzes the interaction between labor market policies/institutions and macro-economic shocks finds that the unemployment benefit system plays an important role in shaping labor market outcomes (Blanchard and Wolfers, 2000). Of course, the current paper abstracts from macroeconomics shocks and can therefore not speak to this interaction. Extending the current analysis to incorporate macro-economic shocks is an important topic for future research.

# 2. Model

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

[6]Neither study reports the implied search elasticity of unemployed workers, which plays a key role in our calibration strategy. Launov and Waelde (2012) argue that Hartz IV had only small effects on net replacement rates for most unemployed workers, a statement that is at odds with most studies of the reform and the OECD data used in this paper.

[7]More recent work that uses country panel data (Bouis, Causa, Dennou, Duval, Zdziemicka, 2012) also finds large and significant effects of unemployment benefits.

### 2.1. Households

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

Households are risk-averse and have identical preferences that allow for a time-additive expected utility representation. We also assume that utility is separable in consumption and search effort, and that the current utility is given by $u(c_t, l_t, s_t) = ln\, c_t - v(l_t) + d(s_{1t})$, where $v$ is the dis-utility from search, a strictly increasing and strictly convex function, and $d$ is a function that describes constant utility difference between the three states employment, short-term unemployment, and long-term unemployment. Expected life-time utility associated with a consumption-effort plan, $\{c_t, l_t | s_0\}$, for a household with initial shock $s_0$ is given by

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

where $\beta$ is the pure discount factor. Note that the expectations in (1) is taken with respect to joint distribution that depends through the transition probabilities $p_{ue}(s_2, l)$ on the effort choice $\{l_t\}$. Thus, we should write $E_{\{l_t\}}[.]$, but for notational ease we suppress the dependence of expectations on effort choice.

At time $t = 0$, the initial state of an individual household is, $(k_0, h_0, s_0)$, where $k_0$ denotes the initial stock of physical capital and $h_0$ the initial stock of human capital. Households can invest in physical capital (save) and human capital. Employed households receive capital and labor income, $r_{kt}k_t$ and $r_{ht}h_t$, where $r_{kt}$ and $r_{ht}$ denote the rental rate of physical and human capital, respectively. For an employed household, the risk-free return to physical capital investment is $r_{kt} - \delta_k$ and the risky return to human capital investment is $r_{ht} - \delta_h + \eta(s_{3t})$. Here $\delta_k$ and $\delta_h$ denote the (average) depreciation rate of physical capital and human capital, respectively, and $\eta$ is a shock to individual human capital that represents wage risk. Unemployed households receive unemployment benefits that are proportional to their human capital, $B_t = b(s_{1t})h_t$, an assumption that keeps the model tractable. Note that unemployment benefits, $b$, depend on the type of the unemployed household (good or bad job seeker), but do not depend on unobserved search effort $l_t$. To rule out large portfolio shifts of the unemployed, we further assume that the unemployed earn a return on physical capital investment that equals the return to human capital investment, that is, income of an unemployed household is $b(s_{1t})(k_t + h_t)$.

Households' sequential budget constraint reads

$$(1+\tau_{ct})c_t + k_{t+1} + h_{t+1} \;=\; \begin{cases} (1+r_{kt}-\delta_k)k_t + (1+r_{ht}-\delta_h+\eta(s_{2t}))h_t & if\ s_{1t}=e \\ (1+b(s_{1t}))(k_t+h_t) & if\ s_{1t}=ug\,,\ ub \end{cases} \tag{2}$$

The consumption tax, $\tau_c$, is used to finance the unemployment benefit system and has no incentive effect in our setting. For given government policy $\{b_t, \tau_{ct}\}$, households choose a plan $\{c_t, l_t, k_t, h_t\}$ that maximizes (1) subject to the constraint (2).

## 2.2. Firms

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

There is a large number of identical firms that have access to the production function (3) and hire physical capital and human capital (labor) in competitive markets at rental rates $r_k$ and $r_h$, respectively. In each period, firms hire physical capital and human capital so as to maximize profit

$$F(K_t, H_t^e) - r_{kt}K_t - r_{ht}H_t^e\ . \tag{3}$$

## 2.3. Government

The government pays out unemployment benefits and collects the consumption tax. We assume that the government runs a balanced budget in every period so that the government budget constraint reads:

$$\tau_{ct}E[c_t] \;=\; E[b(s_{2t})h_t] - E[(r_{kt} - b(s_{2t}))k_t] \tag{4}$$

## 2.4. Equilibrium

Introduce the following new household-level variables:

$$\begin{aligned} w_t &= k_t + h_t \qquad (5) \\ \theta_t &= k_t/w_t \\ r(\theta_t, s_t) &= \begin{cases} \theta_t(1 + r_{kt} - \delta_k) + (1-\theta_t)(1 + r_{ht} - \delta_h + \eta(s_{2t})) & if\ s_{1t} = e \\ b(s_{1t}) & if\ s_{1t} = ug, ub \end{cases} \end{aligned}$$

Here $w$ is the value of total wealth, financial and human, $\theta$ the share of total wealth invested in physical capital, and $r$ is the total return on investment (in human and physical capital). Note that $w_t$ is total wealth before asset have paid off and depreciation has taken place and $(1+r)w$ is total wealth after asset payoff and depreciation has occurred. Note also that the relevant state variable for an individual household now becomes $(\theta_t, w_t, s_t)$.

Using the new definitions, the household budget constraint can be written as

$$w_{t+1} = (1 + r(\theta_t, s_t))\, w_t - (1 + \tau_{ct})c_t \qquad (6)$$

The household problem is now to choose a plan $\{c_t, w_t, \theta_t, l_t\}$ that maximizes (1) subject to (6). The budget constraint (6) in conjunction with the assumption of homothetic preferences (log-utility) is the key to the tractability of the model: individual households solve a Merton-type consumption-saving and portfolio problem, where is our setting there is an added effort choice. The solution to this class of problems is quite simple (see proposition 1).

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

$$\begin{aligned} K_t &= E[\theta_t w_t] \qquad (7) \\ H_t^e &= E[(1-\theta_t)w_t|s_{1t} = e] \end{aligned}$$

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

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

i) for given rental rates $(r_{kt}, r_{ht})$ the production choice $(K_t, H_t^e)$ maximizes profit (3) in each period $t$.

ii) for given sequence of rental rates $\{r_{kt}, r_{ht}\}$ the individual plan $\{c_t, w_t, \theta_t, l_t\}$ maximizes expected lifetime utility (1) subject to the budget constraint (8)

iii) market clearing condition (7) holds in each period $t$

iv) the government budget constraint (4) holds.

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

Note that equilibrium unemployment rates for the short-term and long-term unemployed, which we denote by $U_g$ and $U_b$, are defined through initial values and the transition probabilities in the standard way. The law of motion for the two unemployment rates is given by (16) below.

Finally, note that the aggregate resource constraint reads

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

A standard argument shows that the government budget constraint (4) in conjunction with the household budget constraint (2) imply the resource constraint (9) under the assumption of competitive rental markets and constant returns to scale in production.

# 3. Equilibrium Characterization

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

## 3.1. Household Problem

The recursive formulation of the household maximization problem reads

$$\begin{aligned} V(w,\theta,s) \quad &= \quad \max_{c,\theta',w',l}\left\{ ln\, c - v(l) + d(s) + \beta \sum_{s'} V(w,\theta',s')\pi(s'|s,l)\right\} \\ s.\,t.\quad w' &= (1+r(\theta,s))w - (1+\tau_c)c \end{aligned} \tag{9}$$

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

$$\begin{aligned} c &= \frac{1-\beta}{1+\tau_c}(1+r(\theta,s))w \\ w' &= \beta(1+r(\theta,s))w \end{aligned} \tag{10}$$

Moreover, the value function has the functional form

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

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

$$\tilde{V}(s) \;=\; \max_{\theta', l} \left\{ B - v(l) + d(s) + \frac{\beta}{1-\beta} \sum_{s'} ln\,(1 + r(\theta', s'))\pi(s'|s, l) \;+\; \beta \sum_{s'} \tilde{V}(s')\pi(s'|s, l) \right\} \tag{12}$$

where the constant $B$ is defined as $B = ln(1-\beta) - ln(1+\tau) + \frac{\beta}{1-\beta} ln\beta$.

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

Proposition 1 is useful for two reasons. First, it reduces the problem of solving the Bellman equation (9) to the much simpler problem of solving the intensive-form Bellman equation (12). Second, it states that consumption is linear in wealth and portfolio choice and effort choice are independent of wealth. This property allows us to solve for the general equilibrium without knowledge of the endogenous wealth distribution (proposition 2).

### 3.2. Equilibrium

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

$$\begin{aligned} r_k &= r_k(\tilde{K}) = f'(\tilde{K}) \\ r_h &= r_h(\tilde{K}) = f(\tilde{K}) - \tilde{K} f'(\tilde{K}) \end{aligned} \tag{13}$$

The solution the intensive-form Bellman equation (12) in conjunction with the pricing conditions (13) define optimal portfolio and effort functions $\theta' = \theta'(s, \tilde{K}')$ and $l = l(s, \tilde{K}')$. In the Appendix we show that the market clearing condition (7) is equivalent to the intensive-form market clearing condition

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

where $\Omega(s)$ is the share of aggregate total wealth held by households of type $s$, $U' = U'_g + U'_b$ is the unemployment rate, and a prime indicates a next-period variable. Further, in the Appendix we also show that the law of motion for $\Omega$ is

$$\Omega'(s') = \frac{\sum_s(1+r(\theta'(s,\tilde{K}'),s',\tilde{K}'))\Omega(s)}{\sum_{s,s'}(1+r(\theta'(s,\tilde{K}'),s',\tilde{K}'))\Omega(s)}\ , \tag{15}$$

Finally, the unemployment rates for the short-term and long-term unemployed, $U_b$ and $U_g$, follow the law of motion

$$\begin{aligned} U'_g &= p_{eu}(1-U_b-U_g) + (1-p_{ug,e}(l(g,\tilde{K}')))qU_g \\ U'_b &= (1-p_{ug,e}(l(g,\tilde{K}')))(1-q)U_g + (1-p_{ub,e}(l(b,\tilde{K}')))U_b \end{aligned} \tag{16}$$

In summary, we have the following result:

**Proposition 2.** Any solution to (12)-(16) with $\Omega' = \Omega$ and $(U'_g, U'_b) = (U_g, U_b)$ is a stationary competitive equilibrium.

# 4. Quantitative Evaluation of Hartz IV Reform

In the period 2003-2006, the German government implemented a number of wide-ranging labor market reforms, the so-called Hartz reforms. The first three reforms, namely Hartz I - III, came into effect in January 2002 (Hartz I and II) and January 2003 (Hartz III) and dealt with improvements in active labor market policy, a re-structuring of the German Employment/Labor Agency, and the design of new employment opportunities with low tax wedges (Mini- and Midi-jobs). The last reform, Hartz IV, was implemented in two steps, January 2005 and January 2006, and consisted of a complete overhaul of the German unemployment benefit system. Its main effect, due to the first part of Hartz IV implemented in January 2005, was to reduce substantially the benefits for a large fraction of the long-term unemployed.[8]

The focus of the current paper is the Hartz IV reform. In this section, we calibrate the model to match a number of facts of the German economy before the reform, and then use the calibrated model economy to simulate the long-run effect of Hartz IV on the main macroeconomic variables. To this end, we discuss in section 4.1 the functional form assumptions and the calibration. Section 4.2 then presents the long-run results and also discusses the transitional dynamics. Section 4.3 considers the robustness of our results by conducting a sensitivity analysis and considering an extension with private information about the search type of workers.

### 4.1 Calibration

The basic model period is one quarter. We calibrate the model economy based on its stationary equilibrium and use German data for the period 2000-2004 (before the Hartz IV reform).

#### 4.1.1 Search

In our model, expected unemployment duration of bad job seekers ($s_{1t} = ub$) is higher than expected unemployment duration of the good job seekers ($s_{1t} = ug$), and we therefore identify bad job seekers with the long-term unemployed. We use the standard convention and define long-term unemployment as any unemployment spell that lasts longer than 12 months. Thus, we choose the probability that a good job seeker become a bad job seeker equals $q = .25$.

[8] See, for example, Jacobi and Kluve (2006) for a detailed discussion of the Hartz reforms.

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

$$\begin{aligned} p_{ug,e}(l) &= 1 - e^{-\lambda_g l} \\ p_{ub,e}(l) &= 1 - e^{-\lambda_b l} \end{aligned} \tag{17}$$

We choose the values of $\lambda_g$ and $\lambda_b$ 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. This yields quarterly values of $p_{ub,e}(g) = .06$ and $p_{ug,e}(b) = .24$ (Bundesagentur fuer Arbeit, 2011).

As in Hopenhayn and Nicolini (1997), Ljungqvist and Sargent (1998), and Shimer and Werning (2008), we assume that dis-utility of search is linear in search effort:

$$v(l) = -\bar{v}\, l \,. \tag{18}$$

It is well-known that with specification (17) and (18), the parameters $\lambda_g$, $\lambda_b$ and $\bar{v}$ are not separately identified. We therefore choose a numerically convenient normalization of $\bar{v} = 25$.

We assume a constant utility difference between employment and unemployment that is the same for short-term and long-term unemployed: $d(e) = 0$ (normalization) and $d(ub) = d(ug) = d$. We choose the preference parameter $d$ to match the elasticity of the job finding rate with respect to benefits payments. For the US, there are a number of empirical micro studies estimating this elasticity. The best known study is Meyer (1990) who estimates an elasticity of -0.9, which is also used by Landais, Michaillat, and Saez (2010) for calibration purpose. Subsequent work using US data has found similar results for some groups of workers and lower values for other group of workers (for example, Meyer and Mok, 2007). There is much less work on this issue for Germany, but Hunt (1995) finds estimates for Germany that are similar to the US results. 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. We are not aware of any study that estimates this elasticity separately for the short-term and long-term unemployed. We choose a value of $d$ to match an average elasticity of $-1$ for the short-term and long-term unemployed.

We choose the job separation rate, $p_{eu}$, so that the implied unemployment rate is equal the average unemployment rate in the period 2000-2004, namely 9 percent. This yields a job separation rate of $p_{eu} = 0.0213$, which is in line with Jung and Kuhn (2011). Finally, to match a given fraction of long-term unemployed in the unemployment pool, we allow for the possibility that long-term unemployed household become short-term unemployed without having been in the employment state, that is, we introduce a transition from $ub$ to $ug$ that occurs with a constant and exogenous probability. We choose this transition probability to match a share of long-term unemployment of 50 percent, the average for the period 2000-2004 according to the OECD statistics.

### 4.1.2 Wage Risk

We assume that human capital shocks, and therefore wage risk, is normally distributed: $\eta \sim N(0, \sigma^2)$. One can show (Krebs 2003) that this assumption in conjunction with the i.i.d assumption implies that the log of labor income of individual households follows approximately a random walk with innovation term $\epsilon \sim N(0, (1-\theta)^2\sigma^2)$. For the US, the random walk component of individual labor income has been estimated by a number of empirical studies using data drawn from the PSID, and estimates of $(1-\theta)\sigma$ for the US are in the range of .15. For Germany, Krebs and Yao (2010) and Krueger and Fuchs-Schuendel (2009) find similar values, and we therefore choose the value of the parameter $\sigma$ to yield $(1-\theta)\sigma = .15$ in equilibrium.

### 4.1.3 Production

We follow Krebs (2003) and use quarterly depreciation rates of $\delta_k = \delta_h = 0.0125$. We assume a Cobb-Douglas production function, $F(K, H^e) = AK^\alpha (H^e)^{1-\alpha}$, and set the capital share of output to $\alpha = 0.36$. We choose the technology parameter $A$ and the discount factor so that the model matches the output growth rate and saving rate in Germany before the reform, namely one percent economic growth and a saving rate of 20 percent.

### 4.1.4 Unemployment Benefits

We choose the unemployment benefit parameters $b_g$ and $b_b$ to match the net replacement rate for the short-term (good job seekers) and long-term (bad job seekers) unemployed before the reform (the period 2000-2004),[9] and use OECD data on net replacements rates. The OECD reports the net replacement rate for short-term and long-term unemployed, where long-term unemployment is defined as unemployment duration longer than one year. The Hartz IV reform clearly had different effects on different 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 who had earnings before the job loss equals average earnings. The OECD reports the net replacement rate for two subgroups of this group of households, namely single households without children and single households with two children. We calibrate the parameters $b_g$ and $b_b$ 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

[9] In the model, the net replacement rate is $b/r$.

unemployed.[10]

The Hartz IV reform had almost no impact on net replacement rate of the short-term unemployed, regardless of household type. It is therefore not surprising that the average net replacement rate we construct is the same before and after the reform. In contrast, the net replacement rate for the long-term unemployed dropped sharply after the reform for all households without children. For our average measure, we find that the Hartz IV reform reduced the net replacement rate from 0.57 in the period 2000-2004 to 0.46 after the reform in 2005. Figure 2 depicts the average net replacement rate for short-term and long-term unemployed before and after the reform.

### 4.2 Effects of Hartz IV Reform

We now analyze the effect of the Hartz IV reform, which we model as a change of the unemployment benefit system that reduces the net replacement rate for the long-term unemployed from 0.57 before the reform to 0.46 after the reform. We first present the results for the main macro-economic variables of interest and then discuss the welfare implications.

#### 4.2.1 Macroeconomic Effects

Table 1 presents the long-run effects of the Hartz IV reform on some of the main macroeconomic variables, where the long-run effects are computed by comparing the values in the stationary equilibrium before the reform (first column) with the values in the stationary equilibrium after the reform (second column). The first row of table 1 shows that the reform leads to a substantial reduction in the unemployment rate – from 9 percent before the

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

reform to 7.78 percent after the reform. 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 IV reform and amounts to a permanent reduction in the unemployment rate.

The second and third rows of table 1 show the long-run equilibrium values of the job finding rate for the short-term and the long-term unemployed before and after the reform. As expected, these job finding rates increase since household exert more search effort in response to the reduction in unemployment benefits. We also note that, in percentage terms, the increase in the job finding for the long-term unemployed exceeds the increase for the short-term unemployed, a result that seems intuitive given that the long-term unemployed are more directly affected by the reform than the short-term unemployed. The increase in the job finding rates for short-term and long-term unemployed is the main force behind the decrease in the unemployment rate reported in the first row of table 1. In short, the Hartz IV reform achieved its main goal, namely to reduce the structural unemployment rate by increasing the incentive of the unemployed to search for new jobs.

Figure 3 shows the transitional dynamics of the unemployment rate after the reform. We see that it takes about 8 quarters for the unemployment rate to get half way to the new stationary equilibrium value. This persistence is mainly generated by the fact that the the unemployment rate and the fraction of long-term unemployed are state variables, and both variables take time to adjust to the new long-run equilibrium. Figure 4 shows the dynamic evolution of the unemployment rates of the short-term unemployed and long-term unemployed separately. This share decreases from a long-run value of 50 percent before the reform to a new long-run value of 47 percent after the reform.

We also find that the reform leads to an expansion in output and a decline in real wages. However, the wage effect is relatively mild since we assume that capital can fully adjust, which implies that the capital-to-labor ratio, and therefore the marginal product of labor, is barely affected by the reform. The output effect is also not very strong since there are two opposing forces at work. On the one hand, there is an output expansion driven by the increase in employment. On the other hand, in our human capital model the decline in real wages induces households to invest less in human capital, which is harmful for economic growth. In our baseline calibration, the net effect on output is positive, but relatively small. Figures 5 and 6 show the dynamic path of output and real wages.

There is direct evidence supporting the main mechanism emphasized in this paper. The job finding rates for both the short-term unemployed and long-term unemployed has been very stable before the Hartz IV reform and then began to increase steadily until the year 2007, at which stage they remained relatively stable at a significantly higher level (see Bundesantalt fuer Arbeit, 2011).[11] For the long-term unemployed, the quarterly job finding rate increased from 6.3 percent at the beginning of 2004 to 9.3 percent at the beginning of 2006, and then stayed at this higher level for the subsequent years.

There is additional evidence in favor of our basic mechanism. The OECD reports the fraction of long-term unemployed (the incidence of long-term unemployment), which for Germany decreased from 56 percent in 2005 to 46 percent in 2009. However, the data on the incidence of long-term unemployed are not well suited to "test" the basic mechanism for two reasons. First, this variable is heavily influenced by movements into and out of the labor force, which can be very different for short-term and long-term unemployed workers. Second, the variable has a strong cyclical component.

#### 4.2.2 Welfare Effects

The Hartz IV reform has two opposing effects on welfare of individual households and social

[11] The fact that the German job finding rate has only a negligible cyclical component has been documented in Jung and Kuhn (2011), a finding that stands in contrast to the findings for the US (Shimer, 2005).

welfare. On the one hand, there is a negative effect since the reform reduces insurance against unemployment risk. The long-term unemployed are most directly affected by this reduction in benefits, but also the short-term unemployed and even the employed take into account that there is a chance that some time in the future they might become long-term unemployed. On the other hand, the reform increases employment and therefore production. In the model, all households benefit from this output effect through the reduction in the consumption tax after the reform.

We conduct the welfare analysis as follows. We compute welfare (expected lifetime utility) for each group of households (employed, short-term unemployed, long-term unemployed) in the stationary equilibrium before the reform. We also compute welfare for each group of households after the reform taking into account the adjustment path of the economy towards the new stationary equilibrium (transitional dynamics). We do the same for social welfare, which we define as the population-weighted average of the welfare of the three groups of households. Finally, we translate the computed welfare changes into equivalent consumption units by computing the corresponding change in certainty consumption that would make households indifferent between no-reform and reform (Lucas, 2003).

Table 2 reports the welfare results. The first row shows that employed households are the winners of the reform: their welfare increases by 0.3 percent of lifetime consumption. For the employed households, the gain from the tax reduction outweighs the welfare loss due to the reduction in unemployment insurance. At the opposite end are the long-term unemployed: their welfare decreases by 1 percent of lifetime consumption. For the long-term unemployed, the direct loss of unemployment benefits is much stronger than the gain from the reduction in consumption taxes. Finally, the short-term unemployed are somewhere in between, but they also lose.

To understand better the two effects on welfare, we also show in table 2 the welfare loss that is due to the insurance loss. More precisely, we compute the change in welfare for each group of households assuming that the consumption tax is not changed and the output gain therefore not received by households. We can see that for all three groups, this welfare loss is substantial.

Table 2 also shows that the reform increased social welfare. Put differently, if we distributed more of the output gains to the long-term unemployed and less to the employed, then the reform would benefit all households. However, in reality the long-term unemployed have probably received the smallest fraction of the output gain compared to all other groups, and by assuming that the gains are re-distributed through a reduction in the consumption tax we have already biased our results towards finding gains for the long-term unemployed.[12]

### 4.3 Robustness

#### 4.3.1 Sensitivity

We conducted an extensive sensitivity analysis by changing a number of calibration targets, always one at a time. We found that our main results are surprisingly robust to moderate changes in all parameter values. However, substantial changes in either the targeted share of long-term unemployed or the job finding elasticity have significant effects on our results. For example, if we decrease the share of long-term unemployed before the reform to 0.3 or reduced the job finding elasticity to -0.5, the unemployment effect of Hartz IV is still substantial, but significantly smaller.

We also considered a version of the model in which, as in Ljungqvist and Sargent (1998), job loss leads to the loss of human capital. This extension had only small effects on our main results.

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

#### 4.3.2 Private Information about Search Type

We also considered a version in which the government cannot observe the search type of unemployed workers. In this case, we did not set up the complete optimal taxation problem (the Mirrlees approach), but simply assumed that the government would reduce unemployment benefits stochastically so that on average unemployed workers would receive the lower benefits of the long-term unemployed after one year. In this extension, the unemployment effects of Hartz IV are somewhat smaller, but still substantial.

## 5. Conclusion

In this paper, we used an incomplete-market model with search unemployment to evaluate the macro-economic and welfare effects of the Hartz IV reform. We calibrated the model economy to German data before the reform and then used the calibrated model economy to simulate the effects of Hartz IV. In our baseline calibration, we found that the reform reduced the German long-run unemployment rate by 1.2 percentage points. We also found that the welfare of employed households increases, but the welfare of both short-term and long-term unemployed households decreases even with moderate risk aversion (log utility).

There are at least two important extensions of the current analysis. First, the tractability of the framework makes it an ideal vehicle for the analysis of the interaction between labor market institutions/policies and macroeconomics shocks. The results of such an analysis could provide a structural interpretation of the findings in Blanchard and Wolfers (2000). Further, it would allow for a formal assessment of the contribution of the Hartz reforms to the good performance of the German labor market during the Great Recession. Second, in this paper we made the ad-hoc assumption that unemployment benefits are proportional to human capital (labor income) and therefore ruled out by assumption the use of more sophisticated (non-linear) policies. There is large literature on optimal unemployment insurance

(Hopenhayn and Nicolini, 1997, and Shimer and Werning, 2008) that allows government policy to be a general function of observable variables. In this line of research, government policy is only constrained by the unobservability of search effort (moral hazard). The application of this approach to the current framework is an important topic for future research.

# Appendix

## A.1 Proof of Proposition 1.

The household maximization problem with moral hazard has probabilities depending on choices, in contrast to the class of problem analyzed in Stokey and Lucas (1989). However, the standard argument for the principle of optimality still applies. Similarly, another standard argument shows that the Bellman equation (9) has a unique solution in an appropriately defined function space (contraction mapping theorem). Guess-and-verify then shows that (11) solves (9) with optimal policy function defined in (10).

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.[13] 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 $x \in \mathbf{X}$. This completes the proof of proposition 1.[14]

## A.2 Proof of Proposition 2

From proposition 1 we know that individual households maximize utility subject to the budget constraint. Thus, it remains to be shown that the intensive-from market clearing

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

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

condition (14) is equivalent to the market clearing conditions (7) and that (15) and (16) are the equilibrium law of motions for $\Omega$ and $U$.

First, note that the solution to the household problem (8) only depends on the first component $s_1$, but not on the i.i.d. component $s_2$. Let $\tilde{w}_t = (1 + r_t)w_t$ be total wealth in period $t$ after production and depreciation has taken place. The aggregate stock of physical capital held by households in period $t + 1$ is

$$\begin{aligned} E[k_t] &= E[\theta_{t+1} w_{t+1}] \qquad\qquad (A1) \\ &= \beta E[\theta_{t+1}(1 + r_t)w_t] \\ &= \beta \sum_{s_{1t}} E[\theta_{t+1}\tilde{w}_t | s_{1t}]\pi(s_{1t}) \\ &= \beta \sum_{s_{1t}} \theta(s_{1t}) E[\tilde{w}_t | s_{1t}]\pi(s_{1t}) \\ &= \beta E[\tilde{w}_t] \sum_{s_{1t}} \theta(s_{1t})\Omega(s_{1t}) \ . \end{aligned}$$

The second line in (A1) uses the equilibrium law of motion for the individual state variable $w$, the third line is simply the law of iterated expectations, the fourth line follows from the fact that the portfolio choices only depend on $s_1$, and the last line is a direct implication of the definition of $\Omega$. A similar expression holds for the aggregate stock of human capital held by all households, $E[h_t] = E[(1 - \theta_t)w_t]$, and the aggregate stock of human capital held by employed households, $E[h_t | s_{1t} = e] = E[(1-\theta_t)w_t | s_{1t} = e]$. Dividing the expression for $E[k_t]$ by the expression for $E[(1 - \theta_t)w_t | s_{1t} = e]$ proves the equivalence between (7) and (14).

Define by $\bar{r}(s_{1t}, s_{1,t+1})$ the expected investment return conditional on $s_1$. The law of motion for $\Omega$ can be found as:

$$\begin{aligned} \Omega_{t+1}(s_{1,t+1}) &= \frac{E[\tilde{w}_{t+1} | s_{1,t+1}]\pi(s_{1,t+1})}{E[\tilde{w}_{t+1}]} \qquad\qquad (A2) \\ &= \frac{E[(1 + r_{t+1})\tilde{w}_t | s_{1,t+1}]\pi(s_{1,t+1})}{E[(1 + r_{t+1})\tilde{w}_t]} \\ &= \frac{\sum_{s_{1t}} E[(1 + r_{t+1})\tilde{w}_t | s_{1t}, s_{1,t+1}]\pi(s_{1t}|s_{1,t+1})\pi(s_{1,t+1})}{\sum_{s_{1t},s_{1,t+1}} E[(1 + r_{t+1})\tilde{w}_t | s_{1t}, s_{1,t+1}]\pi(s_{1t}, s_{1,t+1})} \end{aligned}$$

$$= \frac{\sum_{s_1}(1+\bar{r}(s_{1t}, s_{1,t+1}))E[\tilde{w}_t|s_{1t}]\pi(s_{1t})}{\sum_{s_{1t},s_{1,t+1}}(1+\bar{r}(s_{1t}, s_{1,t+1}))E[\tilde{w}_t|s_{1t}]\pi(s_{1t})}$$

$$= \frac{\sum_{s_{1t}}(1+\bar{r}(s_{1t}, s_{1,t+1}))\Omega(s_{1t})}{\sum_{s_{1t},s_{1,t+1}}(1+\bar{r}(s_{1t}, s_{1,t+1}))\Omega(s_{1t})}$$

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

### A.3 Computation

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

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

**Step 1:** Compute the pre-reform and post-reform stationary equilibrium allocation and the respective lifetime utilities.

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

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

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

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

Solving for the transitional dynamics, we find that setting $T = 100$ is sufficient and that the algorithm converges within 5 iterations to a tolerance level $tol = 1e - 8$.

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Table 1. Macroeconomic Effects

| | Pre-Reform | Post-Reform |
|---|---|---|
| unemployment rate | 9% | 7.78% |
| job finding rate (short-term) | 0.24 | 0.252 |
| job finding rate (long-term) | 0.06 | 0.089 |

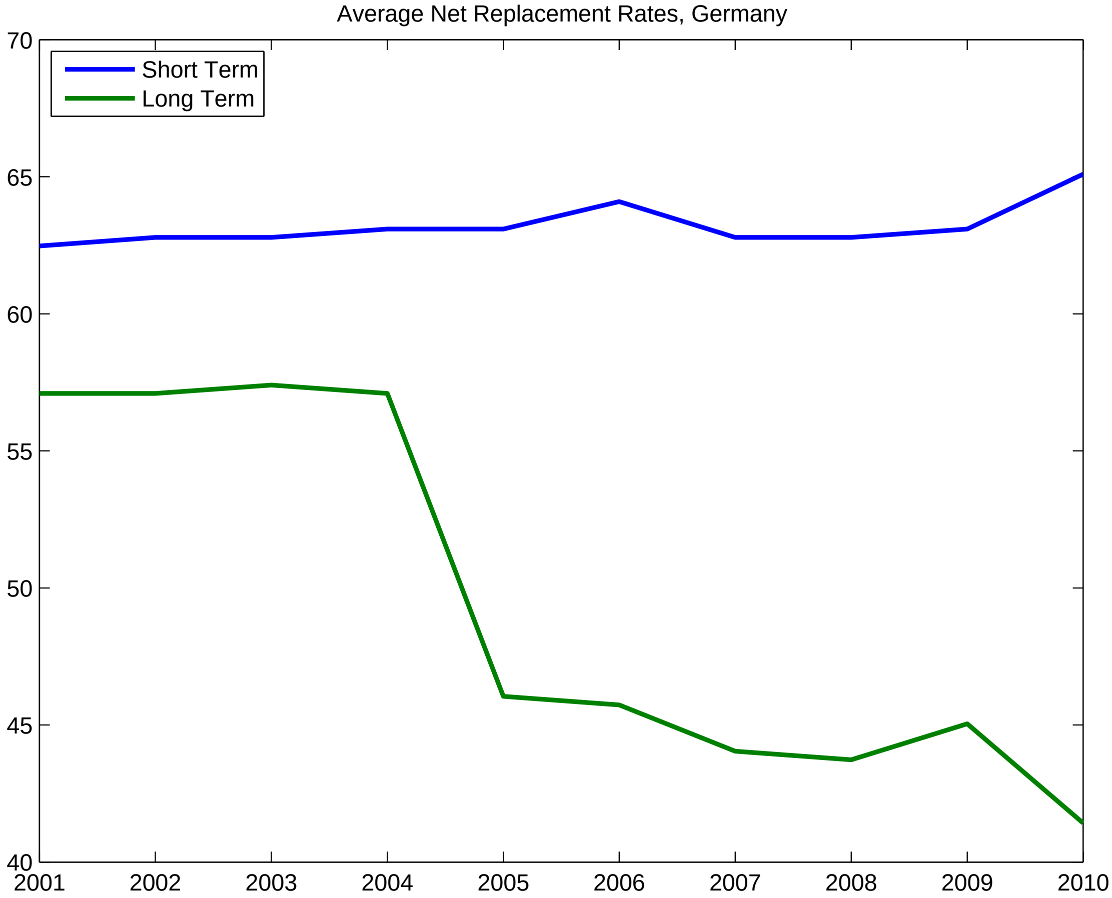
Table 2. Welfare Effects in Percent of Lifetime Consumption

| | Net Effect | Insurance Effect |
|---|---|---|
| Employed | +0.328% | -0.312 % |
| Short-term Unemployed | −0.304% | -0.940 % |
| Long-term Unemployed | −1.012% | -1.643 % |
| Social Welfare | +0.239% | -0.399 % |

Figure 1: Unemployment Rate, Germany 1970 - 2012


*Source: OECD.*

Figure 2: Average Net Replacement Rate, Germany 2000 - 2010




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

Figure 3: Unemployment Dynamics

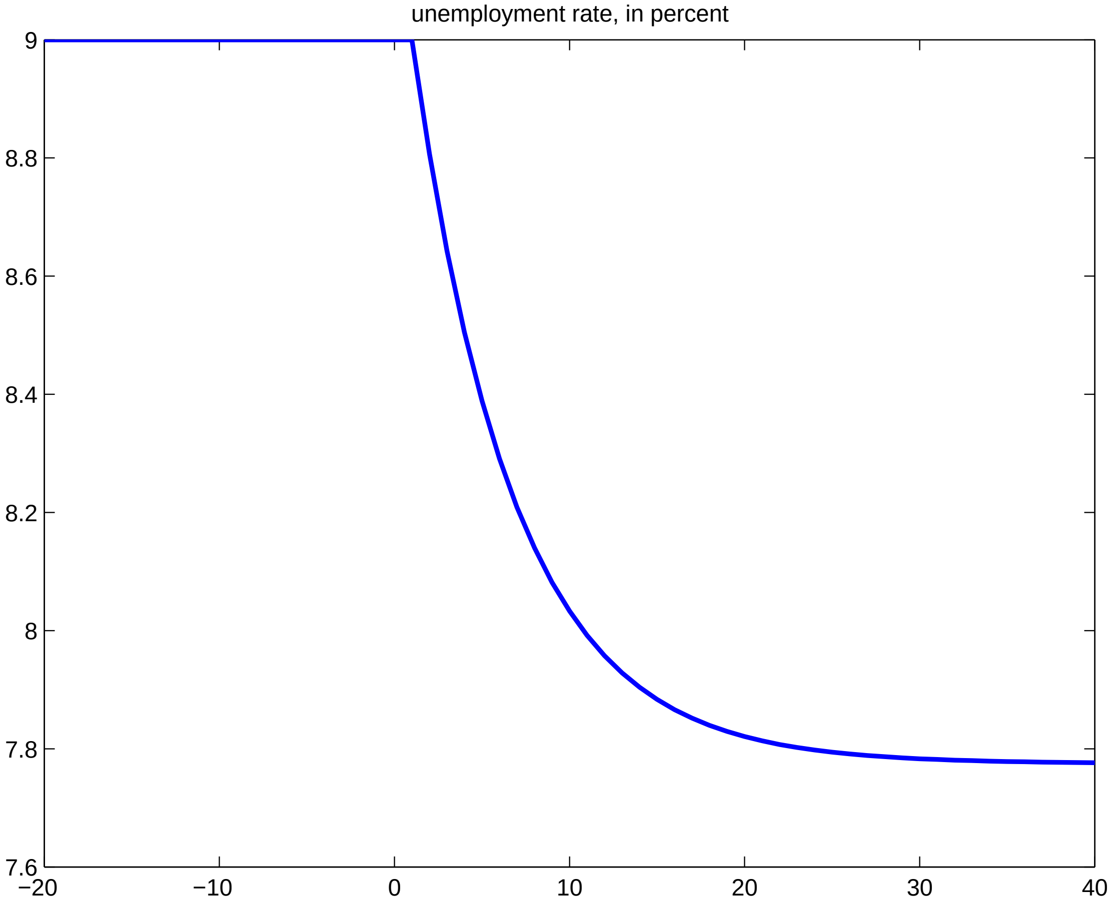


Figure 4: Unemployment Dynamics, Short Term and Long Term Unemployed

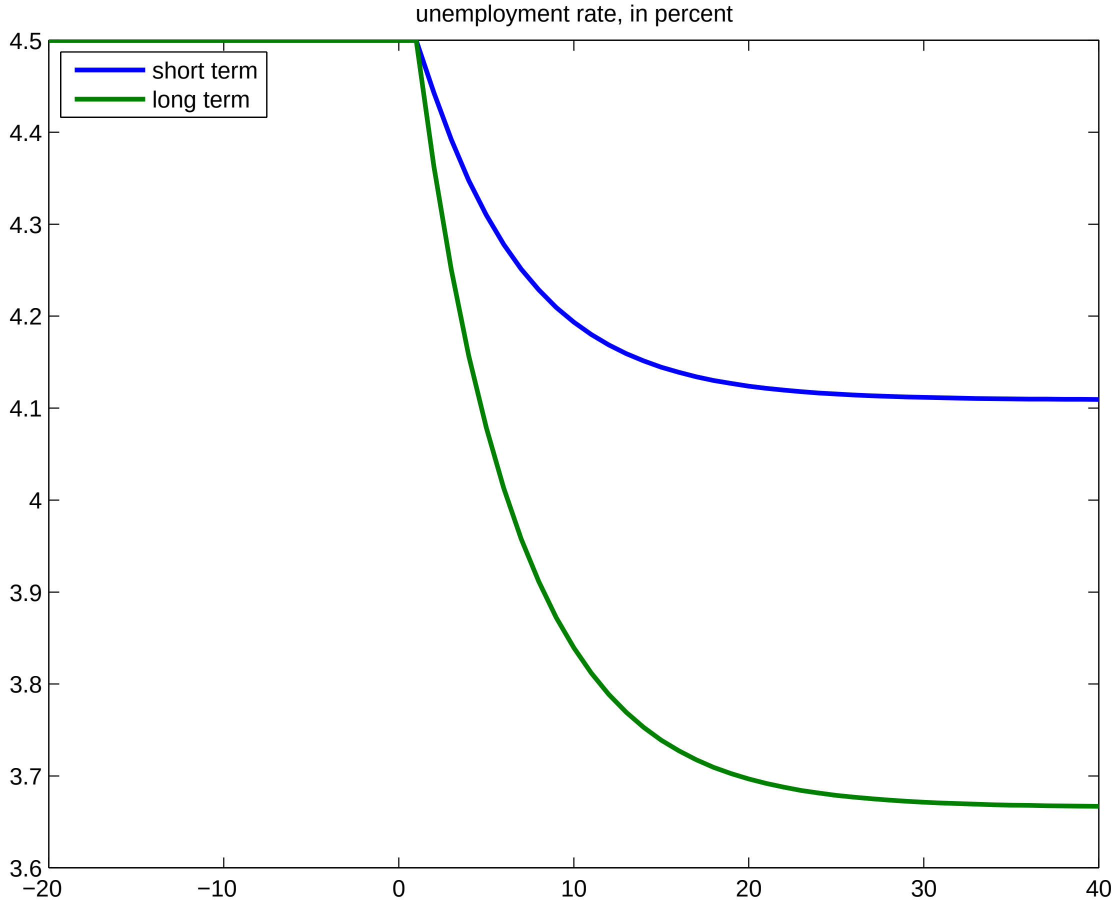


Figure 5: Output Dynamics

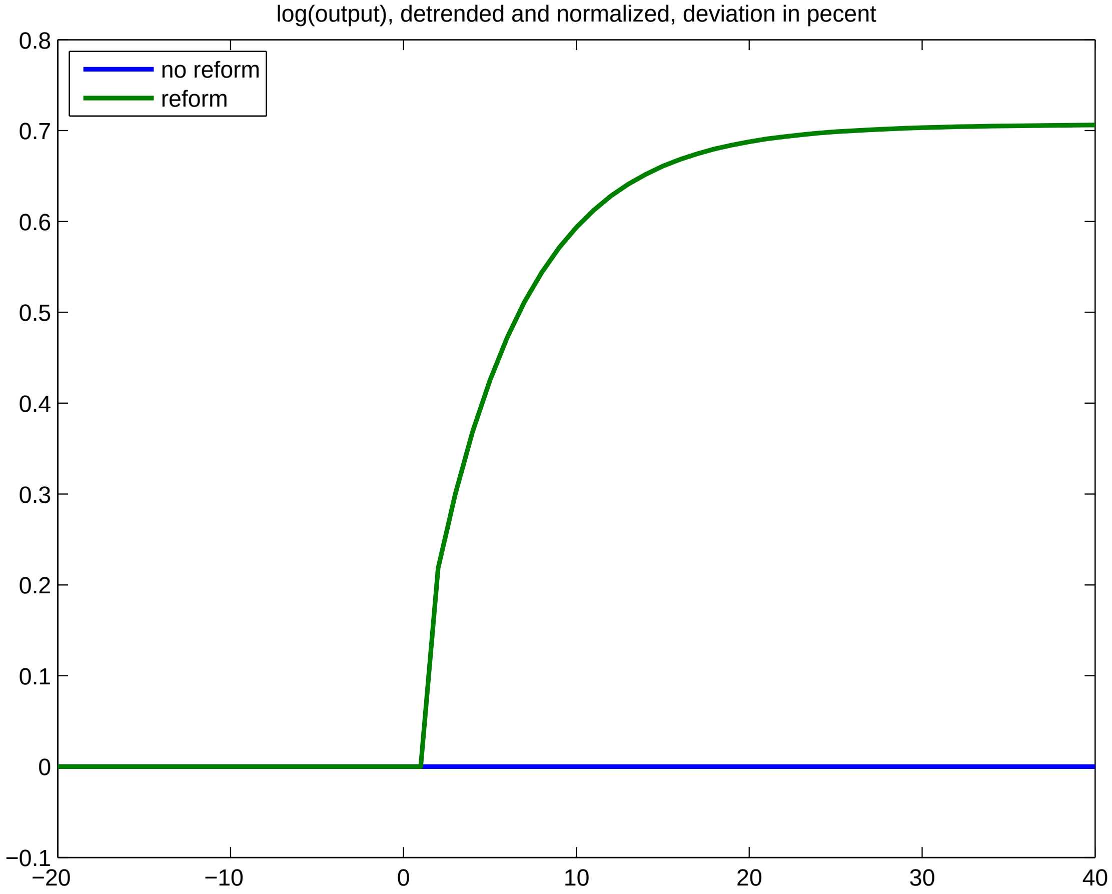


Figure 6: Wage Dynamics